

**REIMAGINING LEARNING IN THE 21ST CENTURY**  
ARTIFICIAL INTELLIGENCE, PEDAGOGICAL  
PRACTICES, AND UNIVERSITY FUTURES





Reimagining Learning in the 21st Century Artificial Intelligence, Pedagogical Practices, and University Futures

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## Prologue

The book you hold in your hands is not simply a collection of chapters; it is the result of an ambitious and rigorous exercise in intellectual and editorial convergence that has brought together, through an open and global call for submissions, a set of fundamental research projects that address the most pressing challenges and transformations in higher education and contemporary social contexts. It represents a living testimony to the vitality and diversity of research in fields ranging from specialized teaching and active methodologies to the ethical implications of artificial intelligence, the complexity of university management, and the urgency of social equity. The gestation of this book was a process of meticulous curation, where each proposal was evaluated not only for its methodological rigor and theoretical soundness, but also for its capacity for dialogue with reality and its potential to generate a significant impact on educational practice and policy. This editorial work has sought to recast scattered research, giving a unified voice to a community of academics who, from different latitudes, share a concern for building a more fair, innovative, and humane educational future. Readers should approach these pages with the expectation of finding themselves in a laboratory of ideas where the global meets the local, and where complex problems are examined with a critical and proactive eye. The works gathered here are an invitation to deep reflection, a spur to debate and, above all, a roadmap for transformative action in our institutions.

The journey begins with a direct analysis of technological disruption, exemplified by the transformation of medical education through Generative Artificial Intelligence (GAI). This research reveals an optimistic outlook among students, who perceive GAI as a useful and applicable tool for simulating clinical cases, offering personalized feedback, and improving competence. The results, which show a positive impact on the motivation and confidence of future physicians, underscore the potential of GAI to bridge the gaps in traditional clinical teaching by diversifying practice scenarios. However, the study does not shy away from the need to verify the reliability of AI-generated content, a point of friction that requires educators to maintain critical oversight and reinforce digital and ethical literacy in the curriculum. Complementing this perspective, another study delves into the implementation of AI tools for asynchronous learning among mobile application development students in Ecuador. This work validates the role of AI as a catalyst for personalization and autonomy in technical environments, with tools such as virtual tutors and code assistants that optimize study time and improve retention. Comparative analysis reveals a clear advantage of AI-



assisted approaches over traditional methods in terms of flexibility and scalability, although it also warns of the risks of overdependence and the persistence of the digital divide in the Latin American context. The challenge, then, is not technological, but pedagogical and structural, and demands institutional policies that guarantee equitable access and continuous teacher training.

The management and ethics of AI in universities become the focus of the following chapters, marking a crucial transition from the classroom to institutional governance. Reflection on ethics as the foundation for the appropriate use of AI is anchored in MacIntyre's virtue ethics, proposing that the integration of AI must be subject to a culture of intellectual honesty, critical thinking, and prudence (*phronesis*). Clear strategies for the constructive use of AI are outlined, such as the automation of repetitive tasks and formative assessment, while identifying the dangers of plagiarism, over-dependence, and the propagation of biases. The message is clear: AI is a tool that must serve the humanistic principles of education, and its governance must be transparent and multidisciplinary to prevent its algorithms from perpetuating or amplifying existing inequalities. Continuing along these lines, research on the challenges and opportunities for university management in Mexico in the face of AI offers a diagnosis of the gap between student adoption and institutional preparedness. The data is revealing: a high rate of use by students (mostly without teaching guidance or ethical training) contrasts with the slowness of universities to generate clear policies and train their teachers. This gap is not only a problem of hardware or software, but also a question of leadership and strategic vision, which requires managers to transform their practices and embrace AI as an ally for administrative automation and pedagogical innovation. Linking concerns about AI management with teaching assessment, another study raises the question of who assesses better, humans or machines, in the context of assessing writing in a second language (ESL/CLIL). The comparison between human and AI-assisted (ChatGPT-4o) grading shows a moderate to acceptable agreement, suggesting that AI can be an ally for consistency and efficiency in formative assessment. However, it is reiterated that human judgment is irreplaceable for interpreting nuances, context, and intent in writing, especially in subjective criteria. The value of AI therefore lies in its complementary function, freeing teachers from repetitive workloads so that they can focus on qualitative feedback and pedagogical mediation.

The systemic vision of education and its issues of permanence and quality are gaining ground with a proposed model for monitoring and projecting the academic trajectories of university students assisted by AI. This model transcends the mere accumulation of data to become an intelligent and

dynamic system that, through GPT-4.0 agents, analyzes in real time the personal, academic, and institutional factors that influence success or dropout. Its value lies in its predictive and simulation capabilities, allowing institutions to anticipate risks and design personalized interventions before the problem manifests itself, marking a milestone in evidence-based decision-making in the context of Mexican public universities. In line with the systemic vision, a Colombian study addresses the effects of student dropout in higher education from a systems dynamics perspective. Through the simulation of six-year scenarios, this research demonstrates that dropout is not only an individual loss, but a force that undermines institutional sustainability, negatively affecting income, faculty staffing, and research capacity. The conclusion is a call to action: coordinated student retention and support policies are key to reversing the trend and generating a virtuous circle of academic and scientific stability.

The focus shifts to teacher training and educational quality, critical elements for the implementation of any innovation. One chapter is devoted to analyzing educational quality in the Chilean school system, where the concept has evolved from a focus on standardized performance (SIMCE) to a multidimensional vision of educational justice. The persistence of structural inequalities and the ambivalence in the relationship between evaluation and improvement are identified. The study emphasizes that the strategic pillars of quality are not only regulatory frameworks, but also distributed pedagogical leadership and teacher collaboration, elements that must be cultivated from initial and continuing training. Delving deeper into university teacher training, a validated model for evaluating the impact of teacher training in the context of curricular innovation in Chilean universities is presented. This five-level model (Institutional Action, Satisfaction, Learning, Transfer/Innovation, and Results) seeks to overcome reductionist approaches to measure not only the acquisition of knowledge, but also the actual transfer to pedagogical practice and the impact on student learning. The high content validity confirmed by experts validates this framework as a robust tool for quality assurance and accountability.

The application of innovative pedagogical approaches in specific disciplines shows the way toward curricular relevance. The experience of the university press *UNA COLUMNA* as a learning space using the Project-Based Learning (PBL) methodology in Peru's journalism program is an eloquent example. This study confirms that PBL is an effective strategy for simulating professional practice, strengthening students' technical skills, autonomy, teamwork, and sense of social responsibility. Despite challenges such as the partial transition to a digital environment and difficulties in finding sources, the initiative

demonstrates the value of placing learning in authentic contexts with tangible results for the community. In the field of industrial engineering, one chapter explores the use of game design as a learning strategy to understand Technology Readiness Levels (TRLs). By involving students in the creation of a board game from conception to functional prototype, the playful PBL methodology integrates abstract TRL concepts through experience, collaboration, and creativity. This approach not only increases motivation and academic performance, but also develops soft skills essential for innovation, such as systemic thinking and adaptability.

A look at active methodologies in civil engineering education using STEM and PBL methodologies in irrigation and hydraulics courses in Ecuador reveals how solving real-world problems—such as designing vertical gardens or analyzing water networks in vulnerable communities—significantly improves student performance and satisfaction. This interdisciplinary approach, which links scientific theory with practice in the field, not only develops technical skills but also promotes social responsibility and environmental awareness. Teacher training in STEAM methodologies and its effect on scientific and mathematical learning in Ecuador is analyzed through the perception of teachers. The research concludes that this training transforms teachers from content transmitters to learning designers, strengthening their teaching, digital, and collaborative skills. Innovative pedagogy with STEAM, which includes project-based learning and the use of simulations, increases student motivation and self-efficacy, revaluing science and mathematics as disciplines relevant to everyday life.

Finally, the prologue delves into the social and psychological dimensions of education. The study on psychological well-being and academic engagement in Peruvian university students establishes a moderate but significant association between the two variables, suggesting that greater well-being translates into greater dedication and effort in academic tasks. The results challenge stereotypes, showing that older students and those who work and study report higher levels of well-being and commitment, suggesting that psychosocial maturity and clarity of life goals act as protective factors. The chapter on the network society and the pedagogy of cyberspace argues that technologies are a non-neutral force that redefines communication and learning, urging cyber pedagogy to develop didactic and technological strategies that overcome the digital divide and promote critical and responsible digital citizenship. The systematic review validates the need to integrate social networks and virtual environments as spaces for dialogue and participation, recognizing their impact on the teaching-learning process.

The construction of professional identity is explored in the context of early childhood education students in Chile. The analysis reveals that their initial vocation, often idealized and laden with gender stereotypes, clashes with the reality of university life, leading to an identity crisis. Despite initial disappointment, most persist, reaffirming a desire for professionalization. The influence of family on career choice underscores the need for more autonomous support in the development of professional identity. A final study on student motivation applies Self-Determination Theory to Spanish university students. Longitudinal results indicate that, although intrinsic motivation (interest, enjoyment, satisfaction) is strongest at the beginning of the semester, it experiences a slight decline towards the end, while extrinsic motivation (achieving grades, acquiring job skills) remains stable or even increases. This finding suggests that pedagogical strategies should focus on keeping intrinsic interest alive, constantly connecting content with personal and professional relevance to combat demotivation and ensure long-term commitment.

In short, this book is a symphony of research voices that resonate with the complexity and hope of an educational future in constant redefinition. Each chapter, from the ethics of AI in management to the playful teaching of engineering, has been carefully selected and reviewed to ensure maximum quality and relevance. The convergence of research projects from multiple universities in an open call has allowed for the creation of a significant contribution that is not limited to describing problems, but is committed to the search for situated, ethical, and innovative solutions. We invite readers, academics, managers, and students to immerse themselves in this rich source of knowledge, to question their own practices, and to join the global effort for educational transformation. This book is, in essence, a tool for thinking and acting, a manifesto of research that dares to imagine and build a new social contract for education in the 21st century.

## Table of contents

|                                                                                                                             |           |
|-----------------------------------------------------------------------------------------------------------------------------|-----------|
| <b>Prologue.....</b>                                                                                                        | <b>1</b>  |
| <b>Table of contents .....</b>                                                                                              | <b>6</b>  |
| <b>Digital reading practice among secondary education students in Peru .....</b>                                            | <b>25</b> |
| Introduction .....                                                                                                          | 25        |
| Theoretical Framework.....                                                                                                  | 26        |
| Digital Reading Sources .....                                                                                               | 28        |
| Digital Reading Media.....                                                                                                  | 29        |
| Types of Digital Texts .....                                                                                                | 29        |
| Digital Reading Strategies.....                                                                                             | 30        |
| Conclusions .....                                                                                                           | 30        |
| References.....                                                                                                             | 31        |
| <b>Artificial Intelligence knowledge and skills in elementary school teachers in<br/>Hidalgo: an exploratory study.....</b> | <b>33</b> |
| Introduction .....                                                                                                          | 33        |
| Case Study .....                                                                                                            | 34        |
| Context description.....                                                                                                    | 35        |
| Conclusions .....                                                                                                           | 38        |
| References.....                                                                                                             | 39        |
| <b>University Newspaper UNA COLUMNA as a Specialized Learning Space<br/>through the Project-Based Method .....</b>          | <b>41</b> |
| Introduction .....                                                                                                          | 41        |
| Journalistic Practice as the Core of Learning .....                                                                         | 42        |
| The Project Method as a Pedagogical Strategy .....                                                                          | 42        |
| Print Journalism and Transition to the Digital Environment .....                                                            | 43        |
| Journalistic Production and Media Reach .....                                                                               | 44        |
| Acquired Skills and Student Perception .....                                                                                | 44        |
| Challenges Identified During the Process .....                                                                              | 45        |
| Editorial Design and Digital Transition .....                                                                               | 45        |
| Conclusions .....                                                                                                           | 46        |

|                                                                                                                              |           |
|------------------------------------------------------------------------------------------------------------------------------|-----------|
| References.....                                                                                                              | 47        |
| <b>From the Classroom to the Metaverse: Emerging Technologies for the<br/>Transdisciplinary Management of Knowledge.....</b> | <b>49</b> |
| Introduction .....                                                                                                           | 49        |
| Case Study .....                                                                                                             | 50        |
| Context description.....                                                                                                     | 50        |
| Cluster analysis.....                                                                                                        | 51        |
| Conclusions .....                                                                                                            | 52        |
| References.....                                                                                                              | 53        |
| <b>Higher education: Graduate degrees in agribusiness in Latin America.....</b>                                              | <b>54</b> |
| Introduction .....                                                                                                           | 54        |
| Conclusions .....                                                                                                            | 59        |
| References.....                                                                                                              | 59        |
| <b>Educational Management in the Digital Age: Digital Ecosystems and<br/>Innovation Strategies with AI .....</b>             | <b>61</b> |
| Introduction .....                                                                                                           | 61        |
| Theoretical Framework.....                                                                                                   | 62        |
| Aims of the study .....                                                                                                      | 63        |
| Pedagogical Innovation: Student-Centered Methodologies and Practices ..                                                      | 65        |
| Proposed Strategic Framework.....                                                                                            | 66        |
| Conclusions .....                                                                                                            | 67        |
| References.....                                                                                                              | 68        |
| <b>INACAP international virtual exchange program: Innovation in logistics<br/>education with a global perspective.....</b>   | <b>70</b> |
| Context and program justification.....                                                                                       | 70        |
| Study objectives .....                                                                                                       | 71        |
| Foundations of Challenge-Based Learning (CBL) .....                                                                          | 71        |
| Virtual Exchange Models and Collaborative Online International Learning<br>(COIL) .....                                      | 71        |
| Development of intercultural competencies in higher education .....                                                          | 72        |
| Integration of sustainability in logistics vocational training.....                                                          | 72        |



|                                                                                                                                                |            |
|------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| Program implementation process .....                                                                                                           | 74         |
| Practical and theoretical implications of the program.....                                                                                     | 76         |
| Conclusions .....                                                                                                                              | 76         |
| References.....                                                                                                                                | 77         |
| <b>Psychological well-being and academic engagement in Peruvian university<br/>students .....</b>                                              | <b>79</b>  |
| Introduction .....                                                                                                                             | 79         |
| Conclusions .....                                                                                                                              | 83         |
| References.....                                                                                                                                | 84         |
| <b>Transforming Student Success: An AI-Supported Model for Monitoring and<br/>Projecting University Students' Academic Trajectories.....</b>   | <b>87</b>  |
| Introduction .....                                                                                                                             | 87         |
| Context Description and Justification .....                                                                                                    | 89         |
| Key Concepts .....                                                                                                                             | 90         |
| Model Description.....                                                                                                                         | 91         |
| Conclusions .....                                                                                                                              | 95         |
| References.....                                                                                                                                | 95         |
| <b>Sustainable accounting education at the university of Cundinamarca, Facatativá<br/>campus: a competency perspective from auditing .....</b> | <b>97</b>  |
| Introduction .....                                                                                                                             | 97         |
| Conceptual, theoretical, and normative framework.....                                                                                          | 98         |
| Previous Research.....                                                                                                                         | 98         |
| Bibliographic analysis .....                                                                                                                   | 99         |
| Expert Interview Analysis.....                                                                                                                 | 101        |
| Academic Plans Analysis .....                                                                                                                  | 102        |
| Conclusions .....                                                                                                                              | 103        |
| References.....                                                                                                                                | 104        |
| <b>Challenges and opportunities for university management in response to<br/>generative AI disruption in Mexico .....</b>                      | <b>106</b> |
| Introduction .....                                                                                                                             | 106        |
| Use of GenAI in Mexican higher education.....                                                                                                  | 107        |

|                                                                                                                                                           |            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| Context overview .....                                                                                                                                    | 107        |
| Educational use of the GenAI .....                                                                                                                        | 108        |
| Advantages and disadvantages in the educational use of GenAI.....                                                                                         | 110        |
| Headmasters perspectives .....                                                                                                                            | 111        |
| Cluster analysis: GenAI trends in higher education .....                                                                                                  | 112        |
| Conclusions .....                                                                                                                                         | 113        |
| References.....                                                                                                                                           | 114        |
| <b>The network society and the pedagogy of cyberspace: a systematic review .</b>                                                                          | <b>115</b> |
| Introduction .....                                                                                                                                        | 115        |
| Stage 1: Interpretation .....                                                                                                                             | 118        |
| Stage 2: Theoretical construction .....                                                                                                                   | 118        |
| AT1. Social networks: impact on the teaching-learning process .....                                                                                       | 119        |
| AT2. Cyberpedagogy in 21st-century education .....                                                                                                        | 120        |
| AT3. Technological and pedagogical strategies from the digital<br>transformation of education .....                                                       | 121        |
| References.....                                                                                                                                           | 123        |
| <b>Technology and Academic Tutoring at the Autonomous University of Baja<br/>California, Mexico: Gained Knowledge Throughout the Pandemic Period ....</b> | <b>129</b> |
| Introduction .....                                                                                                                                        | 129        |
| Academic tutoring and its digital evolution .....                                                                                                         | 130        |
| Institutional transformation and tutorial resilience .....                                                                                                | 130        |
| Core components of academic tutoring: communication, support, and school<br>management .....                                                              | 130        |
| Tutor–Student communication on digital platforms.....                                                                                                     | 130        |
| Academic and emotional support.....                                                                                                                       | 131        |
| Personalized academic management.....                                                                                                                     | 131        |
| Conclusion.....                                                                                                                                           | 135        |
| References.....                                                                                                                                           | 135        |

|                                                                                                                                                                                                                |            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>Proximal composition and potential nutritional value of microgreens (<i>Rumex acetosa</i>, <i>Brassica oleracea</i> var. <i>italica</i>, <i>Beta vulgaris</i>) conventionally packaged in Ecuador .....</b> | <b>138</b> |
| Introduction .....                                                                                                                                                                                             | 138        |
| Selection, harvesting, packaging, and storage of microgreen varieties.....                                                                                                                                     | 139        |
| Experimental design.....                                                                                                                                                                                       | 140        |
| Proximal composition .....                                                                                                                                                                                     | 140        |
| Macroelement and microelement mineral content .....                                                                                                                                                            | 141        |
| Analysis of bioactive compounds.....                                                                                                                                                                           | 141        |
| Sensory evaluation .....                                                                                                                                                                                       | 141        |
| Proximal composition of the microgreens studied.....                                                                                                                                                           | 143        |
| Analysis of macro and micro mineral elements in the varieties studied on day 7 .....                                                                                                                           | 144        |
| Bioactive compounds and antioxidant capacity of microgreens.....                                                                                                                                               | 146        |
| Sensory characterization.....                                                                                                                                                                                  | 148        |
| Conclusions .....                                                                                                                                                                                              | 149        |
| Reference .....                                                                                                                                                                                                | 149        |
| <b>Probiotics, functional groups, and their relationship to health status as continuing education for nurses.....</b>                                                                                          | <b>153</b> |
| Introduction .....                                                                                                                                                                                             | 153        |
| Immunomodulatory microbiota.....                                                                                                                                                                               | 155        |
| Protective microbiota .....                                                                                                                                                                                    | 156        |
| Muconutritive microbiota .....                                                                                                                                                                                 | 157        |
| Saccharolytic microbiota .....                                                                                                                                                                                 | 159        |
| Neuroactive microbiota.....                                                                                                                                                                                    | 160        |
| Proteolytic microbiota .....                                                                                                                                                                                   | 161        |
| Another composition of the microbiota .....                                                                                                                                                                    | 161        |
| Conclusions .....                                                                                                                                                                                              | 162        |
| References.....                                                                                                                                                                                                | 162        |
| <b>Argumentation management in the mathematics class for future teachers....</b>                                                                                                                               | <b>168</b> |
| Introduction .....                                                                                                                                                                                             | 168        |

|                                                                                                                          |            |
|--------------------------------------------------------------------------------------------------------------------------|------------|
| Argumentation management in the mathematics classroom.....                                                               | 170        |
| Error management .....                                                                                                   | 171        |
| Evaluation.....                                                                                                          | 172        |
| Conclusions .....                                                                                                        | 173        |
| References.....                                                                                                          | 173        |
| <b>Educational Quality in the Chilean School System: Key Dimensions,<br/>Measurement, and Current Challenges .....</b>   | <b>176</b> |
| Introduction .....                                                                                                       | 176        |
| Conceptual approaches to educational quality .....                                                                       | 177        |
| Key factors influencing educational quality.....                                                                         | 178        |
| Interaction between public policy and quality measurement .....                                                          | 178        |
| Emergence of new critical dimensions. (post-2020).....                                                                   | 179        |
| From quality as performance to quality as educational justice .....                                                      | 179        |
| Assessment, measurement, and improvement: An ambivalent relationship<br>.....                                            | 180        |
| School factors, leadership, and teacher professionalism .....                                                            | 180        |
| Structural inequalities: a persistent obstacle.....                                                                      | 180        |
| The emergence of new dimensions: well-being, participation, and meaning<br>.....                                         | 181        |
| Conclusions .....                                                                                                        | 181        |
| Educational quality is a multidimensional construct.....                                                                 | 181        |
| Tensions persist between assessment, accountability, and school<br>improvement. ....                                     | 182        |
| Pedagogical leadership and teacher collaboration are strategic pillars. ....                                             | 182        |
| Structural inequalities continue to condition quality. ....                                                              | 182        |
| The incorporation of new dimensions and technologies is both an<br>opportunity and a challenge. ....                     | 182        |
| References.....                                                                                                          | 183        |
| <b>Kingdom, power and glory. Teaching a scientific ontology for international<br/>analysis through a TV series .....</b> | <b>186</b> |
| Introduction .....                                                                                                       | 186        |

|                                                                                                                                                                |            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| How can a Scientific Ontology be taught in the International Relations?...                                                                                     | 186        |
| Borgen: Kingdom, power, and glory as a staging of a case.....                                                                                                  | 187        |
| Systems and Actors .....                                                                                                                                       | 188        |
| Strategic Interactions: Tale of an Eskimo Roll.....                                                                                                            | 189        |
| Conclusions .....                                                                                                                                              | 191        |
| References.....                                                                                                                                                | 192        |
| <b>From design to validation: a model for impact assessment of teacher training in Chilean universities with current curricular innovation processes .....</b> | <b>196</b> |
| Introduction .....                                                                                                                                             | 196        |
| Teacher Training .....                                                                                                                                         | 197        |
| Evaluation Context.....                                                                                                                                        | 197        |
| Context Description .....                                                                                                                                      | 198        |
| Proposed Model.....                                                                                                                                            | 198        |
| Content Validity Analysis (CVR Index) .....                                                                                                                    | 200        |
| Analysis of the Achievement Percentage by Dimension .....                                                                                                      | 200        |
| Conclusions .....                                                                                                                                              | 202        |
| References.....                                                                                                                                                | 202        |
| <b>Authentic Voices: Integrating Slang, Jargon, and Taboo in L2 Spanish via Virtual Coaching.....</b>                                                          | <b>206</b> |
| Introduction .....                                                                                                                                             | 206        |
| Facilitating the understanding and use of culturally specific expressions through virtual interactions .....                                                   | 209        |
| Connecting cultures and fostering intercultural understanding through real-world media in Spanish language learning .....                                      | 211        |
| Conclusions .....                                                                                                                                              | 213        |
| References.....                                                                                                                                                | 214        |
| <b>Citizenship Education: essential competences for initial teacher training in Portugal.....</b>                                                              | <b>216</b> |
| Introduction .....                                                                                                                                             | 216        |
| Basic Law of the Portuguese Education System (BLES) .....                                                                                                      | 219        |

|                                                                                                                                                                                                                         |            |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| Decree-Law 240/2001, of August 30 - Approves the general professional performance profile for kindergarten teachers, primary and secondary school teachers.....                                                         | 219        |
| Decree-Law 9-A/2025 - Approves the legal framework for professional qualifications for teaching in pre-school education and basic and secondary education and the legal framework for continuous teacher training ..... | 220        |
| Profile of Students leaving Compulsory Education (PSLCE).....                                                                                                                                                           | 220        |
| National Strategy for Citizenship Education (NSCE) .....                                                                                                                                                                | 220        |
| Council of Europe documents - Reference Framework of Competences for Democratic Culture .....                                                                                                                           | 221        |
| Analysis of the documents .....                                                                                                                                                                                         | 221        |
| Conclusions .....                                                                                                                                                                                                       | 224        |
| References.....                                                                                                                                                                                                         | 224        |
| <b>Implementation of artificial intelligence tools to support asynchronous learning in mobile application development students .....</b>                                                                                | <b>227</b> |
| Introduction .....                                                                                                                                                                                                      | 227        |
| The evolution of online education and the role of AI .....                                                                                                                                                              | 228        |
| Advantages of personalizing learning in technical environments .....                                                                                                                                                    | 229        |
| Comparison between traditional methods and AI-assisted approaches.....                                                                                                                                                  | 230        |
| Virtual tutors and educational chatbots: Features and use cases .....                                                                                                                                                   | 231        |
| Adaptive content recommendation systems.....                                                                                                                                                                            | 232        |
| AI-based code assistants (GitHub Copilot, Amazon CodeWhisperer) and their impact on autonomous learning. ....                                                                                                           | 233        |
| Factors influencing the adoption of AI in Ecuadorian universities .....                                                                                                                                                 | 234        |
| Perceptions of students and teachers about these technologies .....                                                                                                                                                     | 235        |
| Technical, pedagogical, and ethical challenges .....                                                                                                                                                                    | 236        |
| Metrics for measuring effectiveness (academic performance, retention, student satisfaction).....                                                                                                                        | 237        |
| Preliminary results of implementations in 2024.....                                                                                                                                                                     | 238        |
| Recommendations for future applications in higher education .....                                                                                                                                                       | 239        |
| Conclusion.....                                                                                                                                                                                                         | 240        |

|                                                                                                                                                |            |
|------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| References.....                                                                                                                                | 241        |
| <b>Game design as a learning strategy in industrial engineering: application of technology readiness levels (TRL) .....</b>                    | <b>248</b> |
| Introduction .....                                                                                                                             | 248        |
| Technology Readiness Levels (TRL) and their teaching in engineering.....                                                                       | 249        |
| Game design as a pedagogical strategy.....                                                                                                     | 250        |
| Design and implementation of the experience .....                                                                                              | 251        |
| Game planning .....                                                                                                                            | 252        |
| Execution and development .....                                                                                                                | 253        |
| Conclusions .....                                                                                                                              | 257        |
| References.....                                                                                                                                | 258        |
| <b>Artificial Intelligence and University Students' Perception in Learning.....</b>                                                            | <b>259</b> |
| Introduction .....                                                                                                                             | 259        |
| Artificial Intelligence and Education.....                                                                                                     | 261        |
| Cluster analysis.....                                                                                                                          | 264        |
| Conclusions .....                                                                                                                              | 265        |
| References.....                                                                                                                                | 266        |
| <b>Teacher training in STEAM Methodologies and its effect on Scientific and Mathematical Learning.....</b>                                     | <b>268</b> |
| Introduction .....                                                                                                                             | 268        |
| STEAM Training for teacher .....                                                                                                               | 269        |
| Student interest in learning science and mathematics.....                                                                                      | 270        |
| Transforming pedagogical practices through the STEAM framework: an analysis of the teacher's skills and scientific-mathematical learning. .... | 270        |
| Innovative Pedagogy with STEAM: Effects of Teacher Training on Science and Mathematics Learning .....                                          | 272        |
| Conclusions .....                                                                                                                              | 273        |
| References.....                                                                                                                                | 274        |
| <b>Systematic Review of Educational Reengagement: Factors, Programmes and Strategies under the PRISMA Framework.....</b>                       | <b>277</b> |

|                                                                                              |            |
|----------------------------------------------------------------------------------------------|------------|
| Contextualisation of School Dropout and the Importance of Educational Re-engagement.....     | 277        |
| Definition and Key Components of Educational Reengagement .....                              | 278        |
| Rationale and Objectives of the Systematic Review .....                                      | 279        |
| Factors Influencing Educational Reengagement.....                                            | 281        |
| Conclusions .....                                                                            | 283        |
| References.....                                                                              | 283        |
| <b>Didactic strategies in the bachelor's degree in Administration at FCCA-UMSNH</b><br>..... | <b>285</b> |
| Introduction .....                                                                           | 285        |
| Conclusions .....                                                                            | 293        |
| References.....                                                                              | 293        |
| <b>A Community of Dialogue: An Epistemological Stake in Inclusion Training...</b>            | <b>295</b> |
| Introduction .....                                                                           | 295        |
| A project of continuity.....                                                                 | 296        |
| Opening spaces for dialogue between research and training .....                              | 297        |
| Moving from political duty toward the ethical desire to include.....                         | 299        |
| Conclusions .....                                                                            | 302        |
| References.....                                                                              | 302        |
| <b>Irrigation and Hydraulics with STEM and PBL methodology for Civil Engineering.....</b>    | <b>306</b> |
| Introduction .....                                                                           | 306        |
| Irrigation course .....                                                                      | 309        |
| Hydraulic Course .....                                                                       | 310        |
| Irrigation Course.....                                                                       | 310        |
| Hydraulics Course .....                                                                      | 311        |
| Irrigation Course.....                                                                       | 311        |
| Hydraulic Engineering Course.....                                                            | 314        |
| Conclusions .....                                                                            | 315        |
| References.....                                                                              | 316        |



|                                                                                                                                                              |            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>Conceptions of the human being and their influence on the application of the student-centered educational model in a private chilean university .....</b> | <b>317</b> |
| Introduction .....                                                                                                                                           | 317        |
| Educational Paradigms and their transformation of the educational approach in Chile .....                                                                    | 318        |
| Pedagogical Foundations and Institutional Identity of the UBO Educational Model .....                                                                        | 320        |
| UBO Educational Model: Integration of Meaningful Learning, Autonomy, Inclusion and Formation for Lifelong Development.....                                   | 321        |
| Conclusion.....                                                                                                                                              | 325        |
| References.....                                                                                                                                              | 325        |
| <b>Applying Self-Determination Theory to University Students .....</b>                                                                                       | <b>328</b> |
| Introduction .....                                                                                                                                           | 328        |
| Theoretical framework.....                                                                                                                                   | 329        |
| Key findings.....                                                                                                                                            | 331        |
| Students' motivational state at the beginning of the academic year.....                                                                                      | 331        |
| Students' motivational state at the end of the academic year.....                                                                                            | 332        |
| Evolution of the students' motivational state throughout the academic year .....                                                                             | 333        |
| Conclusions .....                                                                                                                                            | 334        |
| References.....                                                                                                                                              | 335        |
| <b>Innovative education and circular entrepreneurship in the construction sector of Arequipa .....</b>                                                       | <b>338</b> |
| Introduction .....                                                                                                                                           | 338        |
| Innovative Education and sustainable development .....                                                                                                       | 338        |
| Circular economy in the construction sector.....                                                                                                             | 339        |
| Local context: Arequipa .....                                                                                                                                | 339        |
| Recycled tire asphalt panels.....                                                                                                                            | 339        |
| Ecological PET and rubber bricks.....                                                                                                                        | 339        |
| Prefabricated recycled plastic solutions .....                                                                                                               | 340        |
| Social impact and formative.....                                                                                                                             | 340        |

|                                                                                                                                            |            |
|--------------------------------------------------------------------------------------------------------------------------------------------|------------|
| Conclusions .....                                                                                                                          | 341        |
| References.....                                                                                                                            | 341        |
| <b>Population in Statistics as an object of phenomenology .....</b>                                                                        | <b>344</b> |
| Introduction .....                                                                                                                         | 344        |
| Bruner's categories of thought.....                                                                                                        | 345        |
| Types of population in Statistics.....                                                                                                     | 346        |
| Conclusions .....                                                                                                                          | 351        |
| References.....                                                                                                                            | 351        |
| <b>The right to education in rural areas. An approach from K. Tomaševski .....</b>                                                         | <b>354</b> |
| Introduction .....                                                                                                                         | 354        |
| Conclusions .....                                                                                                                          | 360        |
| References.....                                                                                                                            | 361        |
| <b>Enhancing Learning: Glocal Action and Collaboration through Service-Learning<br/>and COIL.....</b>                                      | <b>365</b> |
| Introduction .....                                                                                                                         | 365        |
| Collaborative Online International Learning .....                                                                                          | 365        |
| Service Learning .....                                                                                                                     | 366        |
| Conclusions .....                                                                                                                          | 373        |
| References.....                                                                                                                            | 374        |
| <b>Effects of dropout in higher education: a prospective study from a systemic<br/>approach in the case of Colombia .....</b>              | <b>377</b> |
| Introduction .....                                                                                                                         | 377        |
| Conceptual and contextual framework .....                                                                                                  | 379        |
| General model design.....                                                                                                                  | 381        |
| Conclusions .....                                                                                                                          | 384        |
| References.....                                                                                                                            | 385        |
| <b>Theoretical and Practical Reflections from a University Learning Community:<br/>Strategies for Curriculum Internationalization.....</b> | <b>388</b> |
| Introduction .....                                                                                                                         | 388        |
| Institutional context of internationalization at UC Temuco .....                                                                           | 389        |
| Learning Community: theoretical foundation and practical relevance.....                                                                    | 390        |

|                                                                                                              |            |
|--------------------------------------------------------------------------------------------------------------|------------|
| Design and implementation of the IoC Learning Community .....                                                | 390        |
| Case 1: Faculty of Architecture, Arts and Design – Design Program .....                                      | 392        |
| Case 2: Faculty of Health Sciences – Kinesiology Program .....                                               | 392        |
| Identified obstacles and challenges .....                                                                    | 393        |
| Conclusions .....                                                                                            | 395        |
| References .....                                                                                             | 396        |
| <b>Identity construction in the first year of an early childhood education degree<br/>programme .....</b>    | <b>398</b> |
| Introduction .....                                                                                           | 398        |
| Initial teacher training for early childhood teachers .....                                                  | 399        |
| Preconceptions about being an early childhood educator: .....                                                | 400        |
| Significant people .....                                                                                     | 401        |
| University education .....                                                                                   | 402        |
| Conclusions .....                                                                                            | 402        |
| References .....                                                                                             | 403        |
| <b>Virtual Learning Environment to promote research in education .....</b>                                   | <b>408</b> |
| Introduction .....                                                                                           | 408        |
| Virtual Learning Environments .....                                                                          | 409        |
| Virtual Learning Objet (VLO) .....                                                                           | 410        |
| Educational Digital Platforms .....                                                                          | 410        |
| Google Drive .....                                                                                           | 410        |
| Conclusions .....                                                                                            | 413        |
| References .....                                                                                             | 414        |
| <b>Career choice among domestic non-local students: the case of a private<br/>university in Mexico .....</b> | <b>416</b> |
| Introduction .....                                                                                           | 416        |
| General analysis of the vocational process .....                                                             | 417        |
| Specific analysis of factors influencing career choice .....                                                 | 417        |
| Conclusions .....                                                                                            | 422        |
| References .....                                                                                             | 423        |

|                                                                             |            |
|-----------------------------------------------------------------------------|------------|
| <b>Student retention in for-profit education: an updated analysis .....</b> | <b>426</b> |
| Introduction .....                                                          | 426        |
| Background .....                                                            | 426        |
| Findings and Contributions .....                                            | 428        |
| Conclusions and future research .....                                       | 431        |
| References .....                                                            | 432        |
| <b>PhD research: Can We Talk About a Field of Study? .....</b>              | <b>435</b> |
| Introduction .....                                                          | 435        |
| First period: Prior to 2000 .....                                           | 436        |
| Second period: 2000- 2010 .....                                             | 437        |
| Third period: 2011 to 2015. ....                                            | 438        |
| Fourth period: 2016 to 2020. ....                                           | 439        |
| Fifth period: 2021 to 2024. ....                                            | 440        |
| Conclusions .....                                                           | 441        |
| References .....                                                            | 442        |
| <b>School Leadership Training: Enhancing Well-Being .....</b>               | <b>444</b> |
| Introduction .....                                                          | 444        |
| Flourishing, Perceived Emotional Intelligence, Grit and Growth Mindset ..   | 444        |
| Purposeful Leadership .....                                                 | 446        |
| The Normal Schools of the Autonomous City of Buenos Aires .....             | 446        |
| A workshop on purposeful leadership and growth mindset .....                | 447        |
| Conclusions .....                                                           | 449        |
| References .....                                                            | 450        |
| <b>Hybrid higher education in Ecuador: post-pandemic trends .....</b>       | <b>453</b> |
| Introduction .....                                                          | 453        |
| Ecuador's higher education context .....                                    | 453        |
| Analytical Approach and Data Context .....                                  | 454        |
| Trends in Ecuador's Hybrid and Virtual Higher Education .....               | 455        |
| Conclusions .....                                                           | 459        |
| References .....                                                            | 459        |

|                                                                                                                                                                          |            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>Quality of professional training as perceived by graduates of a Faculty of Information Science and Technology at a public university in southeastern Mexico .....</b> | <b>462</b> |
| Introduction .....                                                                                                                                                       | 462        |
| Public Policies on Higher Education.....                                                                                                                                 | 463        |
| Human Capital Theory (HCT) .....                                                                                                                                         | 464        |
| Socio-demographic and Academic Profile .....                                                                                                                             | 465        |
| Work History.....                                                                                                                                                        | 466        |
| Position and Work Activities.....                                                                                                                                        | 466        |
| Perceptions of University Education.....                                                                                                                                 | 467        |
| Conclusions .....                                                                                                                                                        | 467        |
| References.....                                                                                                                                                          | 469        |
| <b>Quality, accreditation, and teaching profile: an analysis from higher education in Chile and Latin America .....</b>                                                  | <b>471</b> |
| Introduction .....                                                                                                                                                       | 471        |
| Conclusions .....                                                                                                                                                        | 478        |
| References.....                                                                                                                                                          | 480        |
| <b>Digital educational technologies in Ecuador from the perspective of teachers .....</b>                                                                                | <b>482</b> |
| Introduction .....                                                                                                                                                       | 482        |
| Educational vulnerability and ICT use .....                                                                                                                              | 483        |
| Teachers' perspectives on the use of ICT in the classroom.....                                                                                                           | 483        |
| The UTAUT model: Fundamentals and Applications .....                                                                                                                     | 484        |
| Information processing.....                                                                                                                                              | 484        |
| Sociodemographic characteristics of the teachers surveyed .....                                                                                                          | 485        |
| Performance Expectation .....                                                                                                                                            | 486        |
| Expectation of effort.....                                                                                                                                               | 487        |
| Facilitating conditions .....                                                                                                                                            | 488        |
| Conclusion.....                                                                                                                                                          | 489        |
| References.....                                                                                                                                                          | 490        |

|                                                                                                                                                                           |            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>Design and Validation of the Neuropsychological Aptitude Test to Evaluate the Entry Profile of Children Aged Four to Five Years Entering Preschool Education .....</b> | <b>493</b> |
| Introduction .....                                                                                                                                                        | 493        |
| Literature Review: Neurodevelopment in Early Childhood .....                                                                                                              | 494        |
| Evidence of Validity based on Test Content.....                                                                                                                           | 495        |
| Evidence of validity based on Internal Structure .....                                                                                                                    | 497        |
| Item's psychometric parameter .....                                                                                                                                       | 499        |
| Conclusions .....                                                                                                                                                         | 500        |
| References.....                                                                                                                                                           | 500        |
| <b>Comparative Analysis of Governance Models in Europe and Latin America for the Decarbonization of Their Economies.....</b>                                              | <b>503</b> |
| Introduction .....                                                                                                                                                        | 503        |
| Analysis of the main policies and strategies adopted in the governance models for both regions.....                                                                       | 504        |
| Similarities in regional approaches.....                                                                                                                                  | 508        |
| Assessment of the components that contribute to the success or failure of decarbonization policies in the countries analyzed.....                                         | 510        |
| Proposal for best practices and recommendations for optimizing public decarbonization strategies .....                                                                    | 515        |
| Conclusions .....                                                                                                                                                         | 518        |
| References.....                                                                                                                                                           | 519        |
| <b>Artificial intelligence and statistical quality control in manufacturing .....</b>                                                                                     | <b>522</b> |
| Introduction .....                                                                                                                                                        | 522        |
| Statistical Quality Control .....                                                                                                                                         | 523        |
| Artificial Intelligence and Machine Learning in Manufacturing .....                                                                                                       | 524        |
| Integrating AI into quality control.....                                                                                                                                  | 525        |
| Implementation challenges .....                                                                                                                                           | 528        |
| Future prospects.....                                                                                                                                                     | 531        |
| Conclusions .....                                                                                                                                                         | 534        |
| References.....                                                                                                                                                           | 535        |

|                                                                                                                                    |            |
|------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>Pedagogical innovation in interventional radiology: application of the Spatial i.o metaverse for cooperative learning .....</b> | <b>537</b> |
| Introduction .....                                                                                                                 | 537        |
| Overall level of cooperative learning .....                                                                                        | 540        |
| Dimensions of cooperative learning .....                                                                                           | 541        |
| Positive interdependence.....                                                                                                      | 541        |
| Interaction .....                                                                                                                  | 541        |
| Social skills.....                                                                                                                 | 541        |
| Heterogeneity .....                                                                                                                | 542        |
| Group reflection .....                                                                                                             | 542        |
| Evaluation.....                                                                                                                    | 542        |
| Tutoring .....                                                                                                                     | 542        |
| General comparative analysis.....                                                                                                  | 542        |
| General interpretation of the findings.....                                                                                        | 543        |
| Conclusions .....                                                                                                                  | 545        |
| References.....                                                                                                                    | 545        |
| <b>Ethics as the Foundation for the Appropriate Use of IA in Universities .....</b>                                                | <b>549</b> |
| Introduction .....                                                                                                                 | 549        |
| Ideas for the Ethical Use of AI in Universities.....                                                                               | 553        |
| Personalization of Learning .....                                                                                                  | 553        |
| Automation of Repetitive Tasks and Formative Assessment.....                                                                       | 553        |
| Fostering Creativity and Research.....                                                                                             | 553        |
| Development of 21st Century Skills .....                                                                                           | 554        |
| Dangers of Unethical Use and How to Avoid Them: A Deep Ethical Perspective .....                                                   | 554        |
| Plagiarism and Impersonation.....                                                                                                  | 554        |
| Loss of Critical Skills and Over-Reliance.....                                                                                     | 555        |
| Propagation of Biases and Misinformation .....                                                                                     | 555        |
| Lack of Transparency and “Black Box” Phenomenon .....                                                                              | 556        |
| Personal Responsibility in Light of Macintyre’s Virtue Ethics.....                                                                 | 556        |

|                                                                                                                                                         |            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| Intellectual Honesty.....                                                                                                                               | 556        |
| Critical Thinking.....                                                                                                                                  | 556        |
| Prudence (Phronesis) .....                                                                                                                              | 557        |
| Responsibility .....                                                                                                                                    | 557        |
| Conclusions .....                                                                                                                                       | 557        |
| References.....                                                                                                                                         | 558        |
| <b>Humans vs. Machines: Who Grades Best? Evaluating AI Reliability in ESL/CLIL Writing Assessment.....</b>                                              | <b>560</b> |
| Introduction .....                                                                                                                                      | 560        |
| Context: The Rise of AI in Educational Settings, Particularly in Assessment .....                                                                       | 561        |
| Setting the Match: Teacher vs. AI Model .....                                                                                                           | 563        |
| Where Humans and AI Agree and Where They Don't .....                                                                                                    | 564        |
| What Does This Mean for Classroom Assessment? .....                                                                                                     | 566        |
| The Win: Working Side-by-Side .....                                                                                                                     | 567        |
| References.....                                                                                                                                         | 568        |
| <b>Global inclusive trends in higher education: content analysis and case study</b>                                                                     | <b>570</b> |
| Introduction .....                                                                                                                                      | 570        |
| Case studies in higher education .....                                                                                                                  | 571        |
| Context description.....                                                                                                                                | 571        |
| Conclusions .....                                                                                                                                       | 575        |
| References.....                                                                                                                                         | 576        |
| <b>Inclusive Education in University Music Programs: Policies, Teaching Practices, and Experiences of Students with Disabilities in Argentina .....</b> | <b>580</b> |
| Introduction .....                                                                                                                                      | 580        |
| Disability Models.....                                                                                                                                  | 580        |
| Inclusion Paradigms.....                                                                                                                                | 581        |
| Universal Design as an Approach to Inclusion .....                                                                                                      | 582        |
| Inclusive Policies.....                                                                                                                                 | 583        |
| Music Education and Inclusion.....                                                                                                                      | 584        |



|                                                                                                                                                             |            |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| Research Problem.....                                                                                                                                       | 584        |
| Research Objectives .....                                                                                                                                   | 585        |
| Conclusions .....                                                                                                                                           | 586        |
| References.....                                                                                                                                             | 587        |
| <b>Assessment of interdisciplinary learning between design and business students<br/>through agile entrepreneurship methodologies.....</b>                  | <b>590</b> |
| Introduction .....                                                                                                                                          | 590        |
| Design as a Project-Based Discipline .....                                                                                                                  | 592        |
| Learning in Higher Education.....                                                                                                                           | 592        |
| Motivation and Willingness to Collaborate Across Disciplines .....                                                                                          | 593        |
| Impact of Lego® Serious Play® as an Activation Tool .....                                                                                                   | 593        |
| Assessment of Interdisciplinary Learning .....                                                                                                              | 594        |
| Conclusions .....                                                                                                                                           | 596        |
| References.....                                                                                                                                             | 597        |
| <b>Tutoring among higher education faculty: An integrated approach to<br/>collaborative learning.....</b>                                                   | <b>599</b> |
| Introduction .....                                                                                                                                          | 599        |
| Case Study .....                                                                                                                                            | 601        |
| Conclusions .....                                                                                                                                           | 604        |
| References.....                                                                                                                                             | 605        |
| <b>Transforming Medical Education through Generative AI: A Comprehensive<br/>Analysis of Student Experiences and Learning Outcomes in Clinical Practice</b> | <b>608</b> |
| Introduction .....                                                                                                                                          | 608        |
| Quantitative Analysis and Student Perception Distribution .....                                                                                             | 609        |
| Likert Scale Analysis: Specific Benefits and Challenges .....                                                                                               | 610        |
| Qualitative Analysis: Semantic Categories and Student Voices .....                                                                                          | 611        |
| Dimensional Analysis and Implementation Insights .....                                                                                                      | 612        |
| Conclusions .....                                                                                                                                           | 614        |
| References.....                                                                                                                                             | 615        |

# Digital reading practice among secondary education students in Peru

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## Introduction

Digital reading has become a consolidated reality in recent years, as a result of the rapid advancement of digital technologies and the integration of new pedagogical practices. However, this situation does not necessarily translate into improved student performance; on the contrary, data continue to show significant percentages of low reading proficiency.

In 2021, UNESCO emphasized that an additional one hundred million children worldwide failed to reach minimum reading competencies. In Latin America, by the end of 2020, approximately 58.0% of final-year secondary students were unable to read without difficulty (UNESCO, 2021). In the Peruvian context, the 2022 PISA test revealed that 50.4% of 10th-grade students achieved scores corresponding to level 1 (<1c - 1a). Similarly, Peru's 2024 National Student Assessment (ENLA) showed that 14.2% of 6th-grade primary students scored below the initial level and 33.4% at the initial level, indicating that around half of the students were only attaining minimal reading achievements (Ministry of Education of Peru, 2024). Additionally, reading habits among Peruvian students have weakened—unsurprising given that Peru ranks among the lowest in Latin American reading rates.

This problematic situation worsened during the Covid-19 pandemic, when students pursued their educational experiences remotely. This context accelerated reading practices in digital formats and led students to increasingly prefer digital reading, without necessarily improving their reading skills. On the contrary, it has highlighted several challenges affecting digital reading practices: on one hand, students now prefer digital reading to some extent but lack strategies and resources to engage with texts effectively; on the other hand, teachers lack the didactic and technical training to guide these practices.

This problematic situation is evident in schools, where students show decreasing interest in reading, reject lengthy texts, and are unfamiliar with digital reading strategies. Against this backdrop, the following research problem was formulated: What is the level of digital reading practice among third-grade secondary students at an educational institution in the city of Piura (Peru)? Based on this, the general objective was defined as: To diagnose the level of digital reading practice among the students involved in the study. The specific objectives included identifying students' preferred digital reading sources, detecting the devices used for digital reading, identifying the types of digital texts, examining digital reading strategies

## **Theoretical Framework**

The research is grounded in constructivist theories developed within Educational Psychology (cf. Piaget, Ausubel, Vygotsky, Bruner), which assert that learning is an active, internal, and organized process that depends on the meaningful activity of the learner. According to constructivism, reading practice is a "constructive process" in which the reader plays an active role, being responsible for deconstructing and constructing the meaning of the text.

Pinzás (2012) describe three models of reading: bottom-up, top-down, and interactive—the latter being the one that explains reading as a meaningful activity. The interactive model, proposed in the early 1980s by Goodman (1988) and later expanded by Dubois (1995), conceptualizes reading as a complex cognitive activity in which the reader is an active processor of information (Solé, 1987). Additionally, Dubois (1995) emphasized that reading interaction is based on the following assumptions: a) Reading is a global and indivisible process, b) The reader constructs meaning through the interaction between the author and the text, c) The value of the message lies in both the reader's and author's minds, d) The reader's prior experience is essential for comprehension.

Digital reading is further explained through the theory of digital literacy and other theories that account for learning through technological and digital media. These theories promote the development of skills, strategies, and attitudes that facilitate reading in digital formats (O'Brien & Scharber, 2008). That is, they aim to develop readers who are capable of reading, processing, and evaluating information through digital formats and using a variety of digital resources and tools.

Digital reading refers to the interactive and dynamic reading practice conducted through digital texts disseminated via technological media and multimedia resources (Amiama & Mayor, 2017). It takes place using digital

devices such as computers, laptops, or smartphones, as well as other necessary elements like internet access, multimedia texts and digital platforms (Romero, 2014).

Its integration into people's lives and educational mediation has led to new reading sources, new reading media, new types of texts, and new reading strategies. Reading sources are digital spaces that store reading materials—short texts (e.g., social media posts, blogs, messages), medium-length texts (e.g., scientific articles, essays, news), and long texts (e.g., books, literary works, textbooks) (Kovac & Van Der, 2020). Digital reading media are devices that support digital reading, such as computers, laptops, tablets, mobile phones, and e-books (Romero, 2014). Types of digital texts are texts written and distributed in digital format that require digital devices to be read. They may be unimodal—written and digitized using word processors in formats like .doc, .pdf, or .rtf like e-books and digital magazines (Ayala, 2020); —or multimodal, combining text with other semiotic systems such as images, emojis, animations, audio, or video (Yus, 2021). Digital reading strategies are conscious, intentional, and methodical actions used while reading digital texts, including locating, selecting, organizing information, and generating meaning (Reiné et al., 2022).

Digital reading requires the support of technological tools that operate via the web and include various multimedia elements. The study identified various resources supporting reading motivation (e.g., videos, audio readings), information search and selection (e.g., digital libraries, social networks, databases), information organization (e.g., diagrams, infographics), and content production (e.g., short videos, book trailers).

Upon achieving the objectives, the following results were systematized:

**Table 1.** *Level of Digital Reading Practice among the Students*

| Level of digital Reading Practice | Frequency (fi) | Percentage (%) |
|-----------------------------------|----------------|----------------|
| Low                               | 45             | 25.6           |
| Average                           | 69             | 39.2           |
| High                              | 62             | 35.2           |
| Total                             | 176            | 100.0          |

Note: Author's elaboration.

Table 1 shows that students' digital reading practice levels are distributed as follows: average (39.2 %), high (35.2 %), and low (25.6 %). This indicates a growing trend toward the consolidation of digital reading as a learning

practice, although a smaller but significant portion has not yet adopted it—likely due to lack of access to digital devices. The increasing presence of technology, faster access to digital equipment and the internet, and the experience of remote education have all contributed to the expansion of digital reading as a new mode of student engagement with texts.

This trend is supported by prior studies, such as Amiama & Mayor (2017), which described digital reading practices among adolescents in the Dominican Republic, and Calderón & Vargas (2017), which revealed moderate to advanced use of virtual reality reading (56.0 % and 33.0 % respectively). Valderrama (2020) found a similar trend in a school in Chimbote, Peru, linking the use of digital tools to reading comprehension. The report of the specific results was as follows:

**Table 2.** *Digital Reading Practice Level by Dimension*

| Dimensions of Digital Reading Practice | F  | Low  | Average | High | Total |
|----------------------------------------|----|------|---------|------|-------|
| a) Digital reading sources             | fi | 32   | 79      | 65   | 176   |
|                                        | %  | 18.2 | 44.9    | 36.9 | 100.0 |
| b) Digital reading media               | fi | 74   | 46      | 56   | 176   |
|                                        | %  | 42.0 | 26.1    | 31.8 | 100.0 |
| c) Types of digital texts              | fi | 26   | 75      | 75   | 176   |
|                                        | %  | 14.8 | 42.6    | 42.6 | 100.0 |
| d) Digital reading strategies          | fi | 39   | 76      | 61   | 176   |
|                                        | %  | 22.2 | 43.2    | 34.7 | 100.0 |
|                                        | %  | 30.7 | 38.1    | 31.2 | 100.0 |

Note: Author's elaboration.

Table 2 shows that digital reading is becoming integrated into the academic activities of secondary students, a trend intensified by the remote learning experiences of 2020 and 2021.

## Digital Reading Sources

In terms of reading sources, the average level was 44.9 % and the high level 36.9 %, indicating that students show a preference for reading documents from websites and digital-format texts. This reflects an acknowledgment of the use of digital materials in reading, which is a consequence of the growing digitization of bibliographic resources and the rise of technological devices.

This result confirms the findings of other studies that demonstrated a strong preference for digital reading sources. At the international level: López (2017)

and Calderón & Vargas (2017); and at the national level: Valderrama (2020), all agreed that there has been an increase in digital readers and in their preference for digital texts. This situation aligns with practical observations, where an abundance of digital materials has gradually become part of students' lives. Likewise, the increase in digital reading sources has provided greater opportunities for children and adolescents, making the percentage of students who favor digital reading sources significant today (Kovac & Van Der, 2020). These results suggest that digital reading sources are becoming increasingly prominent in students' reading activities, likely because they circulate more rapidly today and are increasingly easier to access. In this regard, it is expected that digital-format texts will continue gaining preference in students' lives, as they are more accessible and affordable.

## Digital Reading Media

With regard to digital reading media, the level of use remains low—especially for computers (54.0 %), tablets (58.5 %), and laptops (51.1 %). Students primarily rely on mobile phones, the most widely used device among them. This is due to limited access to higher-end devices, which creates barriers to more effective reading experiences.

Although digital devices are now a part of daily life, their use is mostly for entertainment, and their educational potential (search engines, websites, libraries, apps) is underused—particularly for digital reading. Calderón & Vargas (2017) reported that tablet reading was at an initial level for 42.0 % of students. Espinoza & Gallegos (2018) found that smartphones, tablets, and computers (in that order) were the main devices used for digital reading.

Despite their increasing presence, many families still lack the financial means to afford mid- or high-end equipment or consistent internet access. Moreover, digital devices were not widely used in schools pre-pandemic and were often even prohibited. Teachers lacked training or confidence in their pedagogical use. It was only during remote learning that mobile phones and other devices gained educational relevance.

## Types of Digital Texts

Regarding types of digital texts, most students reported average (42.6 %) and high (42.6 %) preference levels, especially for extended, continuous, and multimodal texts. This suggests that these text types are increasingly used both in educational mediation and everyday student routines. According to Yus (2021), students are particularly drawn to multimodal and unimodal texts—those combining multiple semiotic elements (images, emojis, video, audio,

etc.). This reflects a shift in how students read, communicate, and engage with texts, likely due to the prevalence of multimodal formats in their daily environments (Amiama & Mayor, 2017).

While few studies have specifically focused on digital text reading, surveys like the one reported by Unidiversidad (2017) show that 100 % of students read on screens, although only 30 % of teachers promote such practices. This confirms a new reading reality for youth and underscores the importance of leveraging digital texts in educational settings.

## Digital Reading Strategies

Digital reading strategies showed average usage (43.2 %), with a strong trend toward high usage (34.7 %). Students reported using strategies such as searching for and downloading digital texts, selecting and digitally highlighting content, organizing information, looking up new words and using self-questioning to review material. These findings reveal that students are beginning to use supportive strategies for digital reading, although further development and promotion are needed.

Digital reading calls for context-specific strategies to locate, select, organize, and interpret information (Reiné *et al.*, 2022). Emerging didactic approaches include comprehension strategies such as summarizing, question formulation, predicting, imagining, and clarifying meanings. There is a need to explore and strengthen digital reading strategies, especially since existing research is scarce and instructional guidance is still limited.

## Conclusions

According to the measurements conducted, students' digital reading practice falls mostly into the average and high levels, meaning that within the educational institution studied, digital reading is being integrated and internalized as a new reading alternative. This outcome is understandable in a world where information flows rapidly and abundantly through technological means, and where the trend indicates that this type of reading will continue to grow and gain importance.

The research confirmed a growing use of digital reading sources, especially websites offering digital books, online publications, and reading platforms—likely due to the increased accessibility of such materials. Regarding digital reading media, their usage remains relatively low, although mobile phones are the preferred devices, given their mass adoption and greater usability. As for types of digital texts, student preference is high, particularly for extended and continuous texts, as well as brief and multimodal ones, which are commonly

shared through virtual environments and social networks. In terms of digital reading strategies, students favored those related to searching for new vocabulary, reviewing content via questioning, digital highlighting or selecting information, and searching/downloading digital texts.

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# Artificial Intelligence knowledge and skills in elementary school teachers in Hidalgo: an exploratory study

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This text is part of a project at the Metropolitan Polytechnic University of Hidalgo on the use of Artificial Intelligence to support basic education.

## Introduction

The technological revolution has driven the development of artificial intelligence (AI)-based tools, which possess great potential to transform education globally. The United Nations Educational, Scientific and Cultural Organization (UNESCO, 2016) has emphasized the need to integrate AI into educational systems to enhance both personalized learning and educational equity. Similarly, the Beijing Consensus on AI and Education (2019) highlights the importance of training teachers so they can leverage these technologies in the classroom, thereby ensuring more inclusive and high-quality education.

Numerous countries have implemented strategies to integrate AI into education. In Europe, initiatives such as the European Commission's Digital Education Action Plan (2021), have promoted the use of emerging technologies to strengthen teachers' digital competencies. In Latin America, countries like Argentina and Brazil have developed teacher training programs in AI, yielding positive results in curricular adaptability and personalized instruction (Fernández & Gómez, 2021).

In contrast, Mexico faces significant challenges in integrating AI into education, including a lack of technological infrastructure and insufficient teacher training (Ramírez et al., 2021). Although the National Digital Agenda and the National Digital Strategy promote the use of educational technologies, AI adoption in classrooms remains limited (Mendoza, 2023). This situation is even more critical in the state of Hidalgo, where many basic education teachers are unfamiliar with AI applications and lack the training to implement them effectively (Martínez & Torres, 2022).

The lack of awareness regarding teachers' current AI competencies and their application in pedagogical practices leads to outdated educational approaches. This affects both teacher training and the professional development that AI could provide to enhance teaching-learning and research processes.

## Case Study

Artificial Intelligence (AI) in education is a multifaceted phenomenon in response to post-pandemic challenges, emerging as a solution to global educational issues, particularly the urgent need to recover learning losses after the pandemic (UNESCO, 2024).

AI initiatives aim to mitigate structural inequalities and enrich teaching practices, though the discontinuity of public policies and resource limitations restrict their reach. The effects of AI in education manifest in various areas, from classifications distinguishing between in-class and out-of-class developments to applications fostering autonomous learning and platforms integrated into school systems with teacher participation (Pons, 2023). Other studies categorize its functions into three axes: educational administration, teaching, and learning (Chen *et al.*, 2020).

Although Hidalgo is one of the states with the highest poverty rates in Mexico, national education indicators do not place it among the lowest. However, its performance in various educational areas remains limited. Therefore, having accurate information for decision-making is key to implementing improvements in public primary and secondary education, which would have a significant social impact.

Gaps in Teacher Training: The Case of Hidalgo, Mexico.

In the digital age, AI represents a transformative opportunity; however, in the state of Hidalgo, Mexico, AI training for basic education teachers is insufficient, limiting its effective application in classrooms. This study analyzes the level of AI knowledge and skills among public-school teachers in Hidalgo, as well as its impact on pedagogical practices. The analysis focuses on:

- The relevance of teacher training in AI.
- The current level of AI competencies among basic education teachers.

The research question guiding this study is:

What is the current level of AI knowledge and skills among basic education teachers in Hidalgo?

### Urgency of Training Teachers in AI:

Recent research highlights the potential of AI in education and the need to prepare teachers for its implementation (Holmes *et al.*, 2022). However, in Mexico, specifically in Hidalgo, there are few studies on AI in basic education, highlighting a critical gap in teacher training. The results of this assessment show that 85% of teachers in Hidalgo lack training in AI, which limits its application in the classroom.

Based on this, we propose exploring, in future research, the design of training programs adapted to the rural/urban context of the region, as well as public policies that prioritize teacher digital literacy. Authors such as Yang (2022) highlight the importance of considering AI literacy. This type of competency is defined by Wang y Siau (2022) as the ability to appropriately recognize, use, and evaluate AI-based technologies, while considering ethical principles (Tramallino, 2024).

### Context description

Teacher training in artificial intelligence is indebted to educational justice, as the effective integration of AI in education requires educators to have solid training in this field. However, data from this study reveal that future teachers have not acquired AI knowledge either during their prior schooling or in their initial teacher preparation. This deficiency represents a serious failure of the educational system's commitment to social justice, particularly cognitive justice the first of its three educational dimensions which postulates the fundamental right of every student to access "powerful knowledge" to understand and transform their reality (Angulo, 2016).

### Impact on Educational Equity:

This issue directly affects the quality of teaching-learning processes and perpetuates inequalities in access to innovative technologies, especially in public schools in Hidalgo. As Rodríguez Vite (2024) notes in their study on teacher training, human resources constitute the most valuable asset of educational institutions, with teachers being primarily responsible for achieving institutional objectives. In the current context, where technological advancements and productivity demands are increasing, it is imperative to enhance teachers' digital competencies.

### Evidence from research:

Recent studies analyzed attitudes toward AI among graduate students, revealing:

- Uncertainties about its educational application.
- Recognition of its potential as an accessible and motivating tool.
- The need to develop specialized skills and ethical criteria for its use.

Results show a significant correlation between:

- Positive perceptions of AI.
- Availability of adequate technological infrastructure.
- Prior training levels.

Teachers-in-training with greater AI preparation and access to technological resources show greater willingness to implement these pedagogical tools. These findings support that the effective use of AI in education critically depends on:

- Structural conditions (technological access)
- Training factors (specialized preparation)
- Development of teachers' digital competencies

Interpretation of Spearman's Rho Correlation Table.

Spearman's ranks range from -1 to +1, measuring the strength and direction of the relationship between two variables, denoted by the symbol rho ( $\rho$ ):

+1: Perfect rank association

0: No association between ranks

-1: Perfect negative rank association

Values near -1 or +1: Stronger relationships

Values near 0: Weaker relationships

Variables Analyzed:

Do you use AI tools in your teaching?

What level of knowledge do you believe you have about AI in education?

The statistical analysis revealed two significant correlations. The first, presented in Table 1, shows a weak but significant positive correlation between the use of AI tools in teaching and prior AI training during teacher preparation ( $Rho = 0.181$ ,  $p < 0.05$ ). This suggests that teachers who received AI training are more likely to use these tools in their pedagogical practices.

**Table 1.** *Correlation between the use of AI tools in teaching and prior training in AI.*

**Correlaciones**

|                 |                                                                                                        |                             | Utilizar herramientas de inteligencia artificial en su enseñanza | A lo largo de su formación ha recibido capacitación sobre el uso de herramientas de IA en la educación |
|-----------------|--------------------------------------------------------------------------------------------------------|-----------------------------|------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| Rho de Spearman | Utilizar herramientas de inteligencia artificial en su enseñanza                                       | Coefficiente de correlación | 1.000                                                            | .181*                                                                                                  |
|                 |                                                                                                        | Sig. (bilateral)            | .                                                                | .024                                                                                                   |
|                 |                                                                                                        | N                           | 155                                                              | 155                                                                                                    |
|                 | A lo largo de su formación ha recibido capacitación sobre el uso de herramientas de IA en la educación | Coefficiente de correlación | .181*                                                            | 1.000                                                                                                  |
|                 |                                                                                                        | Sig. (bilateral)            | .024                                                             | .                                                                                                      |
|                 |                                                                                                        | N                           | 155                                                              | 155                                                                                                    |

\*. La correlación es significativa en el nivel 0.05 (bilateral).

The second correlation, shown in Table 2, indicates a positive relationship between the perception that AI improves the teaching-learning process and the level of knowledge about AI in education ( $Rho = 0.187$ ,  $p < 0.05$ ). Although the correlation is weak, its statistical significance reflects that teachers with greater AI knowledge tend to value its impact on teaching more highly.

**Table 2.** *Correlation between the perception that AI improves the teaching-learning process and the level of knowledge about AI in education.*

**Correlaciones**

|                 |                                                                                          |                             | Considera que la inteligencia artificial mejora el proceso de enseñanza-aprendizaje | Qué nivel de conocimiento considera que tiene sobre inteligencia artificial en educación |
|-----------------|------------------------------------------------------------------------------------------|-----------------------------|-------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| Rho de Spearman | Considera que la inteligencia artificial mejora el proceso de enseñanza-aprendizaje      | Coefficiente de correlación | 1.000                                                                               | .187*                                                                                    |
|                 |                                                                                          | Sig. (bilateral)            | .                                                                                   | .020                                                                                     |
|                 |                                                                                          | N                           | 155                                                                                 | 155                                                                                      |
|                 | Qué nivel de conocimiento considera que tiene sobre inteligencia artificial en educación | Coefficiente de correlación | .187*                                                                               | 1.000                                                                                    |
|                 |                                                                                          | Sig. (bilateral)            | .020                                                                                | .                                                                                        |
|                 |                                                                                          | N                           | 155                                                                                 | 155                                                                                      |

\*. La correlación es significativa en el nivel 0,05 (bilateral).

**Findings and Analysis:**

These findings suggest that while AI knowledge and training influence its classroom application, other factors may also affect the adoption of these

technologies. Further studies are needed to identify additional barriers limiting AI integration in basic education in Hidalgo.

The evaluation instrument was applied to a sample of 155 basic education teachers across different grade levels. The analysis of their responses revealed the following key findings:

- Low AI knowledge among teachers:
- 55% have a basic understanding.
- 9% possess an intermediate level.
- 36% have no training in AI.

Despite this, 75.1% of respondents believe AI enhances teaching.

The correlational analysis shows a weak but significant relationship between teachers' AI knowledge and their positive perception of AI in education ( $Rho = 0.020$ ,  $p < 0.05$ ).

The research demonstrates the need to train teachers in AI to improve teaching in basic education. Eighty-five percent of the teachers surveyed reported not feeling prepared to use AI in the classroom, and only 12% reported using it regularly.

Although this study does not measure the impact on learning, the literature warns that teachers' lack of technological proficiency can reduce opportunities for educational innovation (García & Fernández, 2021). Therefore, future research suggests investigating how this training relates to indicators of student achievement.

## Conclusions

This work allowed us to analyze the current situation regarding the knowledge and use of Artificial Intelligence (AI), specifically in basic education teacher training in public schools in the state of Hidalgo, with the aim of contributing to the improvement of educational standards at this level.

This reflects a social relevance that makes it a priority for the education system to have basic education teachers integrate AI as a pedagogical support tool. This would optimize time, reduce bureaucratic procedures, and minimize the use of resources that, in many cases, go unused during the school year.

Furthermore, the benefited teachers would thus be integrated into current technological innovation. AI is fundamental for educational development, especially in the democratization of knowledge.

This study diagnosed that 78% of basic education teachers in Hidalgo are unfamiliar with basic AI tools and only 15% apply them in class. These results reflect a critical training gap, coinciding with the AI literacy findings of Wang & Siau (2022) which points out certain challenges such as the lack of curricular projects and the absence of teaching guidelines.

Although the sample was limited to urban schools, the data suggest that contextualized training, which has demonstrated the need to develop curricula in this area, would be a first step towards reducing this gap. Future research could evaluate the impact of such interventions on student performance.

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# University Newspaper UNA COLUMNA as a Specialized Learning Space through the Project-Based Method

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## Introduction

University training in journalism is undergoing constant redefinition due to changes in the media ecosystem and the transformation of news consumption habits. In this context, traditional teaching focused exclusively on theoretical transmission has proven insufficient to meet the demands of a labor market characterized by immediacy, interactivity, and multi-platform production. Kirschner & De Bruyckere, (2017). Producing informative content currently requires not only mastery of journalistic genres but also critical interpretation skills, fact-checking, and the management of multimedia narratives.

Given this reality, universities face the challenge of designing active methodologies that allow students to experience journalistic practice in real contexts. Several authors agree that meaningful learning is achieved when students engage in projects that expose them to authentic problems and require decision-making with tangible outcomes. Blumenfeld et al., (1991). Thus, the classroom ceases to be an exclusively theoretical space and becomes a laboratory where critical reflection is combined with content production, generating what Hernández (2000) defines as "learning communities," where knowledge is collectively constructed through interactions among students, teachers, and the social environment.

In this framework, university newspapers have acquired a leading role in journalism education. They function as pedagogical platforms that simulate the dynamics of professional practice, allowing students to assume roles typical of news production: identifying sources, verifying data, prioritizing stories,

working in teams, and taking ethical responsibility before a real audience. Publishing a newspaper requires not only technical skills but also cognitive and social abilities, as it involves organizing teams, planning editions, and meeting journalistic quality standards. Martínez & Parra (1999).

The experience of the university newspaper *UNA COLUMNA*, developed by the Professional School of Social Communication Sciences at the Universidad Nacional del Altiplano (Puno, Peru), represents a paradigmatic example of such initiatives. Since its creation, it has operated as an active learning space that integrates theory and practice, enabling students to transition from learners to producers of information with an impact on a specific reading community.

### **Journalistic Practice as the Core of Learning**

Journalism training cannot be separated from real practice. Maletzke (1970) noted that journalism is a system of interdependencies in which communicative processes cannot be understood in isolation from their social and technological context. Producing a university newspaper replicates these interdependencies, placing students in front of the daily challenges of the profession: seeking reliable sources, meeting deadlines, selecting news angles, and adapting to audience demands.

Hidalgo (1997) argues that production projects implemented in educational environments not only strengthen technical competencies but also contribute to economic, cultural, and social development, as they generate products that circulate in specific communities. This is particularly relevant in local contexts such as Puno, where students, by covering regional issues, establish a direct link between learning and social reality.

Moreover, journalistic practice fosters cognitive skills that are not fully developed in purely theoretical environments. Derry & Lajoie (1993) suggest that the use of “cognitive tools” in educational settings allows students to formulate hypotheses, test strategies, and reflect on their own learning processes. In the case of *UNA COLUMNA*, these tools are evident in collective error discussions, self-criticism, and constant dialogue between students and teachers—fundamental elements for consolidating meaningful learning.

### **The Project Method as a Pedagogical Strategy**

The project method, applied as a training strategy in *UNA COLUMNA*, is based on the premise that students learn better when engaged in authentic projects requiring research, planning, and real production. According to Blumenfeld et al. (1991), this approach motivates learning because students take an active role and feel responsible for the outcomes. Unlike traditional

methods, where the teacher is the primary content provider, in the project method the instructor acts as a guide or “editor-in-chief,” while students plan and execute their own editions. Vera del Carpio & Palomino Asqui (2011).

In the *UNA COLUMNA* experience, this method has proven effective in strengthening both technical skills and organizational abilities. Students have faced challenges in all production stages—from sourcing and writing to editorial design. Far from being failures, these difficulties became learning opportunities, as they forced students to engage in dialogue, reflect on mistakes, and seek collective solutions. As a result, they developed greater autonomy, critical thinking, and confidence in their professional skills.

Furthermore, this methodology fosters what Hernández (2000) calls “socializing learning,” as students not only acquire knowledge but also construct shared meanings and assume responsibility toward their community. Martínez and Parra (1999) emphasize that such practice helps train more thorough journalists, with a sense of social responsibility and better preparedness for labor market integration.

## **Print Journalism and Transition to the Digital Environment**

Print journalism, defined as a technified system of human communication that processes events and transmits them through physical channels such as newspapers Rivadeneira, (2010), has historically been the fundamental medium for journalism education. Its characteristics—periodicity, universality, and commitment to current events—make it an ideal space for students to learn how to prioritize information, write clearly, and adhere to ethical standards. (Groth 1996; Gómez-Diago 2022).

However, the rise of digital platforms has transformed how information is produced and consumed. Digital journalism is not a simple extension of print; it implies new narrative logics characterized by hyper textuality, multimedia, and interactivity. Arias-Robles & García-Avilés (2018) ; Palau-Sampio & Sánchez-García (2020). Flores Infantes et al. (2023) argue that these features create opportunities for audience interaction but also demand specific technical skills that are often underdeveloped in university programs.

In this scenario, *UNA COLUMNA* represents an example of gradual adaptation. Although it originated as a print medium aimed at the university community, its partial migration to the digital environment has expanded its reach and introduced students to new production dynamics. Nevertheless, this transition has also revealed limitations related to the management of digital tools and the need to update teacher training in cyber journalism.

The application of the project method in the university newspaper UNA COLUMNA produced significant results in journalism students' training, both in the development of technical skills and in the construction of reflective learning. The analysis is based on data collected through questionnaires, interviews, and participant observation, allowing the comparison of students' and teachers' perceptions and the identification of advances and challenges in the teaching-learning process.

### **Journalistic Production and Media Reach**

In 2011, fifteen printed issues were published with a circulation of 1,500 copies, distributed mainly within the university community, consisting of 15,000 students, 1,000 professors, and 900 administrative staff. By 2019, the newspaper had reached 57 editions, increasing its circulation to 2,000 copies and expanding distribution to alumni and audiences linked to university-related issues. Additionally, the format evolved into a specialized magazine that included topics such as tourism and local politics, incorporating more in-depth reports.

This growth confirms the capacity of the project method to stimulate news production and generate tangible results, consistent with Hidalgo (1997) and Martínez & Parra (1999), who argue that production projects help students develop discipline, responsibility, and professional confidence. Likewise, the gradual introduction of digital publications responds to the need to adapt to new news consumption dynamics, although, as Flores Infantes et al. (2023) warn, this transition requires specific competencies in managing online platforms, which are not yet fully consolidated in university training.

### **Acquired Skills and Student Perception**

Among the results of the comparative survey, 74% of the students rated the project-based method positively, considering it "very good" or "good". The main achievements, participants highlighted the opportunity to link theory with practice, apply acquired knowledge in real situations, and strengthen their preparation for pre-professional internships. These findings align with Blumenfeld et al. (1991), who argue that project-based learning fosters active engagement, as students perceive the relevance of what they learn and face concrete outcomes.

Interviews confirmed that, by the end of the course, students had gained greater autonomy and confidence in teamwork, as well as improved their ability to organize journalistic content and plan complete editions. According to the course instructor, cited in Vera del Carpio & Palomino Asqui (2011),

journalism, by its very nature, requires constant practical training, and the project method is an effective tool for simulating real working conditions, motivating students to make editorial decisions critically and responsibly.

## Challenges Identified During the Process

Despite these advances, the analysis also revealed significant limitations. Students reported insecurities when searching for news sources, especially during their initial journalistic practice. In 2011, 46% expressed difficulties in identifying relevant contacts, a figure that decreased to 36% in 2019, indicating gradual yet persistent improvement. These difficulties are linked to limited knowledge of local institutions and personalities, as well as a lack of strategies for accessing reliable information.

In terms of writing, 50% of participants acknowledged difficulties in adapting their texts to different journalistic genres, and 22% reported frequent mistakes in applying the inverted pyramid structure or grammatical rules. This latter issue is partly due to the fact that a significant proportion of students speak Quechua or Aymara as their mother tongue, which generates linguistic interferences (Sánchez, 2008). These challenges confirm Derry & Lajoie's (1993) assertion that cognitive problems in learning environments are opportunities to develop new strategies, provided there is reflective support and self-criticism—elements present in the project method.

## Editorial Design and Digital Transition

In the field of editorial design, 36% of students reported difficulties creating infographics and translating data into effective graphic representations. Additionally, 24% mentioned problems writing photo captions, highlighting shortcomings in visual interpretation and specialized writing. However, these problems were partially overcome through continuous practice, especially in composition and page layout, which is consistent with Groth's (1996) assertion regarding the importance of systematic training in print media to strengthen technical skills.

The transition to digital journalism posed new pedagogical challenges. Although *UNA COLUMNA* began managing its own website ([www.unacolumna.pe](http://www.unacolumna.pe)), the adoption of features typical of cyber journalism, such as hyper textuality and interactivity, has not yet been fully consolidated. Arias-Robles & García-Avilés (2018) emphasize that implementing these tools requires a comprehensive understanding of digital news design and a shift in production logic, aspects not always present in traditional teaching. Nonetheless, the gradual migration to the digital environment demonstrates an

effort to respond to the demands of new audiences, who, as Palau-Sampio & Sánchez-García (2020) note, increasingly prioritize interactivity and multimedia content consumption.

## Conclusions

The experience of the university newspaper UNA COLUMNA confirms that the project method is an effective pedagogical strategy for training journalists in university settings, as it promotes situated learning that integrates theory and practice in real news production contexts. The results show that students developed essential technical and cognitive skills, strengthening their autonomy, teamwork capacity, and confidence in making editorial decisions. These conclusions are consistent with Blumenfeld et al. (1991), who emphasize that project-based learning fosters intrinsic motivation and meaningful knowledge appropriation by engaging students in solving authentic problems.

Conceived as a practical laboratory, the newspaper allowed students to understand the dynamics of journalism beyond classroom theoretical routines. As Martínez & Parra (1999) argue, publishing media in academic environments promotes not only technical skills acquisition but also the development of a more reflective and rigorous professional profile. Through continuous practice, students faced challenges in source gathering, genre treatment, and graphic production—difficulties addressed through dialogue, self-criticism, and collaboration—confirming Derry & Lajoie's (1993) argument about the value of cognitive problems as opportunities to develop new learning strategies.

The transition to the digital environment constitutes another relevant finding. Although the adoption of cyber journalism features was partial and revealed limitations in incorporating hyper textuality and interactivity, initiating the migration to online platforms reflects the project method's ability to adapt to the demands of the contemporary media ecosystem. In this regard, the experience aligns with Arias-Robles & García-Avilés (2018), who argue that digital journalism requires a change in production logic and the integration of multimedia narratives—competencies that still need reinforcement in university training.

The research reaffirms that journalism education cannot be detached from practice as the articulating axis of learning. The experience of UNA COLUMNA demonstrates that students not only acquire technical knowledge but also construct shared meanings and develop a sense of responsibility toward their community, consistent with Hernández's (2000) notion of "learning communities." In a media context characterized by technological convergence and constant transformation of news formats, such active methodologies prove

essential for training journalists capable of responding critically to the challenges of the present and the future.

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# **From the Classroom to the Metaverse: Emerging Technologies for the Transdisciplinary Management of Knowledge**

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## **Introduction**

Digital transformation in education is no longer a promise but a tangible reality that is redefining pedagogical practices, institutional dynamics, and the ways knowledge is produced and disseminated (Selwyn, 2020; Williamson, Eynon, & Potter, 2021). In this context, emerging technologies, such as artificial intelligence, extended reality, educational blockchain, and collaborative platforms, are deeply reshaping learning spaces, expanding them beyond the physical classroom into hybrid, virtual, and, more recently, metaverse environments (Wang et al., 2022; Siemens, 2023).

This shift entails not only technological modernization but also a critical revision of the theoretical and methodological frameworks that underpin education. The integration of these technologies presents both challenges and opportunities for the development of digital ecosystems that promote collective knowledge building through a transdisciplinary lens, surpassing the limitations of traditional disciplinary silos (Jandrić et al., 2018; Castañeda & Williamson, 2021). Within these new environments, knowledge management plays a central role in connecting information, learning, and action within complex, dynamic, and interconnected contexts (Nonaka & Takeuchi, 2021; Redecker, 2017).

This study analyzes how emerging technologies are transforming educational processes from a critical perspective, proposing a holistic approach that connects technological innovation, effective pedagogical strategies, and knowledge management practices suitable for the demands of the post-digital

era. It also explores the ethical, epistemological, and operational challenges that accompany this transition toward more immersive, interactive, and collaborative educational environments (Bozkurt et al., 2020; Dede, 2022).

## Case Study

The case study focuses on the implementation of emerging technologies within a transdisciplinary educational environment transitioning from traditional classroom settings to hybrid and virtual platforms, including metaverse spaces. The study was conducted at three public universities in Mexico and involved educators, students, and administrative personnel engaged in [specify program or educational level, e.g., higher education, vocational training, etc.]. The context reflects a digitally evolving ecosystem in which artificial intelligence, extended reality, and collaborative digital tools are integrated to facilitate knowledge management and foster innovative pedagogical practices (Wang et al., 2022; Siemens, 2023). This setting provides a rich foundation for analysing how these technologies impact teaching and learning dynamics, as well as the collective construction of knowledge across disciplines (Jandrić et al., 2018; Nonaka & Takeuchi, 2021).

## Context description

This case study was conducted at three public universities in Mexico—higher education institutions that have been actively integrating emerging technologies into their educational processes. These universities serve a diverse student population across multiple disciplines, reflecting a transdisciplinary approach to learning. In recent years, they have progressively adopted digital tools such as artificial intelligence-driven tutoring systems, virtual and augmented reality platforms, and collaborative metaverse environments to enhance both teaching and knowledge management.

The context is defined by a hybrid educational model in which face-to-face instruction coexists with virtual and immersive learning experiences, aiming to expand the boundaries of traditional pedagogy. Faculty and students engage with these technologies not only to support disciplinary knowledge acquisition but also to foster cross-disciplinary collaboration and innovation. Each institution's strategic plan emphasizes the development of an ecosystem that supports continuous learning, digital literacy, and adaptive knowledge management in response to the demands of the post-digital era.

This study specifically examines how these technologies are integrated into courses and academic programs designed to promote interdisciplinary interaction and enable the collective construction of knowledge. Challenges related to technology access, digital competence, and ethical considerations in immersive environments are also addressed as part of the contextual framework (Wang et al., 2022; Siemens, 2023; Jandrić et al., 2018).

The results of the study highlight the multifaceted role of emerging technologies in reshaping educational dynamics within a transdisciplinary digital ecosystem. Data collected from surveys, interviews, and platform analytics reveal key patterns in technology adoption, perceived pedagogical value, and challenges encountered by both educators and students. Participants reported increased opportunities for collaboration, greater access to knowledge resources, and improved engagement through immersive platforms. However, disparities in digital literacy, infrastructure access, and cognitive overload were recurrent themes in both the qualitative and quantitative data (Bozkurt et al., 2020; Williamson et al., 2021). Educators emphasized the need for institutional support and continuous training to fully integrate technologies into their pedagogical practices. Meanwhile, students expressed enthusiasm about experiential learning opportunities provided by extended reality environments, but also highlighted issues related to platform usability, time management, and assessment coherence.

### Cluster analysis

A cluster analysis was conducted using responses from 182 participants to identify user profiles based on patterns of technology engagement and attitudes toward educational innovation. Four main clusters emerged:

Cluster 1: Digital Enthusiasts (38%). This group reported high usage of emerging technologies, particularly virtual reality (VR) and artificial intelligence (AI)-enhanced tools. They expressed strong confidence in their digital skills and a clear alignment with constructivist learning practices.

Cluster 2: Pragmatic Users (27%). Participants in this cluster used technology primarily to complete academic tasks. Their engagement was functional rather than exploratory, and they showed moderate interest in training opportunities.

Cluster 3: Reluctant Adopters (21%). These individuals demonstrated low digital fluency and limited exposure to immersive technologies. Their responses revealed skepticism about the educational value of metaverse platforms and AI systems.

Cluster 4: Transitional Learners (14%). Participants in this cluster showed a willingness to adopt new tools but faced barriers related to technical infrastructure or institutional support. Many were transitioning from traditional to hybrid learning models.

These results are graphically represented in Figure 1, which shows the relative distribution of the clusters across four key dimensions: technological use, digital literacy, pedagogical innovation, and need for institutional support. The clusters were validated using silhouette coefficients and a K-means clustering algorithm applied to standardized survey data, ensuring internal consistency and interpretability (Siemens, 2023). These clusters provide insight into the diversity of technology experiences within educational contexts and suggest the need for differentiated implementation strategies.).

## Conclusions

This study underscores the transformative potential of emerging technologies in reshaping educational ecosystems through a transdisciplinary lens. The findings reveal that when effectively integrated, tools such as artificial intelligence, extended reality, and collaborative platforms can expand the boundaries of learning, support collective knowledge creation, and foster greater engagement among students and educators (Wang et al., 2022; Selwyn, 2020). However, the transition toward immersive and hybrid educational models is not without challenges. Disparities in digital competence, infrastructural limitations, and varying degrees of user readiness emerged as critical factors influencing the success of technology adoption (Bozkurt et al., 2020; Williamson et al., 2021). Cluster analysis revealed that while a substantial portion of participants actively embrace digital tools, others require targeted support to bridge technological and pedagogical gaps. The study also highlights the importance of institutional strategies that promote continuous training, inclusive access, and pedagogical alignment with technological innovation (Castañeda & Williamson, 2021). A holistic approach—one that integrates ethical considerations, data literacy, and adaptive learning design—is essential for sustaining meaningful transformation in post-digital education (Jandrić et al., 2018; Dede, 2022).

Future research should explore longitudinal effects of immersive learning environments, particularly within metaverse-based platforms, and assess their impact on knowledge retention, collaboration, and the development of critical thinking skills. Additionally, further investigation into equitable technology integration across diverse educational contexts remains a priority to ensure that innovation does not reinforce existing inequalities (Redecker, 2017; Nonaka & Takeuchi, 2021).

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## Higher education: Graduate degrees in agribusiness in Latin America

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### Introduction

Over the past twenty years, Latin America has seen a growing demand for professionals with experience and graduate training in agribusiness to lead sustainable value chains profitably. In this context, graduate programs have been opening opportunities to design analytical frameworks and advanced curricula. These enable professors and researchers to adopt teaching methodologies and strategies previously unthinkable in classrooms.

Likewise, traditional face-to-face classes have been complemented or replaced by technologies that support virtual, hybrid, and Hy-flex sessions, facilitating graduate training for many professionals who cannot attend in person due to the distance between their workplaces or residences and the university.

Agricultural studies are being repositioned as a science deeply committed to agri-food sustainability and aligned with the Sustainable Development Goals as a strategic focus. Therefore, current curricula must move beyond historically agrotechnical approaches and incorporate systemic and holistic perspectives that produce impactful results. This includes integrating local and global perspectives, developing products and services with high socio-environmental value, and managing cooperative businesses, as seen in several master's degree programs analyzed for this study.

Overall, graduate programs in agribusiness in Latin America offer a strategic response to the many contemporary challenges facing the agrifood sector. These programs strengthen skills in innovation and leadership, crucial in management to boost the transformation of production systems toward resilient and sustainable business models.

The programs recognize agribusiness as a dynamic force in regional development and as an integrator of technologies that enhance the economic, social, and environmental purposes of the industry, fostering modernization to meet global demands, emergent environmental rules, and customer priorities. The term agribusiness is widely used today in educational and corporate contexts; it originates from the English term 'Agribusiness', which combines the prefix 'agro' (meaning agriculture) with 'business,' coined in the 1950s. During this period, the U.S. agricultural sector was undergoing a profound transformation, with efforts to integrate it into industrial and commercial processes, recognizing it as a broader and more complex economic system beyond traditional views of isolated activities (Zylbersztajn, 1996).

Academically, this concept was developed by two former Harvard Business School professors, John Davis and Ray Goldberg, who authored *A Concept of Agribusiness* (Davis & Goldberg, 1957). Their work, from a political economic perspective —Davis having worked in public policy— defined agribusiness as all operations involved in manufacturing and distributing inputs, in-field production, storage, processing of agricultural products, and derivatives (Hamilton, 2016). This led to a systemic, integrated view of agriculture as an interdependent system of elements, agents, and sectors. They also introduced the idea that value is not only derived from products but also built throughout the entire chain, from producers and agroindustry to distribution channels and consumers (Nin-Pratt et al., 2023).

Furthermore, Davis and Goldberg emphasized the importance of synergy between agriculture and industry, promoting technological advancement and new organizational models to modernize the sector (Zylbersztajn, 2017). Their contributions influenced public policy, corporate strategies, and academic programs, including the Harvard University Agribusiness Program established in 1955, now known as the Agribusiness Seminar (Harvard Business School, 2025).

This approach, introduced in Latin America during the 1980s and 1990s, involves large agricultural and agro-industrial firms, as well as small and medium-sized businesses, encompassing all stages of the value chain from primary production to final product delivery.

In practice, countries like Argentina, Brazil, and Mexico capitalized on economic liberalization to boost agricultural exports and attract foreign investment, leading to significant structural, productive, and organizational improvements in rural areas. Indeed, agribusiness is vital to Latin America's economies, significantly contributing to GDP, creating jobs, and supplying



food, positioning it as a key driver of both regional and global economic development and integration (Saravia-Matus et al., 2021). Based on the in-depth interviews that were conducted, data were obtained within the three categories of analysis described in the previous section. This will be the route to validate whether the research objectives were met.

Agribusiness in graduate programs in Latin America has increased its offer in recent years, aiming to meet a growing demand based on the growing relevance of this sector in the region. For this study, it is estimated that approximately 41 programs are currently available. One of the countries that stands out, precisely for its growth in the sector, is Brazil. There are two types of graduate training. The first one is called *Stricto Sensu* (in the strict sense) and is the one that leads the graduate program market. The methodology establishes that after completing a master's degree, the students can complete a doctoral program.

The other type is the *Lato Sensu* (in the broad sense). This group includes graduate programs or specializations, typically lasting 360 hours or more. The other option is the MBA (Master of Business Administration), with a course load that can vary between 420 hours or more. It is important to clarify that, according to Brazilian regulations updated in 2018, these types of programs do not require the completion of coursework projects (CDPs). However, it is at the discretion of the university to require them as a graduation requirement. In this regard, Brazil has many universities offering MBAs in agribusiness, primarily public universities. An example of this is the University of São Paulo, with its Luiz de Queiroz School of Agriculture (ESALQ) located in Piracicaba, São Paulo State, with a coverage that not only meets domestic demand but also international demand.

While many professors, who hold doctoral and postdoctoral degrees, teach their knowledge in Brazilian Portuguese during in-person classes, there is also a synchronous virtual modality in which these same professors deliver their courses and share their expertise with both for the domestic market and Spanish- and English-speaking markets.

In this way and with the use of technology, which allows them to perform simultaneous translations, their students are trained in a group of 48 modules that cover different aspects that, in the opinion of their managers, are necessary to lead agribusinesses of any size. Additionally, a course completion project (CCP) must be developed, the objective of which is to apply the acquired knowledge by focusing on one or more of the topics from the modules taken.

In this same country, there is also a graduate offer in agribusiness in private universities, where Fundação Instituto de Administração (FIA Business School) and Fundação Getulio Vargas stand out.

In all observed cases, the curricula show an update in terms of the needs that companies demand, for example, in the fields of technology, big data, and market intelligence; training in family business management and the establishment of corporate governance; sustainability of global supply chains; agro-circular management; and internationalization of agribusiness. among other academic trends required for business management. An important point, observed and mentioned in the interviews, is that these curricula focus on personal aspects, a very clear trend in modern Management 5.0, which involves placing the human at the center of the functional and corporate strategies of modern companies and management.

Another advantage of Brazilian MBAs is the teacher-student communication, using platforms such as Teams, Zoom, Moodle, Blackboard, etc. 76% of those interviewed expressed that the use of hybrid formats, hyflex, and synchronous and asynchronous modalities allows them to overcome distance barriers. In this regard, the agreements between universities in Central and South America, such as INCAE (Costa Rica) and Zamorano (Honduras), and Zamora University with EAFIT University (Colombia), which combine short residencies with synchronous classes, stand out. The master's program in agribusiness at the Tropical Agricultural Research and Higher Education Center in Turrialba, Costa Rica, also uses these technologies for its graduate teaching.

It's worth noting that 26% of the privileged informants interviewed stated that a graduate degree in agribusiness should be offered in person, as this format allows for deeper engagement with real-world issues and day-to-day business practices.

This may be questionable given that the Agribusiness MBA at the Universidad Austral de Argentina, on its Rosario campus, maintains a hybrid format and, in its curriculum, establishes the analysis of real cases as the central teaching-learning methodology, which allows its students to adopt the position of a manager and make decisions at the highest business level.

Additionally, this MBA stands out for being considered by Eduniversal Best Masters (2025) as number 1 in the Americas and number 2 in the world rankings. This goes some way to demonstrate that today, the modality (in-person or virtual) in which a graduate degree in agribusiness is taught does not define it as having added academic value for the person taking it.

For its part, the University of Buenos Aires (UBA) in its Faculty of Agronomy, maintains its offer as a prestigious public university at the local and global level, being this the most representative of the proposals of public universities in Argentina. It also appears in the Eduniversal Best ranking (2025) in 10th place and the CEMA university in 48th place globally. Regarding business needs for graduate training in agribusiness, 89% of respondents expressed a wide gap in management and technological (AgTech) skills, which they described as a barrier to hiring. 40% of privileged witnesses highlighted that candidates for management positions without graduate studies have weaknesses in several areas that are currently considered strategic, including: quantitative data analysis; leadership; innovation management; and entrepreneurship. Possibly because at the undergraduate level, agricultural schools focus much more on technical-agricultural aspects than on business.

But precisely to overcome this barrier, Zamorano University has a focus on agribusiness within its undergraduate program. This is something that other universities, such as the UPC in Lima, Peru, have dropped from their undergraduate offerings due to weak demand. Meanwhile, the University of La Molina, along with ESAN, is the most representative in the country in terms of offering this graduate program.

Regarding the challenges facing graduate programs in agribusiness, it was identified that only 16% of the universities studied have agrifood chain simulation laboratories. In this regard, it is also important to recognize that digital disruption demands investments that many of the region's institutions cannot meet, either because they are focused on other aspects, they consider more strategic or because available resources are insufficient to invest.

It is therefore understandable that generational changes are necessary in these graduate programs, since a lack of participatory planning was observed in some institutions, which hinders curricular updating and the transfer of teaching positions to profiles much more suited to the demands of companies and markets.

Another relevant aspect is financing and scholarships. In this regard, it was not possible to clearly identify the actual considerations used by several institutions when granting such benefits, as the decisions are left to the discretion of graduate committees, with no clear criteria or process in place. Likewise, with regard to international certifications, these graduate programs depend on the prestige of the universities to which they are affiliated, which can create ambiguity for prospective students. There is no direct correlation between

institutional prestige and the quality of the program itself. This could be the subject of extensive debate, it falls outside the scope of this document.

## Conclusions

The findings demonstrate that graduate programs in Latin America are in a mature stage with opportunities for expansion. However, there are gaps in their curricula that compromise the delivery of the academic value expected by current and potential students. Furthermore, the Identification of 41 active programs in this research underscores the strategic importance and growing relevance of the agribusiness sector across the region. This data also reflects the capacity of graduate programs to design academic curricula and establish course modalities. However, the content does not always align with the demands of the business market, which renders many of these programs outdated in this regard.

Moreover, the academic offering remains concentrated in a few countries, such as Brazil and Argentina. In these cases, most university curricula include elements such as Management 5.0, sustainable value chain management, circular economy approaches, and the use of simulation labs to generate uncertainty scenarios to train students in unstructured decision-making.

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# Educational Management in the Digital Age: Digital Ecosystems and Innovation Strategies with AI

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## Introduction

The rapid expansion of Information and Communication Technologies (ICT) has reshaped the way organizations operate in the 21st century, and education is no exception. Digital tools have not only streamlined administrative processes but also enriched teaching and learning by enabling more flexible, efficient, and student-centered approaches to education. In this context, artificial intelligence (AI), educational technologies, and pedagogical innovation have emerged as critical drivers of transformation, prompting institutions to reassess how they manage resources, design learning experiences, and make informed strategic decisions.

This paper proposes a strategic framework for digital ecosystems in educational management that integrates AI, educational technologies, and innovative pedagogical practices. By framing digital ecosystems as interconnected environments where tools, people, and processes interact, the study emphasizes their potential to improve efficiency, support data-driven decision-making, and promote more personalized forms of learning. AI contributes predictive and adaptive capabilities to both administrative and pedagogical functions. Educational technologies provide the infrastructure and platforms that sustain collaboration and scalability. Pedagogical innovation ensures that digital ecosystems remain grounded in student-centered and meaningful practices.

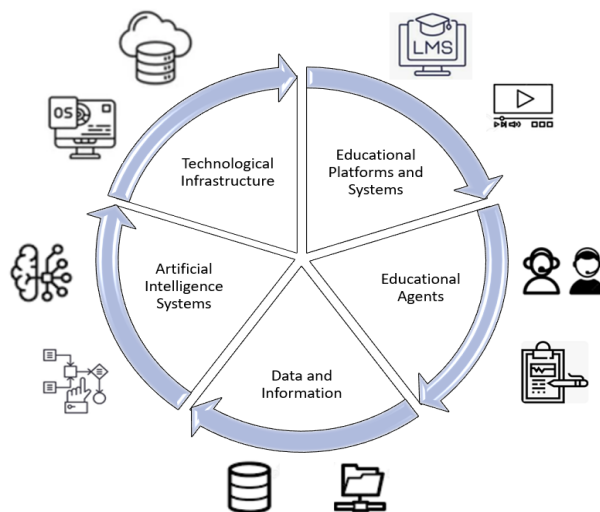
Taken together, these three dimensions form the foundation for the design of digital ecosystems capable of fostering institutional innovation, strengthening technological sustainability, and advancing educational quality. The following sections present the aims of the study, the theoretical framework that supports this proposal, and the methodological design used to analyse current practices and derive the proposed strategic model.

## Theoretical Framework

The literature highlights that digital ecosystems have emerged as a fundamental component of educational transformation (González-Pérez et al., 2023; Holmes et al., 2019). Digital ecosystems for educational management are understood as integrated environments that combine technology, processes, people, and data to optimize administration, learning, and decision-making within academic institutions. These ecosystems are not limited to a single platform or software; rather, they operate as interconnected systems in which various digital tools—such as AI, learning management systems, data analytics, and administrative automation—work in a coordinated manner to support both institutional management and pedagogical processes.

In the current context, the integration of diverse ecosystems fosters the development and evolution of educational management practices. Effective educational management requires both knowledge of and proficiency in administering state-of-the-art digital tools to enhance the teaching–learning process (Fredy & Calderón, 2020; Martínez-Ruiz, 2019). These ecosystems are characterized by the intelligent interconnection of multiple digital technologies (Chávez & Carreto, 2020). Figure 1 illustrates the core components of such ecosystems.

**Figure 1.** Fundamental components of ecosystems.



AI is currently employed as a driving force in data-driven educational management. As a discipline within computer science, AI is capable of reasoning, learning, and adapting based on data patterns. In educational management, its applications are primarily directed toward predictive analytics for identifying dropout risks, intelligent tutoring systems that adapt content

and methodologies, the automation of administrative tasks, and data-informed decision-making to enhance institutional efficiency.

AI is increasingly integrated into a wide range of processes, and education is no exception. It can be defined as a branch of computer science that aims to create systems or programs capable of performing tasks that typically require human intelligence, such as learning, reasoning, and decision-making. Within this context, AI functions as an assistant that helps students progress at their own pace in the learning process. Educational technologies have thus become a common denominator in teaching and learning. Digital platforms enable the creation of flexible, collaborative, and adaptive learning environments. These technologies include learning management systems (LMS), adaptive platforms, interactive digital resources, automated assessment tools, and applications for immediate feedback. Their integration into digital ecosystems fosters learning that is continuous, personalized, collaborative, and measurable (Chatti et al., 2012; Rodríguez-Torres et al., 2020).

Pedagogical innovation, in turn, centers on student-focused methodologies and practices. It involves a profound redesign of teaching practices through the strategic use of ICT (Salinas, 2020; UNESCO, 2022). Importantly, pedagogical innovation also considers the human dimension of the digital ecosystem. It encompasses the application of active methodologies, hybrid models, and student-centered approaches, such as project- and problem-based learning, gamification, digital storytelling, flipped classrooms, blended learning, formative assessment, and the use of e-portfolios. Together with digital tools, these practices promote student participation, motivation, and ownership of the learning process.

### **Aims of the study**

The main aim of this research is to propose a strategic framework for the design and implementation of digital ecosystems in educational management, integrating artificial intelligence, educational technologies, and innovative pedagogical practices with the aim of enhancing administrative efficiency, data-driven decision-making, and personalized learning.

The specific aims are:

- To identify the key components of digital ecosystems applied to educational management, emphasizing the role of technological infrastructure, AI, and educational platforms.



- To analyse innovative pedagogical strategies that, when integrated with technology, support personalized and student-centered learning.
- To describe the theoretical and practical implications of implementing digital ecosystems in educational institutions, taking into account relevant institutional experiences.

Table 1 shows a summary of the main results from the 68 publications analyzed in the systematic literature review.

**Table 1.** *Results of the systematic review*

| Category                          | Description                                                                       | Number of Publications | Percentage (%) |
|-----------------------------------|-----------------------------------------------------------------------------------|------------------------|----------------|
| <b>Thematic Areas</b>             |                                                                                   |                        |                |
| Artificial Intelligence Education | Applications of AI for in personalization, predictive analytics, and automation   | 25                     | 36.8           |
| Educational Technologies          | LMS platforms, interactive digital resources, and adaptive tools                  | 22                     | 32.4           |
| Pedagogical Innovation            | Active methodologies, hybrid learning, and student-centered strategies            | 15                     | 22.1           |
| Digital Educational Management    | Models and strategies for technological integration in educational administration | 6                      | 8.7            |
| <b>Type of Study</b>              |                                                                                   |                        |                |
| Empirical Studies                 | Research involving quantitative and qualitative data                              | 38                     | 55.9           |
| Systematic Reviews                | Analysis and synthesis of previous literature                                     | 18                     | 26.5           |
| Theoretical Studies               | Conceptual models and theoretical frameworks                                      | 12                     | 17.6           |
| <b>Predominant Methodologies</b>  |                                                                                   |                        |                |
| Documentary Review                | Comprehensive analysis of the literature                                          | 28                     | 41.2           |

|                        |                                                     |    |      |
|------------------------|-----------------------------------------------------|----|------|
| Case Studies           | In-depth analysis of specific experiences           | 21 | 30.9 |
| Surveys and Interviews | Collection of perceptions and opinions              | 13 | 19.1 |
| Quantitative Analysis  | Data Use of KPIs and statistics to evaluate impacts | 6  | 8.8  |

Additionally, (Gisbert & Esteve, 2011) argue that it is necessary to redesign student training processes and orient them toward the development of digital literacy throughout the entire undergraduate program. This would enable students to acquire the skills, knowledge, and attitudes required for the effective use of Information and Communication Technologies (ICT). On the other hand, (Martín & Grudziecki, 2015) suggest that skills, attitudes, and conceptual understanding are limited to the initial level of digital literacy, which they refer to as digital competence. Other scholars propose the use of artificial intelligence for intelligent tutoring (González, 2014; González-González, 2004), which involves modelling student knowledge, maintaining expert knowledge bases, designing teaching strategy models, and utilizing intelligent virtual agents to provide feedback and support to learners.

In today's educational landscape, teachers, students, administrators, and digital ecosystems must work together and integrate effectively to achieve academic goals.

## Pedagogical Innovation: Student-Centered Methodologies and Practices

Table 2 presents the analysis of innovative pedagogical strategies integrated with technology that support personalized and student-centered learning.

**Table 2.** *Analysis of Pedagogical Strategies*

| Pedagogical Strategy   | Technological Integration                     | Benefits for Personalized Learning                                         |
|------------------------|-----------------------------------------------|----------------------------------------------------------------------------|
| Project-Based Learning | Collaborative platforms, digital repositories | Promotes autonomy, problem-solving skills, and real-world connections      |
| Flipped Classroom      | Multimedia repositories, videos, LMS forums   | Allows self-paced learning and uses class time for deepening understanding |

|                                       |                                                            |                                                       |                                                                        |
|---------------------------------------|------------------------------------------------------------|-------------------------------------------------------|------------------------------------------------------------------------|
| Gamification                          | Challenge badges, dashboards                               | applications, progress engagement, immediate feedback | Increases motivation, and provides                                     |
| Adaptive Learning                     | Platforms that adjust content based on student performance |                                                       | Personalizes learning pace and level                                   |
| Formative Assessment and E-Portfolios | Online tracking tools, digital rubrics                     |                                                       | Strengthens self-assessment, metacognition, and continuous improvement |
| Digital Storytelling                  | Multimedia augmented reality                               | tools,                                                | Fosters creativity, critical thinking, and meaningful narratives       |

## Proposed Strategic Framework

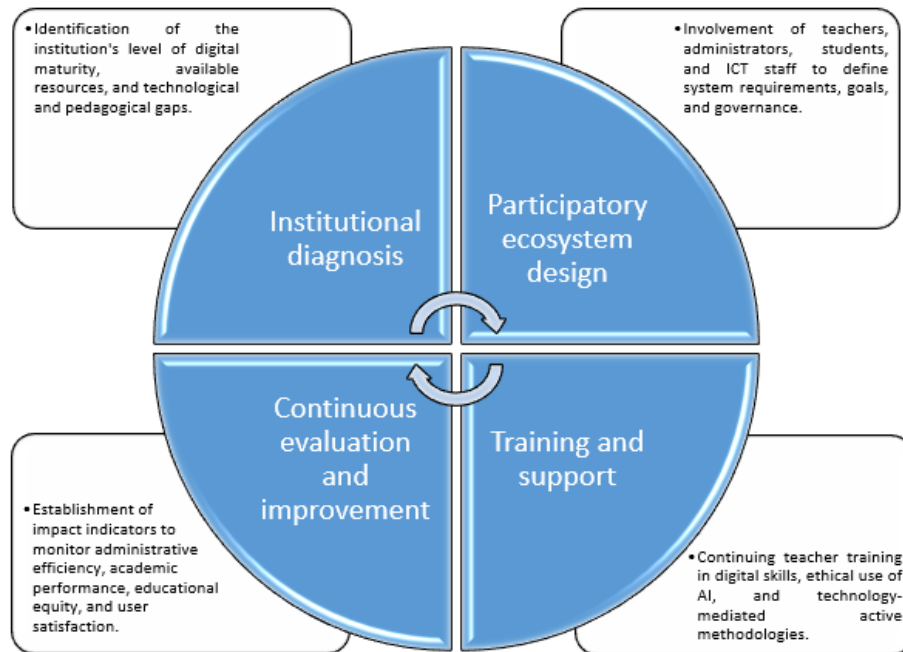
Based on the findings of this study, a strategic framework is proposed that harmoniously integrates three fundamental dimensions: artificial intelligence, educational technologies, and innovative pedagogical practices. The purpose of this framework is to enhance administrative efficiency, optimize data-driven decision-making, and promote personalized, student-centered teaching.

The technological dimension will involve the adoption of a robust infrastructure, including LMS platforms, school management systems, educational databases, and digital access devices. This dimension also encompasses investment in connectivity, information security, and technological maintenance.

The cognitive-pedagogical dimension focuses on redesigning the educational process through active methodologies such as Project-Based Learning (PBL), the flipped classroom, and gamification, along with student-centered strategies supported by digital tools that foster personalized learning, autonomy, and self-regulation.

The intelligent and analytical dimension will implement AI systems capable of collecting, processing, and analysing educational data in real time to support decision-making. This includes the use of learning analytics systems, intelligent tutoring systems, chatbots, predictive dashboards, and content recommendation engines. Figure 2 shows the implementation phases of the framework.

**Figure 2.** Implementation Phases of the Framework



Implementing the proposed strategic framework should significantly reduce administrative burdens in educational institutions by automating routine processes, enabling leadership teams and teaching staff to concentrate on pedagogical tasks and strategic planning.

In addition, data analytics and artificial intelligence will make decision-making more informed by providing real-time feedback on key areas such as student performance, engagement, and retention.

With regard to learning, a more adaptive, personalized, and flexible environment is anticipated, one in which students can progress at their own pace, receive immediate guidance, and actively engage in their academic development. This approach fosters student motivation, critical thinking, and learner autonomy.

Lastly, the structured integration of these digital ecosystems is projected to drive organizational innovation and strengthen technological sustainability, promoting an institutional culture oriented toward the strategic use of ICT at all levels of educational management.

## Conclusions

Digital ecosystems represent a significant opportunity to transform educational management through the strategic integration of artificial intelligence (AI),

information and communication technologies (ICT), and innovative pedagogical practices. This study has shown that their design and implementation not only support administrative processes but also enhance data-driven decision-making and personalized learning. The data gathered through the systematic literature review reveals that the success of these ecosystems relies on three key factors: appropriate technological infrastructure, continuous professional development for teaching staff, and the adoption of student-centered methodologies. Moreover, innovative pedagogical strategies empowered by technology are emerging as key drivers of change in teaching and learning environments, strengthening student autonomy, motivation, and academic performance.

This analysis allows us to conclude that there is a solid knowledge base regarding the benefits and challenges of digital ecosystems. However, there are still gaps related to their evaluation, sustainability, and large-scale impact.

The proposed strategic framework serves as a comprehensive guide for institutions aiming to pursue digital educational transformation with pedagogical relevance and a forward-looking vision. The transition to these environments requires not only investment in technology but also a reconfiguration of institutional practices, teaching roles, and educational policies. Finally, digital ecosystems offer a pathway toward more efficient, personalized, equitable, and learning-centered education, positioning educational institutions as active agents in the digital society of the 21st century.

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# **INACAP international virtual exchange program: Innovation in logistics education with a global perspective**

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This paper synthesizes the ongoing work of the INACAP International Virtual Exchange Program, whose conceptualization arose from the collaborative vision of Miguel Valencia H., its principal architect, and Marisol Tapia C. They share a foundational commitment to fostering societal progress through innovative educational opportunities, with a keen awareness of environmental stewardship.

## **Context and program justification**

In today's globalized logistics landscape, vocational education must prepare professionals for complex, multicultural, and sustainable contexts (Tapia, 2024). Literature recommends integrating technical, intercultural, and sustainability competencies into logistics curricula (Pacher, 2022; Ibrahim *et al.*, 2024; Godwin-Jones, 2022; Sauro & O'Dowd, 2021). The INACAP International Virtual Exchange Program, led by Miguel Valencia Herrera and Marisol Tapia Céspedes, addresses limited research in Latin America by involving students in global logistics challenges (Tapia, 2024). Integrating technological innovation, applied research, and active pedagogy, it fosters process optimization, intercultural skills, and sustainability awareness—aligned with green supply chain demands and offering a replicable model (Pacher, 2022; Ibrahim *et al.*, 2024). Logistics increasingly prioritizes innovation-driven sustainability to achieve environmentally friendly operations (Ibrahim *et al.*, 2024). At its pandemic peak, the program exemplified “internationalization at home” by enabling global collaboration without mobility (Godwin-Jones, 2022; Sauro & O'Dowd, 2021). In 2021, 873 Chilean and 906 international students participated (Tapia, 2024), showcasing virtual platforms' potential to expand access to technical and intercultural education.

The study poses the research question: What is the impact of a challenge-based learning model on the development of technical, intercultural, and sustainability competencies in logistics students within an international virtual exchange program? This addresses a research gap by exploring the integration of challenge-based learning (CBL) and virtual exchange in technical logistics education (Pacher, 2022; Sauro & O'Dowd, 2021).

## Study objectives

Aligned with the research question, the study objectives are the following: (1) To evaluate technical competency in logistics process optimization among participating students; (2) To assess intercultural communication and teamwork, skills; (3) To analyze the effectiveness of the challenge-based learning methodology in fostering these competencies in a virtual international setting; (4) To explore participants' perceived benefits and challenges of the virtual exchange program, including sustainability awareness.

## Foundations of Challenge-Based Learning (CBL)

Challenge-Based Learning (CBL) is an active methodology connecting education with the productive sector by engaging participants in real-world problems (Universitat Autònoma de Barcelona, n.d.; Prova Fàcil, n.d.). Students explore improvement paths and propose solutions, ideally implemented and evaluated. Inspired by experiential learning theorists (Piaget, Kilpatrick, Rogers, Kolb), CBL promotes contextualized learning through problem identification, innovation, and reflection (Tecnológico de Monterrey, 2016; Tapia, 2024). Solutions must be original, feasible, and value-adding.

INACAP's program explicitly uses CBL, with international teams solving real logistics challenges like vaccine distribution, humanitarian logistics, circular economy applications, and tariff analysis (Tapia, 2024). This practical application of constructivist and experiential learning theories connects academic learning directly with industry-relevant problem-solving in complex global contexts, effectively training professionals with applicable skills.

## Virtual Exchange Models and Collaborative Online International Learning (COIL)

Virtual exchange creates cultural, research, and language interaction spaces among students and faculty across locations (Lafont Castillo, 2020). COIL (Collaborative Online International Learning) is a broad term for online intercultural collaborative projects with partners from different cultural contexts, guided by professors (Grupo Compostela de Universidades, n.d.). COIL offers multiple benefits: "internationalization at home" by removing economic barriers to overseas stays (Grupo Compostela de Universidades, n.d.), development of digital and intercultural competencies, multicultural classroom experiences, international collaboration, exposure to new teaching techniques, and linguistic skill development (Grupo Compostela de Universidades, n.d.).

Challenges include teacher training, student monitoring, and robust



infrastructure (Lafont Castillo, 2020). INACAP addressed language barriers with real-time translation and technology access differences through methodological adjustments (Tapia, 2024). Overcoming these difficulties, driven by motivation (Tapia, 2024), highlights the critical role of pedagogical adaptation and participant commitment in successful virtual internationalization.

## **Development of intercultural competencies in higher education**

Intercultural competencies (IC) are fundamental for university students' global mobility and employability (CLADEA, 2021). IC is an interactive process with three dimensions:

- Cognitive (Intercultural Awareness): knowledge and understanding of diverse cultures, values, customs, and work styles (CLADEA, 2021).
- Affective (Intercultural Sensitivity): aptitude and interest in interacting with diverse cultures, willingness to question own values, empathy, and open-mindedness (CLADEA, 2021).
- Behavioral (Intercultural Skill): effective and appropriate interaction in intercultural situations, achieving communication goals through verbal and non-verbal skills, and adapting communication styles (CLADEA, 2021).

Intercultural competence (IC) development requires deliberate educational planning (CLADEA, 2021). Virtual Global Teams (VGTs) are effective in fostering IC, with instructors serving as key intercultural facilitators. Tasks should capitalize on cultural diversity and use rich communication tools like videoconferencing.

## **Integration of sustainability in logistics vocational training**

Sustainability in logistics is crucial for competitiveness, resource optimization, emission reduction, and ESG compliance (Llera, 2024). The logistics professional profile increasingly demands social responsibility and environmental sustainability.

INACAP's program integrates sustainability into CBL modules. In 2024, it focused on circular economy for companies like Aza Acero Sostenible and Cordobes Industrial Ltda., while 2025 will address "Tariffs and Supply Chains: Sectoral adaptation and sustainability strategies" (Tapia, 2024). This inclusion aligns with global industry demands and UN Sustainable Development Goals, preparing professionals for the intersection of business and environmental responsibility. The program evolves its challenges, positioning INACAP as a

leader in adaptive technical-professional education.

The study involved students from INACAP's logistics programs across 27 campuses offering Logistics Technician and Engineering programs, and from partner institutions chosen for established academic collaborations (Tapia, 2024). Purposive sampling ensured representation from diverse geographic and socioeconomic backgrounds, aligning with INACAP's nationwide coverage and international partnerships.

Overall participation since 2021 has been significant, involving 2,923 students (1,551 Chilean, 1,626 international), with equitable gender distribution (51.34% women, 48.66% men) (Tapia, 2024). Annual student and faculty distribution is in Table 1.

**Table 1.** *Annual participation in the INACAP Virtual International Exchange Program (2021-2024)*

| Item / Year             | 2021 | 2022 | 2023 | 2024 | Total  |
|-------------------------|------|------|------|------|--------|
| Inacap students         | 873  | 232  | 135  | 311  | 1551   |
| Foreign students        | 906  | 301  | 166  | 253  | 1626   |
| Inacap faculty members  | 34   | 15   | 9    | 11   | 69     |
| Foreign faculty members | 26   | 15   | 9    | 10   | 60     |
| Institutions            | 7    | 7    | 7    | 10   | (*) 10 |
| Foreign countries       | 8    | 8    | 8    | 8    | (**) 8 |

(\*) There was a growth of three foreign institutions in 2024.

(\*\*) The number of participating countries has remained at eight, despite some changes in composition.

Note. Data compiled from INACAP internal reports (INACAP, 2021b, 2022, 2023; Tapia, 2024).

Table 1 shows participation fluctuations, with a peak in 2021 (873 Chilean, 906 international students) attributed to the global pandemic's amplification of digital platforms and cross-border academic connectivity (INACAP, 2021b; Tapia, 2024). Subsequent decreases in 2022-2023, followed by a slight recovery in 2024 (INACAP, 2022, 2023), suggest a shift from necessity-driven to sustained program enrollment, offering insights into long-term sustainability. The distribution of foreign students by country is in Table 2.

**Table 2.** *Distribution of foreign students by country (2021-2024)*

| Country / Year | 2021 | 2022 | 2023 | 2024 | Total |
|----------------|------|------|------|------|-------|
| Colombia       | 442  | 92   | 55   | 65   |       |
| El Salvador    | 0    | 26   | 24   | 26   |       |
| Paraguay       | 92   | 44   | 43   | 64   |       |
| Ecuador        | 0    | 25   | 0    | 0    |       |
| México         | 48   | 27   | 14   | 28   |       |
| Brasil         | 251  | 27   | 0    | 0    |       |
| Costa Rica     | 27   | 34   | 19   | 26   |       |
| Uruguay        | 0    | 26   | 0    | 0    |       |
| Perú           | 26   | 0    | 0    | 0    |       |
| España         | 20   | 0    | 0    | 0    |       |
| Panamá         | 0    | 0    | 11   | 44   |       |
| Total          | 906  | 301  | 166  | 253  | 1626  |

Note. Data compiled from INACAP internal reports (INACAP, 2021b, 2022, 2023).

### Program implementation process

The program's implementation was structured to maximize learning and collaboration (Tapia, 2024):

- Call for participants: students from INACAP's logistics programs and partner institutions were invited.
- Icebreaker activities: synchronous and asynchronous activities (e.g., sharing cultural foods, videos) fostered group cohesion and cultural empathy.
- Team formation: multicultural teams of approximately 6 students were formed, assigned challenges like 2025 tariff analysis or green supply chain optimization.
- Virtual sessions: weekly sessions (8–12 weeks) via Zoom, Google Meet, or Microsoft Teams, guided by academic tutors.
- Teams conducted comparative analyses using Bizagi (e.g., vaccine distribution modeling), Flexsim (e.g., humanitarian logistics simulation), and Trello (e.g., managing circular economy proposals). Sustainability tools emphasized route optimization and resource efficiency (Ibrahim *et al.*, 2024)
- Evaluation: technical (e.g., software proficiency), soft skills (e.g., cultural empathy), and sustainability competencies (e.g., green logistics practices) were assessed via standardized rubrics, with pre/post surveys and peer

feedback (Tapia, 2024; Pacher, 2022).

The program leveraged robust ICT infrastructure, including cloud-based tools (e.g., Microsoft PowerPoint for presentations) and real databases from WHO and UNDP for analyzing global logistics trends (Tapia, 2024).

The program enhanced student competencies with improvements of 67.21% in technical skills (e.g., Bizagi, Flexsim), 72.45% in soft skills like intercultural communication, and 65.30% in sustainability awareness (Tapia, 2024). Supported by icebreakers and multicultural teams, it also fostered affective and social dimensions of intercultural competence, strengthening the human side of global collaboration. Qualitative findings, derived from thematic analysis, revealed three main themes:

- Intercultural connections: students reported improved cultural empathy and teamwork through virtual collaboration (Godwin-Jones, 2022; Sauro & O'Dowd, 2021). A Chilean student befriended a Brazilian peer, and a Mexican student discovered unique Chilean vaccine distribution logistics (Tapia, 2024). These narratives show how the program fosters self-reflection, broadens perspectives, and promotes global citizenship and empathy.
- Development of key competencies: participants improved ICT use, intercultural skills through cultural engagement, and high-level thinking (coordination, analysis, research, synthesis) (Tapia, 2024). They also cultivated autonomous learning and teamwork, promoting mutual respect. Inclusion of students from engineering, administration and sustainability provided complementary approaches (Tapia, 2024).
- Challenges and adaptations: students identified language barriers and technology access differences (Tapia, 2024). Motivation drove solutions like real-time translation, demonstrating participant and program adaptability and resilience (Tapia, 2024).
- Value of real-world challenges: participation in topics like vaccine distribution, humanitarian logistics, and circular economy enabled comparative analysis and innovative solutions (Tapia, 2024). This connection to authentic industry problems was a key driver for contextualized learning.
- Technical proficiency: enhanced skills in logistics tools (e.g., Bizagi, Flexsim) were linked to challenge-based learning (Pacher, 2022).
- Sustainability awareness: students developed a deeper understanding of

green logistics, such as route optimization and circular economy principles (Ibrahim *et al.*, 2024).

Challenges included technological barriers (e.g., unstable internet) and cultural misunderstandings, mitigated through tutor support and icebreaker activities (Tapia, 2024).

The study's findings, showing significant increases in technical and soft skills (Tapia, 2024), validate CBL's effectiveness in virtual. The program's design, including icebreakers and multicultural teams (Tapia, 2024), specifically fostered intercultural competencies, particularly affective and cognitive dimensions. The greater increase in soft skills, supported by qualitative testimonials, highlights the program's effectiveness in fostering intercultural sensitivity and awareness.

The program integrates key pedagogical strategies for 21st-century professionals by developing technical and soft skills in a virtual setting. It combines CBL's problem-solving focus with virtual exchange's intercultural and digital collaboration, enabling holistic skill development across global environments.

### **Practical and theoretical implications of the program**

From a practical perspective, INACAP's model is highly replicable, with flexible design allowing integration with diverse curricula and adaptation to various academic backgrounds (Tapia, 2024). It offers a cost-effective alternative to physical mobility, promoting internationalization at home. The study provides empirical evidence on CBL and virtual exchange effectiveness in technical-professional education, enrich literature on intercultural competence in online collaboration. The virtual, challenge-based format (Tapia, 2024) dismantles academic silos and fosters interdisciplinary problem-solving. Participation from students in engineering, administration, and sustainability programs underscores its integrative potential.

### **Conclusions**

The INACAP International Virtual Exchange Program significantly enhanced students' technical, intercultural, and sustainability competencies, with gains of 67.21%, 72.45%, and 65.30%, respectively (Tapia, 2024). The challenge-based learning model, paired with virtual exchange, effectively fostered these skills, aligning with industry demands for sustainable logistics (Ibrahim *et al.*, 2024; Pacher, 2022). Virtual platforms enabled global collaboration, overcoming economic and mobility barriers (Godwin-Jones, 2022; Sauro & O'Dowd, 2021).

Limitations and improvements: Self-assessment bias and purposive sampling limit generalizability. Improvements could address tutor training, tech access, and sustainability metrics. The study supports virtual exchange in logistics education as a scalable model. Formalizing “parallel faculty activities” (Tapia, 2024) may foster a community of practice and improve feedback integration.

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# Psychological well-being and academic engagement in Peruvian university students

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## Introduction

University students often face high levels of psychological distress, academic pressure, and stress during their years of professional training (Alvarado-García et al., 2025; Kiliñç & Kendirikiran, 2025). In addition to the current academic demands, these factors are known to affect students' ability to regulate their emotions, which in turn can negatively impact on their overall well-being and academic performance (Duchi et al., 2025). When referring to psychological well-being, it is important to recognize its core components, which include life satisfaction, self-esteem, and the ability to cope with adversity (Gumusgul et al., 2025).

Psychological well-being is closely linked to an individual's mental health, encompassing emotional, psychological, and social aspects. In other words, it reflects the capacity to experience positive emotions, maintain life satisfaction, and develop healthy psychological functioning that enables individuals to adapt and thrive across different life contexts (Marques-Pinto et al., 2025). This broad approach to mental health highlights the relevance of both the positive and negative dimensions of mental health in the lives of university students (Han et al., 2025). In academic settings, psychological well-being is therefore associated with students' motivation and performance.

In addition to the above, psychological well-being is positively associated with academic performance and self-directed learning (Duchi et al., 2025); therefore, it is essential for universities to promote the conditions necessary to support students' well-being. Moreover, when academic environments not only foster academic excellence but also prioritize students' mental and emotional health, favorable outcomes can be achieved, contributing to students' academic satisfaction (Moreno-Montero et al., 2024). It is also important to acknowledge the role of support networks within academic settings, as they can significantly influence psychological well-being.

Students with strong support networks tend to experience better mental health, lower emotional stress, and greater development of their psychological well-being, as demonstrated in a study conducted with Chinese university



students (Man & Jing, 2025). Similarly, research in Turkey found that students' psychological well-being is linked to the level of positive interactions within educational settings, regardless of whether instruction is delivered virtually or in person. Furthermore, academic performance and motivation emerged as key factors within this dynamic (Gumusgul et al., 2025). Thus, psychological well-being can be considered an influential factor in both academic performance and academic engagement, suggesting that higher levels of personal well-being may help mitigate the negative effects of academic stress (Marques-Pinto et al., 2025).

Academic engagement can be described as a motivational construct that encompasses students' involvement in their academic activities. This type of engagement is characterized by behaviors oriented toward completing academic tasks that promote positive connections with performance and satisfaction, which are closely linked to students' academic success (Alé-Ruiz et al., 2024; Tannoubi et al., 2025). Academic engagement refers to the dedication, effort, and connection that a student demonstrates toward their learning process. This construct involves not only the fulfillment of academic tasks but also the expression of interest and motivation to learn, as well as the ability to persist in the face of academic challenges (Hong, 2025).

According to Estrada and Paricahua (2023), other key components are involved in academic engagement, including: participation, which reflects students' emotional disposition toward learning; academic responsibilities, such as attending classes and completing assignments; psychological state, which relates to the sense of belonging and valuing the educational process; and specific dimensions of engagement, namely vigor, dedication, and absorption. Vigor reflects energy and enthusiasm toward academic tasks, dedication represents commitment to one's academic path, and absorption refers to deep concentration and enjoyment of studying. Ultimately, students who exhibit high academic engagement tend to demonstrate proactivity and initiative in seeking resources and support, maintaining a positive attitude toward academic challenges (Janson & Janke, 2024).

For example, research has shown that vigor acts as a full mediator of students' persistence expectations (Galve-González et al., 2024). Based on the evidence described, it can be stated that academic engagement influences academic performance and is closely linked to students' overall well-being (Ghbari et al., 2024). Higher education institutions must recognize the relevance of these psychoeducational constructs as fundamental pillars of academic success. Failing to address these needs may not only negatively affect academic performance but may also have long-term consequences for students' personal

and professional lives. All of the factors described above highlight the need to conduct this research, especially in an increasingly demanding and challenging environment for university students. In this regard, the main objective of the study was to analyze the relationship between psychological well-being and academic engagement in a sample of Peruvian university students.

**Table 1.** *Correlation between the study variables*

|                     | Psychological well-being |         |
|---------------------|--------------------------|---------|
|                     | $r_s$                    | $r_s^2$ |
| Academic engagement | 0.392*                   | 0.154   |

\*  $p < 0.05$

$r_s$ : Spearman correlation

$r_s^2$ : coefficient of determination

Table 1 shows the relationship between psychological well-being and academic engagement among the university students surveyed ( $r = 0.392$ ,  $p < 0.05$ ); this indicates that higher levels of psychological well-being are positively associated with higher levels of academic engagement. This moderate relationship was established by analyzing the total scores for each variable.

**Table 2.** *Differences by age*

|                          | 18 to 30<br>years<br>(n=608) | 31 to 40<br>years<br>(n=134) | U        | p     |
|--------------------------|------------------------------|------------------------------|----------|-------|
|                          | Mdn                          | Mdn                          |          |       |
| Psychological well-being | 98.00                        | 105.00                       | 29082.00 | 0.000 |
| Academic engagement      | 61.00                        | 66.00                        | 28570.00 | 0.000 |

n: number of participants

Mdn: median

U: Mann-Whitney U test

p: p-value

Table 2 presents the differences in the scores of each variable based on the sociodemographic characteristic of age. According to the results, older students (aged 31 to 40) reported higher levels of psychological well-being as well as higher levels of academic engagement.

**Table 3.** *Differences by sex.*

|                          | Men<br>(n=370) | Women<br>(n=372) | U        | p     |
|--------------------------|----------------|------------------|----------|-------|
|                          | Mdn            | Mdn              |          |       |
| Psychological well-being | 100.00         | 98.00            | 59568.00 | 0.002 |
| Academic engagement      | 62.00          | 62.00            | 66932.00 | 0.518 |

n: number of participants

Mdn: median

U: Mann-Whitney U test

p: p-value

Table 3 shows that male participants reported higher levels of psychological well-being compared to female participants, and this difference was statistically significant. On the other hand, no significant differences were found in academic engagement based on sex.

**Table 4.** *Differences by employment status*

|                          | Students only<br>(n=242) | Work and<br>study (n=500) | U        | p     |
|--------------------------|--------------------------|---------------------------|----------|-------|
|                          | Mdn                      | Mdn                       |          |       |
| Psychological well-being | 97.00                    | 99.50                     | 49046.00 | 0.000 |
| Academic engagement      | 60.00                    | 63.00                     | 47744.00 | 0.000 |

n: number of participants

Mdn: median

U: Mann-Whitney U test

p: p-value

The results based on employment status show significant differences in both variables. As presented in Table 4, participants who both work and study reported higher levels of psychological well-being and greater academic engagement compared to those who only study.

**Table 5.** *Differences by study modality*

|                          |  | In-person<br>(n=420) | Blended<br>(n=234) | Online<br>(88) | H      | p     |
|--------------------------|--|----------------------|--------------------|----------------|--------|-------|
|                          |  | Mdn                  | Mdn                | Mdn            |        |       |
| Psychological well-being |  | 97.00                | 99.00              | 105.00         | 37.310 | 0.000 |
| Academic engagement      |  | 61.00                | 64.00              | 64.00          | 14.972 | 0.001 |

n: number of participants

Mdn: median

H: Kruskal-Wallis H test

p: p-value

Table 5 shows that students enrolled in the virtual modality reported higher levels of psychological well-being. Regarding academic engagement, students in both blended and virtual modalities showed higher scores compared to those studying face-to-face modality.

## Conclusions

The correlational results indicate that the variables are moderately but significantly associated, suggesting that higher levels of psychological well-being correspond to greater academic engagement among university students. The coefficient of determination showed that 15.4% of the variability in academic engagement is attributable to psychological well-being. In other words, psychological well-being plays an important role in academic engagement outcomes. However, it is important to emphasize that, given the relatively low percentage of explained variability, academic engagement also depends on other factors within the broader context of psychoeducational research. This highlights the relevance of promoting a positive educational climate within universities, reinforcing the need to strengthen students' sense of belonging and motivation. Furthermore, it calls for the continuous assessment of psychological well-being as part of a monitoring system aimed at supporting student retention through comprehensive and preventive strategies.

In addition, the results showed that male students reported higher levels of psychological well-being. Adults aged between 31 and 40, as well as those who combine work and study, demonstrated higher levels of both academic engagement and psychological well-being. These findings could be explained

by the fact that older participants tend to have more advanced psychosocial development, greater maturity, life experiences, and better skills to cope with academic demands. Moreover, it is possible that, due to their age, participants between 31 and 40 years old have greater clarity regarding their academic goals and life purpose.

This study contributes to understanding the behavior of the analyzed variables within the Peruvian context and in relation to participants' sociodemographic characteristics. However, it is recommended that future research explore these topics in greater depth, potentially from a qualitative perspective.

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# Transforming Student Success: An AI-Supported Model for Monitoring and Projecting University Students' Academic Trajectories

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## Introduction

Higher education institutions in Mexico operate in an increasingly dynamic environment, where social, economic, and technological changes demand new ways of understanding problems, generating strategic knowledge, and strengthening institutional capacities for anticipatory and evidence-based decision-making. In this context, key educational challenges such as student dropout, low graduation efficiency, and poor academic performance have become more pronounced. However, beyond these visible symptoms lies a deeper structural issue: the absence of a comprehensive model that allows for the systematic analysis and interpretation of the vast amount of data generated about students —data that could inform decisions to address these challenges more effectively.

Data analysis is essential for effective decision-making. As Deming (1993) famously stated: *“Without data, you're just another person with an opinion.”* The field of education is no exception: it is crucial to use quantifiable evidence to assess students' academic paths, to inform the actions that should be implemented to address challenges, and to evaluate whether those actions are truly having the intended impact.



However, this this data-driven approach must be complemented by an equally relevant insight: *“Without information, you're just another person with a lot of data.”* This statement emphasizes that data, by itself, does not constitute useful information. It only gains value when it can be contextualized and interpreted—that is, when it helps build a meaningful narrative to guide decision-making.

A university working model grounded in information analysis is key, as it impacts everything from academic planning to student support across the entire academic path, from enrollment to graduation. Integrating existing technological tools is no longer a trend, but a necessity for making informed decisions and improving students' academic trajectories.

Recently, Learning Analytics (LA) has emerged as a relevant line of research within the field of educational technology, with the main purpose of making use of data generated in educational contexts to support teaching and learning processes (García-Peñalvo, 2020; Siemens, 2013). This discipline is closely related to areas such as Educational Data Mining, which focuses on data collection, and Academic Analytics, oriented toward data analysis for institutional and administrative purposes (Campbell et al., 2007). Learning Analytics takes into account various types of data (with different characteristics in terms of volume, distribution, and privacy) and employs tools such as artificial intelligence, data visualization, dashboards, and mixed methods to analyze the available information (García-Peñalvo, 2020).

Learning Analytics approaches respond to a wide range of educational stakeholders' needs, as they enable monitoring, prediction, intervention, assessment, and feedback in the learning process. By analyzing academic data, the goal is to support informed decision-making that enhances the educational experience and outcomes. In this way, Learning Analytics and Academic Analytics are consolidated as strategic tools to understand and optimize learning from an evidence-based perspective.

Today, accessible technologies are available that can radically transform educational management. Artificial intelligence and the use of intelligent agents not only enable analysis of students' current academic situations but also allow for future scenario projections based on historical patterns. Through simulation models and strategy testing, it becomes possible to anticipate outcomes, assess hypothetical interventions, and generate personalized proposals for each type of student trajectory.

This paper presents a proposed model for analyzing academic trajectories, which begins with the systematic identification of relevant student and

environmental data, organized into personal, academic, and institutional dimensions. This information is structured into databases that, through AI-powered intelligent agents, enable automated and predictive analyses. The results are visualized through dynamic dashboards, making it easier to interpret key indicators and optimize decision-making in real time.

By implementing this academic trajectory analysis model, it becomes possible to answer key questions such as: What types of students are most likely to drop out in the first semesters, and what characteristics do they share? What are the most common pathways among those who graduate on time? Which courses act as bottlenecks in certain degree programs, and how do they affect graduation rates? The model allows for a comprehensive consideration of environmental variables, evaluating their positive or negative weight depending on the specific phenomenon being analyzed.

The proposed model goes beyond the concept of a simple institutional data storage platform. It is conceived as a living, intelligent system capable of real-time analysis of students' academic progress. Its dynamic design makes it possible to identify, in a timely manner, the factors that contribute to poor academic performance or student attrition, while recognizing that these factors may evolve over time or vary by region—for example, between the north and south of the country—or due to more specific conditions, such as particular characteristics of the teaching staff or the academic organization.

Furthermore, this model enables institutions to observe and understand, in a comprehensive and updated way, the academic behavior of individual students as well as entire cohorts, specific programs, or targeted groups. In doing so, it facilitates strategic, personalized decision-making aimed at improving support services and student retention.

## **Context Description and Justification**

Public universities in Mexico face the ongoing challenge of making sound decisions in complex contexts marked by regional diversity, pressure to improve quality indicators, and the need to respond swiftly to social demands. Although institutions often manage large volumes of academic and administrative data, many lack effective mechanisms to transform that data into actionable knowledge. This limitation reduces their ability to anticipate risks, assess the impact of policies, and develop targeted strategies to improve student retention, academic performance, and graduation rates. In this scenario, the incorporation of data-driven and AI-based analytical models represents a valuable opportunity to strengthen institutional decision-making.

In a context where dropout, academic lag, and low graduation efficiency remain persistent challenges, it is urgent to move away from rigid, fragmented, and perception-based models, and toward intelligent, flexible systems grounded in evidence. This proposed model not only demonstrates what is currently possible with existing technological tools but also outlines a clear path toward the future of higher education—one in which decisions are based on data and information, processes adapt to students, and institutions evolve into truly intelligent spaces committed to the academic and human success of their communities.

## Key Concepts

An academic trajectory is understood as the path a student takes through their academic program, including the duration of their studies, regularity in coursework, and eventual graduation (Sepúlveda, 2013). This trajectory can be visualized as a timeline influenced by multiple conditions, stages, and particular circumstances that must be identified, measured, and understood.

To carry out an effective analysis of academic trajectories, the proposed model incorporates elements of artificial intelligence (AI), which is classically defined as "the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings" (Banco Interamericano de Desarrollo, 2023).

During the model's design process, various AI tools were explored to identify those with the greatest potential for analyzing academic trajectories. After technical and functional evaluation, the use of intelligent agents was selected due to their ability to operate autonomously, process large data volumes, and produce contextualized, real-time analyses (Coloma-Garofalo *et al.*, 2020).

These intelligent agents not only generate immediate alerts and analyses but also enable the simulation of prospective scenarios by applying different academic or institutional conditions. This makes it possible to anticipate the effects of various strategies—such as adjusting course loads, reassigning tutors, or redesigning key courses—before implementation.

But how should the processed data be presented? It is essential that trends and problems identified through data analysis be easily interpreted by school administrators, teaching staff, and support personnel, most of whom are not data analysis experts. For this reason, the proposed model incorporates the use of dashboards, which are visual tools that integrate and represent key data about students' academic trajectories, facilitating ongoing monitoring and evidence-based decision-making (García-Peñalvo, 2020; Verbert *et al.*, 2014).

In this context, discussing educational analytics and the use of dashboards also involves understanding the role of Key Performance Indicators (KPIs), which are quantitative metrics used to continuously monitor progress toward strategic goals. In education, KPIs allow institutions to assess academic performance, identify areas for improvement, anticipate risks, and make real-time, data-driven decisions. An effective KPI should meet SMART criteria: it must be Specific, Measurable, Achievable, Relevant, and Time-bound (Bedoya Barrantes, 2024).

All these elements converge to form a structured analytical model that transforms raw data into a solid information base for strategic decision-making—one that strengthens institutional management, anticipates risks, and guides actions to improve academic performance and student retention.

## Model Description

The proposed model has been designed with an open-system approach, meaning it can integrate new variables as institutional needs evolve or as new data becomes available. For example, indicators related to emotional well-being or alumni data could be incorporated, with the analysis algorithms adjusting automatically—without the need to redesign the core system.

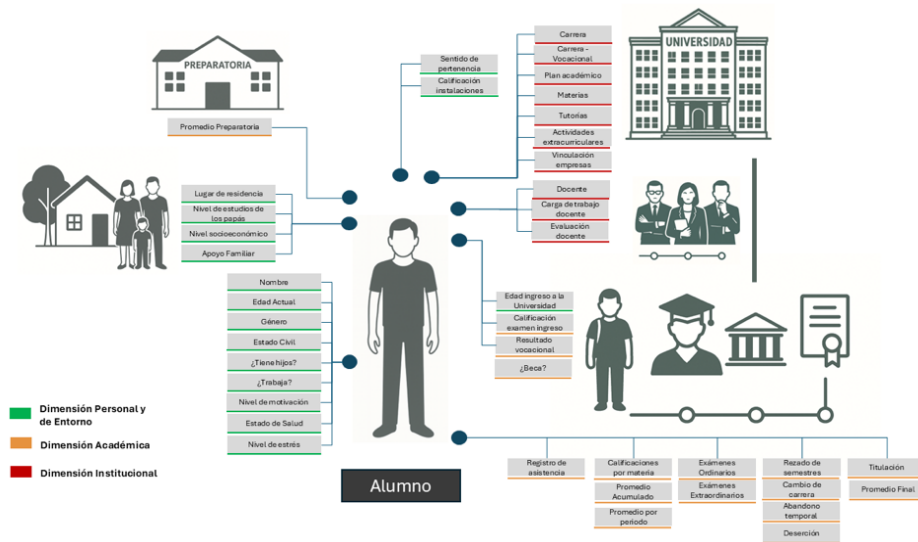
**Model Dimensions.** The model is structured around three dimensions that allow for a comprehensive analysis of each student: personal and environmental, academic, and institutional. Each dimension is composed of interconnected variables, briefly described as follows:

- **Personal and Environmental Dimension:** Considers factors such as place of residence, socioeconomic status, employment, family support, sense of belonging, and stress levels to identify risks of dropout or academic lag and to design more human-centered interventions.
- **Academic Dimension:** Analyzes academic performance (both past and current), attendance, evaluation opportunities (such as the use of remedial exams), and academic lag, in order to detect learning difficulties or challenges in adapting to university life in a timely manner.
- **Institutional Dimension:** Examines the out-of-class school context, including teaching quality, access to tutoring, availability of extracurricular activities, and partnerships with external organizations to assess how the institution supports academic progress beyond the classroom.

The combination of these dimensions enables the identification of risk and protection factors, supports decision-making, and allows for the delivery of

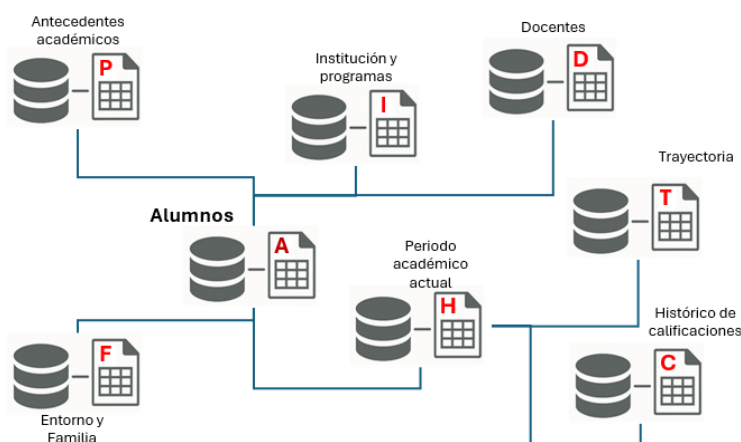
targeted interventions to improve student retention and academic success (see Figure 1).

**Figure 1.** Data diagram by dimension.



**Model Architecture and Intelligent Agent.** The data from the three dimensions described above are organized into interrelated databases which, when connected, offer a holistic view of each student. This structure makes it possible to identify patterns, contextualize information, and generate precise analyses. The model thus operates dynamically, updating key indicators in real time and supporting decisions with contextualized evidence (see Figure 2).

**Figure 2.** Database relationship diagram.



The model incorporates an intelligent agent based on GPT-4.0, implemented using Python and Azure OpenAI. This agent operates autonomously within the institutional system, continuously analyzing available databases, interpreting the behavior of variables associated with each student, and evaluating their academic trajectories.

For instance, if the system detects that a student's GPA is declining, they have changed their academic program, live far from campus, and are working part-time, the agent compares this profile to previously recorded similar cases. Based on that comparison, it anticipates a high dropout risk and triggers an alert on the monitoring dashboard, suggesting actions such as adjusting the course load, providing tutorial support, or offering socio-emotional assistance.

Conversely, if a student maintains a GPA above 8.5, actively participates in tutoring, holds a merit-based scholarship, and receives positive teacher evaluations, the agent associates this profile with successful trajectories from previous cohorts and projects a high probability of on-time graduation.

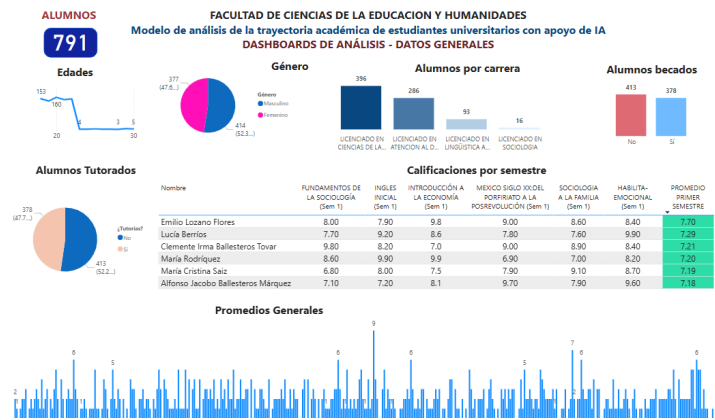
**Model Adaptability and Learning.** One of the model's strengths is its dynamic and adaptive nature. As variables change or new data is introduced, the system automatically adjusts its projected trajectories. For example, if a new variable with a favorable impact is added, the model recognizes the new pattern and redefines the optimal trajectory, highlighting the combination of factors that lead to better outcomes.

This approach enables not only reactive monitoring but also strategic forecasting, by simulating hypothetical scenarios through intentional modification of certain variables. This opens the door to predictive analysis and preemptive evaluation of intervention strategies. In this way, trajectories are no longer seen as static diagnoses but rather as living, adaptable processes that support informed decision-making.

**Visualization and Evidence-Based Decision-Making.** To support analysis and decision-making, the model integrates data into interactive dashboards developed in Power BI. These dashboards allow users to visualize key information such as the number of students by gender or academic program, average grades per course and semester, use of tutoring services, among other elements.

The display of these dashboards is based on a predefined set of rules that determine the expected behavior of each variable. Each is assigned a positive or negative weight according to its individual value and interaction with other variables. For example, high attendance, strong academic performance, and participation in tutoring are considered positive indicators of a successful trajectory.

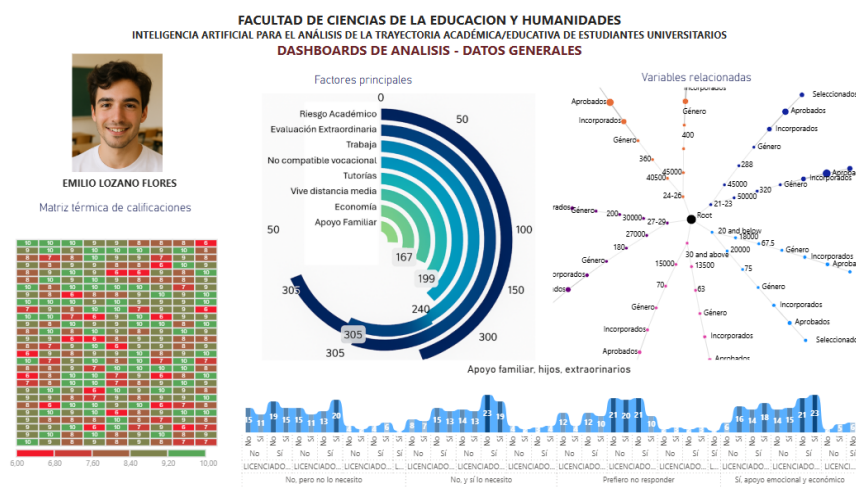
Figure 3. Student information dashboards.



**Contextual and Comparative Analysis.** The model does not analyze student cases in isolation. On the contrary, it cross-analyzes data from hundreds of students, identifying patterns, correlations, and risk levels. This allows for a deeper understanding of each individual case within its context. This comparative analysis strengthens the model's predictive capacity and enhances the effectiveness of its recommendations.

Once the entire analytical process is structured, dashboards of key performance indicators (KPIs) are designed to display in real time the critical factors affecting student performance and retention. These tools become strategic instruments for institutional management, enabling evidence-based decisions that are tailored to the realities of the student body.

Figure 4. Student-level analysis dashboard.



As an example, Figure 4 presents the dashboard for student Emilio Lozano Flores, analyzed through key visualizations: In the lower-left corner, a heat map

of grades indicates academic risk using color coding; in the center, a spiral chart highlights risk factors such as family support, financial situation, and distance from campus; on the right, a radar chart (or star diagram) links variables such as gender, age, and academic status; at the bottom, a variable cross-tabulation positions the student within groups with similar behavioral patterns.

## Conclusions

The proposed model represents a new approach to academic management, integrating artificial intelligence, data structuring, and educational analytics into a system that not only monitors but also interprets and projects students' academic trajectories in a comprehensive way. Its foundation is organized into three key dimensions —personal and environmental, academic, and institutional—which allow for a holistic understanding of each student.

One of its most innovative contributions is the incorporation of intelligent agents, such as GPT-4 from Azure OpenAI, which operate autonomously within institutional databases to identify risk factors, recognize successful academic trajectories, and generate predictive alerts that support decision-making. This capacity for automated analysis turns the system into a high-value predictive tool for strategic decision-making.

Unlike traditional models that rely solely on historical data processing, this model is conceived as a living, dynamic, and adaptable system, capable of real-time updates and offering a current, flexible view of each student's academic status —whether on an individual level or as part of a group, cohort, or academic program. This adaptive nature enables the model to evolve continuously, respond swiftly to institutional needs, and better guide efforts toward student retention, academic support, and performance improvement.

In a context marked by high dropout rates and academic lag, this model offers an intelligent, evidence-based alternative, moving beyond rigid or fragmented approaches. Moreover, its scalable and adaptable design allows it to be implemented in any university setting, regardless of technological infrastructure, making it possible to generate meaningful analyses using existing institutional data.

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# **Sustainable accounting education at the university of Cundinamarca, Facatativá campus: a competency perspective from auditing**

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## **Introduction**

Climate change has demonstrated progressive environmental deterioration, reflected in the alteration of ecosystems and the increase in extreme weather phenomena. Despite governmental policies aimed at mitigating pollution impacts and promoting sustainable development, environmental indicators continue to show concerning trends. In this context, the National Development Plan 2022-2026: Colombia, World Life Power, emphasizes a territorial approach to understanding economic, social, and cultural dynamics. Accounting education for life is of crucial importance for society and the country's development, as it represents the National Government's commitment to environmental protection and actions guaranteeing organizational social responsibility, increasingly concerning due to the evident effects of climate change and its repercussions on the economy, society, and territorial sustainability. Professional practice has been based on criteria that distance it from knowledge development, generating a dichotomy between theory and practice, resulting from a lack of training in specific competencies that allow for the incorporation and communication of social representations influencing community development.

## Conceptual, theoretical, and normative framework

The National Development Plan 2022–2026 (Colombia, World Life Power) redefines sustainability as a systemic imperative, emphasizing the interdependence between economic development and environmental resilience. It advocates for productive diversification based on biodiversity, innovation, and territorial responsibility, urging accounting to reflect ecological systems rather than merely economic transactions.

Colombian environmental policy frameworks—such as the National Policy on Cleaner Production (1997), Law 1124 of 2007, and Decree 1299 of 2008—mandate organizational accountability through environmental management systems, life-cycle analysis, and pollution control. These norms establish the foundation for integrating sustainability into corporate governance and financial reporting.

The National Policy on Sustainable Production and Consumption (2010) and the Green Growth Policy (CONPES 3934) promote value creation through standardized processes, risk mitigation, and sustainable innovation. However, the country faces challenges in waste management, with only 17% of solid waste recycled, compared to 67% in European nations (Ferronato & Torretta, 2019), highlighting the urgency for improved environmental accounting and performance metrics.

## Previous Research

In coherence with the discourse of the discipline as a social science, authors such as Franco (1998) state: "Rethinking the theoretical reflections of INTEGRAL ACCOUNTING became a necessity, it forces us to reconsider many concepts, (...) the traditional accounting discourse exchanged regulation for standardization, technique for science, knowing for doing, and covered it with an argumentative wrapper that made it seem like science, standardization, and technology." (p. 13) Among the many enigmas of accounting research, which the author himself points out, are the community, and within it, identity with the territory (soil, water, atmosphere, flora, and fauna), and culture, incorporating the concept of social patrimony, recognizing the existence of goods that satisfy social needs rather than private interests. From this, the accounting of social flows is discussed as a system that relates value and physical aspects, where the object of information incorporates the state as an agent of citizen duties and rights, and citizenship itself as the recipient and builder of social organizations and patrimonies, different from traditional financial information (p. 246).

**Audit Quality, Competencies for Sustainability:** The implementation of international financial information auditing standards issued by the IAASB and IFAC made it relevant to address other aspects necessary for strengthening professional work and, consequently, in the training of future public accountants and auditors. The International Education Standards (IES) are issued by the International Federation of Accountants (IFAC), a global organization for the accounting profession founded in 1977. Authors like Alegre and Berbegal-Mirabent (2021) remind us that "The IES for professional accountants prescribe generally accepted good practice standards in training and development programs for professional accountants, hence the importance of incorporating into educational processes the necessary competencies to timely address the challenges imposed by social needs." As DeFond and Zhang (2014) states, "there is a consensus to understand that audit quality is related to the simultaneous presence of the auditor's competence and independence" (p.2). Audit quality contributes elements of trust in financial statements and capital providers, as well as in the decisions made by other stakeholders. On the other hand, Minutti-Meza (2013) refers to the necessary experience and specialization or lack thereof of the auditor in the sector being audited. He indicates that "there are conceptual and econometric problems associated with the use of market share within the audit industry as a proxy for experience" (p. 809).

Results are structured across three dimensions: bibliographic synthesis, expert interviews, and curricular analysis. Each component contributes to a comprehensive understanding of how sustainability principles—particularly those aligned with ESG frameworks and IFRS S1/S2—are being conceptualized, operationalized, and taught within Public Accounting programs. The findings reveal critical gaps in normative alignment, interdisciplinary integration, and academic depth, underscoring the urgency for curricular reform and professional reorientation in response to global sustainability standards.

### **Bibliographic analysis**

The bibliographic records showed a conceptual and methodological evolution around sustainable accounting, from introductory approaches to normative and applied proposals (Table 1). Three main lines are identified:

**Basic and educational accounting:** Texts such as "Accounting for Dummies" and "Introduction to Accounting" seek to democratize accounting knowledge, with an emphasis on decision-making and social responsibility.

Environmental and sustainable accounting: Works such as "Environmental Accounting," "Sustainable Accounting," and "Green Accounting" address the link between accounting, business ethics, and sustainability, highlighting the role of ESG reports and carbon accounting.

International standards and accounting harmonization: Texts such as "Accounting Standards in the EU" and "Comparative Accounting" analyze the adoption of IFRS and their impact on financial transparency and professional training.

**Table 1: Summary Table of Bibliographic Analysis**

| Analysis Category    | Subcategory                 | Code | Analytical (summarized)                                                                               | Observations |
|----------------------|-----------------------------|------|-------------------------------------------------------------------------------------------------------|--------------|
| Thematic Focus       | Basic Accounting            | CTB  | Introductory texts facilitating access to accounting knowledge for non-specialized audiences.         |              |
|                      | Environmental Accounting    | CTA  | Address the ecological and social impact of accounting practices, promoting corporate responsibility. |              |
|                      | Sustainable Accounting      | CTS  | Integrate global trends such as ESG, integrated reports, and carbon accounting.                       |              |
|                      | International Standards     | CNI  | Analyze accounting harmonization in the EU and Latin America, highlighting the role of IFRS.          |              |
|                      | ESG Accounting Planning     | PCE  | Propose practical guidelines for integrating sustainability into accounting and financial planning.   |              |
| Research Methodology | Systematic Review           | MRS  | Systematize academic literature to identify trends and gaps in sustainable accounting.                |              |
|                      | Case Study                  | MEC  | Apply contextualized analysis in real organizations, especially in Mexico and Latin America.          |              |
|                      | Technical/Documentary Essay | MET  | Normative and conceptual reflections on the transformative role of accounting.                        |              |

## Expert Interview Analysis

Sustainability is already integrated into international accounting standards, but not always in university curricula. The lack of interdisciplinary training leads to a disarticulation between technical and accounting areas, limiting the capacity to respond to environmental risks. The teaching of environmental accounting must go beyond reporting, incorporating governance, financial planning, and scenario analysis. Universities have a duty to train accountants with ethical, critical, and strategic capacities, capable of facing the economic challenges derived from climate change and global regulatory pressure. Table 2 shows an analytical synthesis.

**Table 2:** *Qualitative Analysis Matrix - University Education in Sustainable Accounting*

| Analysis Category                  | Subcategory                                        | Interview Fragment / Textual Quote                                                                                                                                                            | Analytical Observations                                                                                                                                                                                                               |
|------------------------------------|----------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Importance of University Education | Relationship between sustainability and accounting | "...IFRS are governed in terms of risks and opportunities... financially accounting for those risks and opportunities... how much it cost and how it is reflected in the accounting books..." | It is evident that sustainability is already part of international accounting frameworks. Therefore, its teaching in universities is key for professionals to understand how to translate environmental impacts into financial terms. |
|                                    | Difference between control and quality management  | "...control is linked to compliance with the standard... management is linked to risks and opportunities... depending on financial materiality..."                                            | The conceptual distinction between control and quality management demands that academic programs train accountants capable of interpreting financial materiality from an environmental                                                |

|                                                            |                                             |                                                                                                                                       |                                                                                                                                                                                                                                   |
|------------------------------------------------------------|---------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                            |                                             |                                                                                                                                       | perspective, something not achieved without specialized training.                                                                                                                                                                 |
| <b>Professional Challenges derived from Sustainability</b> | Disarticulation between areas               | "...environmental teams don't know if a flood affects financially... financial teams don't know how to read future risks..."          | A training gap between disciplines is revealed. Universities must foster interdisciplinary competencies so that accountants understand environmental variables and collaborate with technical areas in strategic decision-making. |
|                                                            | Need for training in sustainable governance | "...the first thing is governance... that the Board of Directors understands that it's not just reporting, but financial planning..." | Sustainable accounting cannot be taught as an isolated module.                                                                                                                                                                    |

## Academic Plans Analysis

Environmental accounting in Colombian Public Accounting programs exhibits three dominant curricular trends: (1) disciplinary formalization through credit-bearing subjects (e.g., UDCA, UNAD, Central, Luis Amigó), enabling technical training; (2) ethical-transversal integration without formal modules (e.g., Javeriana, El Bosque, Santo Tomás), limiting depth; and (3) proposals under review or elective formats (e.g., Univalle, La Gran Colombia, UCEVA), reflecting institutional intent but lacking consolidation. A regional asymmetry persists, with stronger curricular structuring in Bogotá and Antioquia, and emerging efforts in Valle del Cauca. The average academic load (2–3 credits) remains insufficient to develop competencies aligned with international standards such as GRI, SASB, and IFRS S1/S2. Table 3 summarizes the analysis of some academic plans of different universities offering the public accounting program.

**Table 3:** *Universities with a Public Accounting program*

| Analysis Category          | Subcategory                            | Analytical Observations (summarized)                                                                                  |
|----------------------------|----------------------------------------|-----------------------------------------------------------------------------------------------------------------------|
| <b>Curricular Presence</b> | Formal subject with defined credits    | UDCA, UNAD, Central, and Luis Amigó present specific subjects, strengthening technical training.                      |
|                            | Transversal ethical-formative approach | Javeriana, El Bosque, and Santo Tomás address sustainability from an ethical perspective, without evaluable subjects. |
|                            | Proposal under curricular review       | Univalle and UCEVA show institutional intention, but without consolidation in the curriculum.                         |
|                            | Interdisciplinary elective             | ITM, La Gran Colombia, and UCC offer optional subjects, limiting their formative scope.                               |
| <b>Academic Load</b>       | 2 credits                              | Most subjects have a low hourly load, hindering the development of ESG competencies.                                  |
|                            | 3 credits                              | UDCA, UNAD, and Luis Amigó offer greater technical depth and professional articulation.                               |
| <b>Type of Approach</b>    | Technical disciplinary                 | UDCA, Luis Amigó, and Central link environmental accounting with auditing and financial management.                   |
|                            | Interdisciplinary optional             | Politécnico Jaime Isaza and Tecnológico de Antioquia address sustainability from organizational management.           |
|                            | Ethical-formative institutional        | UDEC, Javeriana, and El Bosque promote sustainable values without curricular formalization.                           |

## Conclusions

The research evidences a progressive evolution in the conceptualization and implementation of sustainable accounting, transitioning from foundational pedagogical approaches to normative frameworks and applied methodologies. The integration of sustainability principles into international accounting standards—particularly those embedded in ESG disclosures and IFRS S1/S2—reinforces the imperative for higher education institutions to recalibrate their curricula. This recalibration must ensure that future professionals are equipped with the analytical competencies required to identify, measure, and report environmental, social, and governance-related risks and opportunities with financial materiality and strategic relevance. The empirical findings resonate with global academic discourse on the transformative role of sustainability in accounting education. As Gray (2010) asserts, accounting for sustainability must evolve beyond compliance-based reporting to encompass a systemic redefinition of organizational accountability, stakeholder engagement, and long-term value creation. This perspective challenges traditional accounting paradigms and demands a pedagogical shift toward interdisciplinary, ethics-driven, and impact-oriented learning models.



In the Colombian context, the study reveals a marked regional asymmetry in the curricular incorporation of sustainable accounting. Institutions in Bogotá and Antioquia demonstrate more advanced formalization through dedicated subjects and credit-bearing modules, whereas other regions exhibit incipient or fragmented integration, often limited to transversal ethical discourses or elective offerings. The prevailing academic load—typically ranging from 2 to 3 credits—is insufficient to foster the depth of technical, normative, and applied competencies required to engage with global standards such as GRI, SASB, and IFRS S1/S2. This underscores the urgency for institutional reform that aligns accounting education with the demands of sustainability governance and international regulatory convergence.

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# Challenges and opportunities for university management in response to generative AI disruption in Mexico

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This study is set within the framework of the research project 20250609, ESCA-S.T., "Uses of artificial intelligence in higher education" of the National Polytechnic Institute.

## Introduction

Generative artificial intelligence is one of the most controversial global challenges higher education, both in institutions and in the university community itself. According to UNESCO (2024), "Generative AI (GenAI) is an artificial intelligence (AI) technology that automatically generates content in response to written instructions in natural language using conversational interfaces (prompts)" (p. 8). Its integration into higher education remains a pressing issue for governments, but especially for higher education institutions (HEIs) management.

The methodological framework of this study was grounded in a qualitative, exploratory, and descriptive approach. Data were collected through a field study that comprised 744 surveys administered via Google forms to students from three public higher education institutions in Mexico, complemented by four in-depth interviews with institutional administrators. Subsequently, the analysis was conducted by structuring analytical categories and performing cross-tabulations of the variables. ChatGPT was employed as a supporting tool for transcription and for consolidating frequency data directly associated with the research problem.

## Use of GenAI in Mexican higher education

Regarding to previous research, at the National Autonomous University of Mexico, Benavides-Lara et al. (2025) note that "students use generative AI more frequently than academic staff, especially to look for information and to support academic activities" (p. 26), underscoring the gap in utilization and exploitation of this tool. Institutional strategies for teachers' training and ethical regulation are urgently needed. Silgado-Tuñón and López-Flores (2025) identify six key categories in recent academic production: "pedagogical impact, teacher and student perceptions, ethical dilemmas, and specific applications" (p. 7). From conceptual and critical levels, other sources have emphasized the tensions between the transformative potential of these tools and the associated risks. Sánchez Mendiola & Carbajal Degante (2023) warns that "Generative artificial intelligence offers important pedagogical potential, but its effective integration depends on the critical evaluation of its limitations and risks" (p. 4). Drawing on Vygotsky's notion of sign, the use of cultural tools like GenAI is not neutral; they can foster autonomy or submission depending on the social practices in which they are imbedded. The use of GenAI in Mexican higher education is thus a complex and multidimensional phenomenon, combining innovative potential with ethical challenges, demanding articulated institutional responses tailored to the national context.

In this context, the Institute for the Future of Education at ITESM (2024) lists the institutions that have generated regulatory frameworks to address ethical challenges in the use of GenAI: UNESCO Ethics AI (2020), UNESCO Education & AI (2021), Beijing Consensus, OECD (2021), European Commission (2019), European Parliament Report AI Education (2021), UNICEF (2021) and World Economic Forum (2019). The international organizations mentioned, along with the documents that have been generated, state that institutions do not have a regulatory framework, decision-making support, or informed actions for regulation and use (ITESM, 2024).

## Context overview

In Mexico, the regulation of GenAI in higher education remains limited, with national regulations lagging behind. This study focuses on three Mexican educational institutions, two state supported universities with autonomy: the University of Colima (UCOL), located in the state of Colima, the Universidad Veracruzana (UV), based in Veracruz and the National Polytechnic Institute (IPN), settled in Mexico City.

The sample was non-probabilistic one and, therefore, it lacks representativeness for generalization. In the survey, based on a general

invitation, 744 students agreed to participate voluntarily: 50.7% of them were men, 47.4% women and 1.9% did not specify sex, as shown in Table 1.

**Table 1.** *Sample size by sex.*

| Sex          | Frequency  | Percentage |
|--------------|------------|------------|
| Men          | 377        | 50.7       |
| Women        | 353        | 47.4       |
| Unspecified  | 14         | 1.9        |
| <b>TOTAL</b> | <b>744</b> | <b>100</b> |

Making a distinction by educational institution, 545 students (73.1%) study at the IPN, 140 (18.8%) belong to UCoL and 60 (8%) to the Universidad Veracruzana (UV).

By area of knowledge, Table 2 shows the number of students who answered the survey, with the responses in the areas of engineering and social sciences standing out.

**Table 2.** *Sample size by area of knowledge of students' careers.*

| Areas of knowledge                      | Student Sample | Percentages |
|-----------------------------------------|----------------|-------------|
| Engineering                             | 347            | 46.5        |
| Social sciences                         | 332            | 44.6        |
| Physics, Mathematics and Earth Sciences | 42             | 5.6         |
| Humanities and behavioural sciences     | 15             | 2.1         |
| Medicine and health sciences            | 8              | 1.1         |
| <b>Total</b>                            | <b>744</b>     | <b>100</b>  |

Although the sample is not representative and has different sizes in some areas, it nevertheless offers an indicative view of some characteristics of educational use of the GenAI in students.

## **Educational use of the GenAI**

In addition to the data above, Table 3 shows a significant proportion (74.2%) of general students' use of GenAI out of the total number of students who responded to the survey. By sex, 78.6% of men use the GenAI, while 69.7% of women do that along with 6.4% who did not specify their sex.

**Table 3.** *Educational use of GenAI by sex.*

| Sex          | Sample     | Uses GenAI | Percentage  |
|--------------|------------|------------|-------------|
| Men          | 377        | 297        | 78.6        |
| Women        | 353        | 246        | 69.7        |
| Unspecified  | 14         | 9          | 6.4         |
| <b>TOTAL</b> | <b>744</b> | <b>552</b> | <b>74.2</b> |

By educational institution, despite the heterogeneous sizes of the samples, they indicate heterogeneous proportions of use of the GenAI. Namely, the UCoL stands out with 92.1% of students who use it, followed by the UV with 76.7% and, finally, the IPN with 69.2%, as shown in Table 4.

**Table 4.** *Educational use of the GenAI by educational institution.*

| Institution  | Sample     | Uses GenAI | Percentage  |
|--------------|------------|------------|-------------|
| UCoL         | 140        | 129        | 92.1        |
| UV           | 60         | 46         | 76.7        |
| IPN          | 544        | 377        | 69.2        |
| <b>TOTAL</b> | <b>744</b> | <b>552</b> | <b>74.2</b> |

By area of knowledge, Table 5 also shows heterogeneous percentages in the use of GenAI, namely, 91.1% of Engineering students, 87.5% of Medicine and Health Sciences students, 81% of Physics, Mathematics and Earth Sciences students, 66.7% of Humanities and Behavioural Sciences students and, finally, 55.6% of Social Sciences students.

**Table 5.** *Use of the GenAI by area of knowledge.*

| Areas of knowledge                      | Student Sample | They use GenAI | Percentages |
|-----------------------------------------|----------------|----------------|-------------|
| Engineering                             | 347            | 316            | 91.1        |
| Medicine and health sciences            | 8              | 7              | 87.5        |
| Physics, Mathematics and Earth Sciences | 42             | 34             | 81.0        |
| Humanities and behavioural sciences     | 15             | 10             | 66.7        |
| Social sciences                         | 332            | 185            | 55.6        |
| <b>TOTAL</b>                            | <b>744</b>     | <b>552</b>     | <b>74.2</b> |

In a more detailed analysis by sex, two areas of knowledge stand out in the educational use of GenAI. The above data suggest the predominant male tendency over female to enrol in engineering, in contrast to the female tendency over male to enrol in social sciences.

Even more, if the weekly frequencies of use are added, the percentage increases to 77%, which shows a frequent student practice of educational use of GenAI. Students primarily accessed GenAI on their own initiative (68.8%), to a lesser degree on the recommendation of a friend (21.6%) and with limited influence of teachers (9.6%).

Another point to consider is the granting of credits in the use of the GenAI in the student's academic work. In this regard, a notable percentage (43.7%) of students usually cite according to the accepted guidelines in academic works (APA, MLA, etc.) or do so without formal citations (6.7%). However, there is no small percentage of students (35.3%) who omit to give credit to the sources of information, or the content obtained with the use of GenAI, which shows a practice that is at odds with academic integrity or indicates the lack of training on the use of references from the sources from which the information is extracted. It also shows the absence, ignorance or lack of application of institutional guidelines or regulations on their use. In fact, 73.7% of students reported a lack of training for GenAI use, and 90.8% do not apply or are unaware (59.2%) of any guide, directive, regulation or guideline that explains the ethical and academic use of the GenAI.

Regarding inclusion and sustainable development in relation to the use of GenAI, students show little knowledge and awareness. Only 22 students (3%) stated that they were aware that the educational use of GenAI influences environmental deterioration and could contribute to educational inclusion.

## **Advantages and disadvantages in the educational use of GenAI**

Students identified five key advantages of GenAI use.

1. Data access or collection (111 mentions)
2. Time saving or management (83 mentions)
3. Inspiration or support for creativity (60 mentions)
4. Completion of academic tasks (27 mentions)
5. Speed in obtaining responses to requests (25 mentions)

However, five key disadvantages were also pointed out.

1. Obtaining incorrect or unreliable data (127 mentions)
2. Risk of technological dependence (41 mentions)
3. Obtaining information from unverified sources (21 mentions)
4. Errors or inaccuracies in the results obtained (20 mentions)
5. Obtaining responses generated without critical analysis (18 mentions)

Students also pointed out the abuses while working with GenAI, among which the following five stand out:

1. Prepare academic tasks by copying without understanding the information provided by the GenAI (70 mentions)
2. Simulate self-knowledge when taking assessments (60 mentions)
3. Inappropriate use or plagiarism of information in academic papers (47 mentions)
4. Lack of self-reflection in academic activities (40 mentions)
5. Total replacement of individual effort (27 mentions)

Therefore, it is understandable that students highlight four challenges faced by their educational institutions for an ethical and academic use GenAI, namely:

1. Train teachers for ethical and academic educational use
2. Institutionally, promote the responsible and ethical use
3. Prepare students for the responsible use

Adapt curricula and syllabus for the academic use

## **Headmasters perspectives**

Irruption by the arrival of GenAI represents the beginning of a new era in management in Mexico, since it challenges the traditional management structures, teaching and institutional infrastructure. Based on the analysis of interviews with headmasters of the UCol, the IPN and the UV, common challenges are identified, such as the urgent need for regulatory guidelines, the limited technological infrastructure and the scarce training of academic and administrative staff. Although progress is recognized such as the development of the first institutional guidelines in this regard, as well as the inclusion of GenAI in some educational and administrative processes, institutional resistance and slow policy integration persist.

The interviewees agree that management must lead to an urgent adaptation process, not only through access to advanced platforms, but also through the ethical, pedagogical and technical strengthening of the university ecosystem. From the institutional point of view, there are very polarized views among teachers about the educational use of the GenAI in contrast to the wide acceptance and use of the students, which reflects the coexistence of digital divides tinged with technophobic and technophilic attitudes.

However, far from considering GenAI as a threat, managers believe that it should be understood as a strategic ally to fulfil its social function, thus triggering management processes to be much more agile and innovative.



The results of the interviews reveal both commonalities and contrasts among university directors: at the UCOL, emphasis is placed on training and individual responsibility in the use of AI; at the IPN, Education 4.0 is being promoted despite certain generational resistances; and at the UV, attention is drawn to technological and managerial gaps in the face of the rapid pace of change. This comparative analysis makes it possible to enrich the findings and move beyond the generality of the results by highlighting contextual nuances that distinguish each case. At the same time, contrasting these results with bibliographic references on educational management and the adoption of disruptive technologies strengthens the validity of the study, providing a conceptual framework that underscores the importance of clear institutional policies, faculty training, and infrastructure updates for the effective integration of generative artificial intelligence in higher education.

### **Cluster analysis: GenAI trends in higher education**

The emerging trends of GenAI in education in Mexico, in agreement with the Horizon 2025 Report (Robert, et al, 2025) identified in this research, can be summarized as follows:

Accelerated development of digital tools, driven by the professional expectations of students and the increasingly demanding labour market; it highlights that technology is changing students' cognition.

Governance of the GenAI that allows participatory, democratic and inclusive regulation for the efficient and ethical use in the training processes of students and in the development of teachers.

Strengthening of new modalities for teaching and learning, especially in higher education that is moving towards hybrid proposals that require the use of digital technologies, notably GenAI. This shows the interest in continuing with the design of inclusive learning environments. Creation of learning networks supported by GenAI to promote international cooperation between institutions, developing joint projects. Automation of the administrative and management process with systematization of data and patterns that will allow managers to better understand the behaviour of their institution and make better decisions. In this context, management is assumed as an area of opportunity to transform institutional practices from the pedagogical, technological and social spheres.

## Conclusions

Statistical data show a significant educational use of GenAI among students, although unequal by institution, by sex and by area of knowledge. Students use GenAI, usually on their own, without prior training or knowledge or guides or guidelines for its ethical and responsible use. There is little influence from teachers to recommend the educational use of this tool to their students, which shows not only the existence of a digital gap but also the low presence of it in teachers' methods. Students are aware of the advantages, disadvantages and risks that challenge managers to promote an ethical and responsible use of IAGen. This demands the design and application of institutional policies, along with teachers' and students' training; as well as the adaptation of curricula and syllabuses to new modalities such as hybrids, an emerging weight trend in higher education. In this context, the inclusion of GenAI in management is assumed as an area of opportunity to transform institutional practices in the pedagogical, technological and social fields.

Additionally, it is important to note that the results reflect not only the technological but also the social and pedagogical dimensions involved in GenAI integration. The data reveal persistent disparities among institutions and fields of knowledge, suggesting the need for context-sensitive policies that recognize local differences while aiming for common ethical standards. Moreover, the findings indicate the urgency of developing institutional cultures that encourage critical reflection, continuous training and open dialogue among stakeholders. This requires management practices that are not limited to technological adoption but include ethical deliberation, curricular adaptation and collaborative governance structures.

Another relevant conclusion is the recognition of students as active agents who, despite limited institutional support, have appropriated GenAI tools in creative and self-directed ways. This calls for management strategies that value student perspectives, promoting participatory approaches in policy design and implementation. Finally, the research highlights that the effective incorporation of GenAI in higher education management is not a purely technical task, but a complex transformation that demands coordinated efforts across administrative, academic and technological domains. This transformation should be guided by principles of inclusion, equity and sustainability to ensure that GenAI becomes a meaningful ally in fulfilling the social mission of higher education institutions.

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# The network society and the pedagogy of cyberspace: a systematic review

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## Introduction

Spanish sociologist Manuel Castells has developed the concept of the "network society" to describe the new social structure of the Information Age, which is based on networks of production, power, and experience. This definition leads us to understand the network society as a constantly evolving environment in which changes in perceptions, attitudes, and everyday behaviors influence and are influenced by society as a whole. As a result, citizens, organizations, and markets play a fundamental role in promoting collective changes that can be both rapid and unpredictable (Uriarte & Acevedo, 2018).

To address this new social paradigm, it is important to understand the main characteristics of networks, their basic structure, and how they connect and operate through ICTs. However, the problem is that there is no widespread consensus on the definition of networks. Nevertheless, Rissoan (2016) conceptualizes social networks as "a means of consolidating, reestablishing, and creating relationships with other people and interacting with them through virtual messaging" (p. 34).

Virtual social networks increasingly have their own functionalities that are more similar to other social media in order to meet user expectations: games, classified ads, photo management, videos, among others. Their connection logic is significantly changing the way production processes operate and are carried out, as well as the experience of knowledge, power, and culture. As mentioned above, the networked society is a dynamic and open system that has the capacity to evolve and expand.

Given the social landscape created by the digital revolution of the Web and the expansion of various social networks and virtual communities, it is increasingly common to use these tools continuously to find out about news, participate in commercial activities, receive information, establish contacts, play games, work collaboratively, and share personal interests. As a result, the environment in which people operate has undergone radical changes in the way they communicate, and this phenomenon has also affected the field of education (Malpica Capacho, 2020).

The influence of social media has also reached the educational sphere, and educators claim that it can be beneficial in promoting dialogue and participation. Experts also point out that educational social media represents a new way of understanding learning, aimed at different ages and stages of education. It is therefore essential that educational institutions are aware of and use these tools so that students can take advantage of them for their education and personal development.

However, other education professionals believe that educational social networks can be addictive for teenagers and children. Some teachers are reluctant to implement them in their teaching system due to a lack of training in this area and a lack of technological resources in classrooms (Jiménez, 2023).

The author states that there are various factors in people that falsely facilitate "the perception of addiction to social networks as a result of these networks themselves," a hypothesis that is debunked when analyzing these individuals and finding that they have problems with self-esteem, family dysfunction, and a need for peer approval, which coincides with studies conducted by Gutiérrez Solares & Sánchez Olivares (2021), which conclude that being male and adolescent is associated with social media addiction, low self-esteem, and poor social skills are assumed to be causes of this addiction, and among the main consequences are low academic performance and problems with partners and family.

It is necessary to adapt to technological changes and promote the appropriate use of digital tools to enrich learning. In this way, we can promote a more inclusive and diverse education, capable of adapting to the needs of students in an increasingly connected environment. For the reasons outlined above, the objective of this essay is to conduct a systematic review of the Network Society and Cyberspace Pedagogy and its didactics as content, as a technological tool, and as a means of teaching.

A systematic review was conducted to answer the research question: What will be the impact of social media use on the teaching-learning process from the perspective of cyberpedagogy? The steps for developing the work began with searching for and compiling sources of information, reading the sources found, and classifying the articles, methodologies, and reference frameworks (Calderón Villafáñez et al., 2016). The search for sources was carried out in two stages: 1) a review of the literature using a traditional strategy, and 2) a systematic review of the literature. Each of the stages is described below:

This review was conducted following the steps indicated in Table 1, described below:

**Table 1.** *Methodology for reviewing the state of the art based on Arnau Sabatés & Sala Roca (2020)*

| Steps               |                                           | Description of the action                                                                                                                                                                                                                                                                                                                                                             |
|---------------------|-------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Design              | the search for the search                 | The basic questions for the search were chosen: Which fields of inquiry are related to the research topic? Which contents or topics have been defined as priorities? The databases to be consulted were selected: Google Scholar, Scopus, Microsoft Academic. The search was focused according to the descriptors A= social networks, B= digital tools, C= virtual teaching-learning. |
| Identify literature | and select the relevant                   | Considering the descriptors A, B, C are identified and selected 30 articles relevant to the study.                                                                                                                                                                                                                                                                                    |
| Store results       | and record the search                     | The results obtained during the search were recorded in a bibliographic matrix that included the following data: author(s), country, year, title, methodological approach, and disciplinary field.                                                                                                                                                                                    |
| Model               | and organize the selected references      | The selected references were organized in a bibliographic manager: Zotero.                                                                                                                                                                                                                                                                                                            |
| Analyze selected    | and interpret the results of the selected | For the analysis and interpretation of the results, considered the gaps, gaps and contradictions in the knowledge.                                                                                                                                                                                                                                                                    |

Source: Taken from Arnau Sabatés & Sala Roca (2020) Stage 2: Systematic literature review (SLR)

The second stage of the search involved a systematic literature review, which was a descriptive and exploratory process to highlight how research is conducted in the area in which the study is being carried out. For this second literature review, the methodology described in (Okoli, 2015) was followed, the steps of which are detailed below:

As a result of the two search stages, a total of 35 articles were obtained that contribute to the state of the art of research. In the first stage, a total of 30 articles were obtained, and in the second stage, a total of 5 articles were

obtained. These articles present quantitative, qualitative, and mixed approaches, for a total of 35 articles that address key terms such as: Network Society, Cyberspace, virtual teaching and learning. In terms of the percentage distribution by methodological approach, 25.71% (9 articles) of the documents reviewed have a quantitative approach, while 54.28% (19 articles) correspond to qualitative studies and 20% (7 articles) present a mixed approach, as shown in Figure 2. When classifying the articles by year of publication, the trend is in 2021, see Figure 3. In terms of theoretical perspectives, 34.28% of the articles reviewed consider networked learning as a socio-educational perspective adopted in cyberspace pedagogy.

A hermeneutic phase was carried out through the reading, analysis, interpretation, correlation, and classification of information, according to the degree of interest and necessity for the research. To this end, two stages proposed by Londoño Palacio (2016) were followed: interpretation, which consists of analyzing the documents by subject area (SA), and theoretical construction, which involves reviewing and interpreting core themes.

### **Stage 1: Interpretation**

From the review and analysis of each of the articles, three thematic areas (TA) emerged that allowed us to establish the state-of-the-art approach. These areas are listed below with the percentage of articles reviewed:

TA1. Social networks: impact on the teaching-learning process (37.14%) TA2. Cyberpedagogy in 21st-century education (25.71%)

TA3. Technological and pedagogical strategies from the digital transformation of education (37.14%)

### **Stage 2: Theoretical construction**

In this stage, a review and interpretation by subject area was carried out, allowing for a general analysis of each one. In the literature, studies related to education, sociology, and communication can be found that highlight the links between networked society and the educational process. Research has also been conducted linking computer engineering education to topics aligned with technological and pedagogical strategies that promote innovation and educational transformation through the use of virtual platforms. This has generated a reflective process on the impact of technology-mediated learning in educational environments. Below are some topics that emerged from the theoretical construction of the reviewed articles, which will provide a more detailed understanding of the direction of this study.

## **AT1. Social networks: impact on the teaching-learning process**

In the context of higher education universities, Robles Vega (2022) states that the use of social media has facilitated communication and collaborative learning. It has introduced new ways of working between teachers and students in the teaching-learning processes. These platforms provide a virtual space where ideas, resources, and experiences can be shared quickly and effectively.

The integration of social media into higher education has created a dynamic and participatory environment that promotes interaction and collaboration among all stakeholders. It also offers access to a vast repository of information and educational content, enriching the teaching process and expanding learning opportunities. According to Dumford et al. (2023), while the use of social media in the university environment can have benefits, there are also associated challenges and concerns. It is important to critically evaluate the impact of social media on students and promote responsible and balanced use of these platforms.

It should be noted that the use of social media in higher education has transformed the way we learn and communicate. These tools provide the ability to connect and share knowledge more quickly and efficiently, promoting creativity, collaboration, and meaningful learning. Casimiro Urcos et al. (2022) comment that students make use of some of these tools, with WhatsApp being the most popular, and that the most widely used social media platforms for academic purposes are WhatsApp, followed by YouTube.

In the context of networked society, it is essential to recognize and value the learning opportunities that arise. González Sanmamed et al. (2021) point out that this involves considering the interaction between people and technology, as well as understanding the impact of new tools and forms of communication in the educational field. The different "ecologies" generated by devices, communication, and information have significantly expanded the possibilities for learning and collaboration.

However, Ramírez Hernández (2023) points out that, even though networks have transformed the way we entertain ourselves, obtain information, communicate, and even educate ourselves, they have come to meet the needs of different sectors of society that have access to and knowledge of these digital platforms. Nevertheless, it is important to recognize that the 2020 pandemic exposed the existence of a digital divide between those who are part of this "connected" society and those who are excluded from it.



This divide manifests itself in a lack of access to hardware, such as computers or mobile devices, software, such as applications and programs, and the training necessary to use these digital tools effectively.

Those who do not have access to these resources are excluded from the wide range of opportunities offered by the online world, including access to distance learning, remote employment, and other services. (Mendiguren Galdospin et al., 2023)

It is essential to address this digital divide and work to create equal opportunities for all (Rodríguez-Suárez et al., 2020). This involves implementing policies and programs that guarantee access to the internet and technological devices in disadvantaged communities, as well as training and digital literacy for those who have no previous experience with these tools (Vargas Huanca, 2021). Only through an inclusive and equitable approach can we ensure that all sectors of society can benefit from networks and the potential they offer for entertainment, information, communication, and education. (Ramírez Hernández, 2023) (Ruiz Domínguez & Area Moreira, 2021)

## **AT2. Cyberpedagogy in 21st-century education**

Cyberpedagogy in 21st-century education is a discipline that has emerged in response to technological advances and the need to adapt teaching methods to new digital generations. In this context, it focuses on the strategic use of information and communication technologies in the teaching-learning process.

These digital tools enable the creation of virtual learning environments, in which students can access more diverse and up-to-date educational resources. In addition, cyberpedagogy encourages active student participation, promoting collaboration and teamwork through online platforms. It also highlights the development of digital skills in students, preparing them to face the challenges of today's working world. (Prieto Urgilés et al., 2020)

In this way, it offers new possibilities for enriching the educational process, adapting to the needs and characteristics of students in the digital age. Within the new educational paradigm, the virtual modality stands out, based on the extensive use of Information and Communication Technologies (ICT) and computer science (Barria Huidobro, 2021). This modality translates into a broad network of shared and applied knowledge in various spaces, where participants in the system interact. Virtual education is conceived as an open, flexible, dynamic, **a n d** continuous system, based on a pedagogical approach that promotes autonomous study by students. (Barragán Giraldo, 2020) (Lamoth Soler et al., 2020)

With the help of facilitators, self-directed learning, teamwork in cyberspace, and the creation of academic and interactive processes are encouraged with the support of advanced communication technologies both on and off campus (Garcia Grau et al., 2022). In this new scenario, it is interesting to carefully review the didactics of cyberspace, which fulfills three functions: 1) as content, 2) as a technological tool, and 3) as a means of teaching (Vargas-Murillo, 2020). Currently, the relationship between education and cyberculture is a crucial issue for understanding the different forms of the social and the possibilities for intervention by educational actors. The new subjectivities that move between the virtual and the traditional must show their new forms of knowledge emergence.

In this context, education must reflect on how teachers approach their pedagogical practices, especially with regard to curriculum, teaching, and assessment, among other aspects (Demera-Zambrano et al., 2023).

### **AT3. Technological and pedagogical strategies from the digital transformation of education**

Technological and pedagogical strategies based on digital transformation in education are essential in today's context. These strategies seek to make the most of information and communication technologies in the teaching-learning process (Mono Castañeda, 2023). Through the use of digital tools and online platforms, virtual learning environments are created that promote interactivity, collaboration, and access to up-to-date educational resources. In addition, the development of digital skills in students is encouraged, preparing them for an increasingly technological world of work (Cruz Rodríguez, 2019). From a pedagogical perspective, the aim is to generate meaningful learning experiences, facilitating the personalization and adaptation of content to the individual needs of students. The digital transformation of education also involves rethinking traditional educational models and making room for new innovative methodologies that promote the use of technologies as tools for learning (Demera-Zambrano et al., 2023). Technological and pedagogical strategies from the digital transformation

allow us to maximize the potential of technologies for the benefit of education, creating dynamic and constantly evolving learning environments.

The Human Rights Watch report (2021) highlights this issue significantly, showing that after schools closed, hundreds of millions of students found themselves in an abrupt transition to distance learning, in which physical classrooms were replaced by radios, televisions, cell phones, tablets, and computers. This created an overwhelming dependence and need for

affordable and reliable connectivity, as well as adequate devices that met learning needs and the ability to use these technologies safely and reliably.

This sudden massive shift to online education exposed large gaps in digital literacy among students, parents, and teachers. Those who were unfamiliar with using technology or creating digital content found the transition quite challenging. Likewise, some students with some digital knowledge and access to technology struggled with the risks of spending too much time online without the necessary structure (Human Rights Watch, 2021).

Torrico (2021) highlights data from the United Nations Educational, Scientific and Cultural Organization (UNESCO), which explains that the arrival of COVID-19 affected more than 23 million students and 1.4 million teachers when face-to-face classes were suspended on university campuses throughout Latin America.

The acquisition and development of digital skills are presented as one of the main priorities of the Recovery, Transformation, and Resilience Plan. The green and digital transition is being carried out jointly to boost economic recovery, create quality jobs, modernize the productive model, and strengthen the country's social and territorial cohesion.

In Ecuador, the focus of the Digital Education Agenda ...

is a strategy of the Ministry of Education that establishes guidelines for the inclusion of Information and Communication Technologies, to bring about changes aimed at transformation through the transition from Information and Communication Technologies (ICT) to Learning and Knowledge Technologies (LKT) in conjunction with Technologies for Empowerment and Participation (TEP) as a process of pedagogical innovation (Ministry of Education, 2017, p. 37). Today we live in a digital age where technology has transformed the world,

Although technology is not everything, it plays a crucial role in the changes it drives in society, culture, the economy, values, and education, encouraging the development of new strategies and better learning styles through knowledge management, where teachers have the ability to educate the entire community using multimedia resources. This allows teachers to transcend the teaching of knowledge in a way that was never before possible. (Lamoth Soler et al., 2020)

When pedagogy and technology are combined in a digital context, the results are impressive, ideas multiply, and the educational community is empowered. Today, the influence of digital technologies has become firmly established in our societies. This means learning how to use them properly, putting them at

the service of education, and training an e r citizenry capable of using these tools ethically and responsibly. The Digital Education Agenda (AED) 2021-2025 arises from this need. (Ministry of Education, 2021).

Given the inextricable relationship between today's society and technology, the Digital Education Agenda 2021-2025 aims not only at the acquisition of technological skills and competencies, but also at the development of Digital Citizenship. This involves establishing a digital culture that allows for the competent and responsible use of digital tools, taking into account both the rights and responsibilities of users.

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# Technology and Academic Tutoring at the Autonomous University of Baja California, Mexico: Gained Knowledge Throughout the Pandemic Period

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The present document is based on the Institutional Tutoring Program (ITS), which is overseen by the General Coordination of Student Services and School Management (CGSEGE) of the Autonomous University of Baja California (UABC), Mexico.

## Introduction

The COVID-19 pandemic brought a profound shift in higher education, prompting the Autonomous University of Baja California (UABC) to rapidly adapt its Institutional Tutoring Program (ITS) to digital environments. Consequently, this study, utilizing a quantitative and longitudinal approach, analyzed the variations in tutorial practices within the Faculty of Tourism and Marketing (FTYM) across three key stages: before, during, and after the pandemic. In particular, taking into account a sample of 1,200 students and applying a validated questionnaire with 10 items grouped into three dimensions (communication, academic support, and school management).

In particular, prior to the pandemic, while tutor–student relationships were generally positive, ITS usage and mentoring attendance were moderate. However, during the lockdown, tutor availability declined, yet the use of ITS and virtual interaction increased. On the other hand, in the post-pandemic stage, indicators showed both recovery and even improvements compared to pre-pandemic levels.

The COVID-19 health emergency triggered a paradigmatic shift in higher education. Specifically, at the Autonomous University of Baja California (UABC), the Institutional Tutoring Program (ITS) had to immediately adapt to virtual

environments. Notably, tutoring, understood as an integral strategy for accompanying students throughout their academic journey, faced the challenge of migrating to digital formats while preserving its core elements: communication, academic support, and school management.

### **Academic tutoring and its digital evolution**

Academic tutoring in higher education is a fundamental practice for guiding students through their formative process, directly impacting their retention, performance, and integral development (Araya & Corrales, 2022).

According to Brindley, Blaschke, & Walti (2009), online academic tutoring should foster active interaction between students and academic tutors, creating collaborative, motivational, and individualized support environments.

The health emergency accelerated the digitalization of these processes. Hodges et al. (2020) clearly discern between planned online education and emergency remote teaching.

### **Institutional transformation and tutorial resilience**

The institutional capacity of resilience in crisis scenarios is linked to the ability to adapt organizational structures, teaching methodologies, and academic support models. At UABC, the ITS played a crucial role in coordinating tutoring efforts through a digital platform that facilitates continuous academic follow-up, even during lockdown conditions. Studies by Terrazas-Marín and Solís-Cámara (2022) show how platforms like Moodle, Microsoft Teams, and Zoom helped to restructure tutoring relationships, facilitating synchronous meetings, agile communication, and ongoing feedback. As a result of the pandemic experience, hybrid tutoring has emerged as a promising modality. Meaning that, the combination of face-to-face and virtual interactions, offer flexibility, continuity and personalization of academic support (Salmerón y Gálvez, 2021).

### **Core components of academic tutoring: communication, support, and school management**

Speaking of higher education, academic tutoring is an institutional strategy. This task is generally structured around three interrelated components: effective communication, formative companion throughout the learning process, and personalized educational management.

### **Tutor–Student communication on digital platforms**

When it comes to communication, it's spoken about the link between tutors and students, which allows the building of trust, identifies academic companion

needs and academic management in a timely manner. According to Garrison and Anderson (2003), social presence and frequent interaction are crucial in online learning environments. During the lockdown, communication channels such as email, video calls, and instant messaging became the primary means for maintaining academic and emotional contact (Salinas et al., 2021).

Experiences from several Latin American universities show evidence that clear, empathetic, and two-way dialogues have a positive effect on students' perception of institutional support, especially in contexts marked by uncertainty and social isolation (Cabero-Almenara y Llorente-Cejudo, 2020).

### **Academic and emotional support**

As mentioned, accompaniment involves providing academic, psychological, and motivational guidance throughout the student's entire educational journey. This role became especially important during the pandemic, when the emotional impact of lockdown became evident (such as anxiety over academic performance and the widening digital inequity). According to Pantoja et al. (2022), effective tutorial support promotes self-regulated learning, problem-solving skills, and a sense of belonging within the university environment. In the context of FTYM at UABC, the implementation of the ITS system enabled continuous support through virtual strategies, including synchronous videoconferencing sessions, written feedback, and self-management resources. These efforts helped to sustain students' academic continuity and offered emotional support during a period of heightened vulnerability (Ramírez-Torres & Martín-Galindo, 2024).

### **Personalized academic management**

When speaking of academic management, tutoring refers to the monitoring of both administrative and academic processes, such as course enrollment, academic regularization, and referrals to institutional support services. The digitalization of these processes, although accelerated by the pandemic, was already part of the necessary changes to improve efficiency within universities (Flores y Roig-Vila, 2021). According to López and Martínez (2021), academic management helps students to make more informed and confident decisions, resulting in more efficient educational pathways and reducing the risk of academic underperformance and/or dropout.

The target population consists of undergraduate students from the three academic programs of the Faculty of Tourism and Marketing (FTYM) at UABC. A sample conformed by 1,200 students (600 per semester), the selection used a finite sampling method, considering a 5% margin of error and a 95%

confidence level (Lind et al., 2019). The instrument consisted of 10 Likert-scale items (Strongly Agree, Partially Agree, Partially Disagree, Disagree), organized into three dimensions: communication, academic support, and school management (see Table 1).

**Table 1.** *Structure of the applied research instrument*

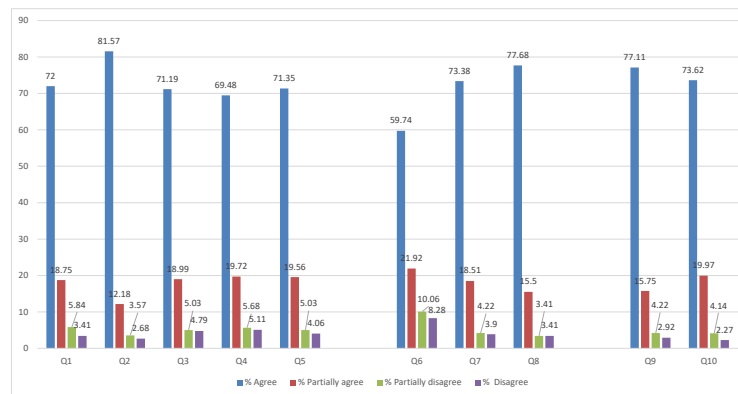
| Dimensions          | #   | Items                                                                                                                                                                         |
|---------------------|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Communication       | Q1  | Do I find my tutor in his/her office in the assigned schedule for tutoring?                                                                                                   |
|                     | Q2  | The relationship with my tutor consists of cordiality and respect?                                                                                                            |
|                     | Q3  | Do I attend the tutoring sessions demanded by my tutor?                                                                                                                       |
|                     | Q4  | Do I promptly provide the information requested in the Institutional Tutoring System (ITS) by my tutor?                                                                       |
|                     | Q5  | Do I continue a follow-up with guidance and referrals suggested by the tutor?                                                                                                 |
| Accompaniment       | Q6  | The tutor explains the basic elements of structure and organization of my study plan?                                                                                         |
|                     | Q7  | The tutor guides me about study programs for my academic journey, such as Academic Tutoring?                                                                                  |
|                     | Q8  | The tutor guides me about support programs for my academic journey, such as Academic and Psychological Orientation, Scholarships, Entrepreneurs program and Student Exchange? |
| Academic management | Q9  | My tutor guides me about Social Service, Professional Internships, Degree Completion Processes, Learning Modalities and Administrative Procedures?                            |
|                     | Q10 | ITS its a tool which allows me to organize my Academic and Professional Project?                                                                                              |

Source: Elaborated by the authors based on ITS (2024)

Data collection was carried out through an online questionnaire, validated by the General Coordination of Student Services and Academic Management (CGSEGE) and applied via the ITS platform. In the pre-pandemic phase (2019), the communication dimension showed that 75.73% of students agreed with the accessibility of their tutor, the cordiality of the relationship, and clarity of interaction, showing a positive perception of tutor availability and interpersonal dynamics. However, attendance at in-person tutoring sessions (59.74%), and the use of ITS to provide solicited information (73.62%), indicating room for

improvement. Regarding the academic support dimension, 72.71% of responses agreed with the guidance received on topics such as academic orientation, study plans and class enrollments, however there was a portion of answers with a Partially Agree response 18.08%. Regarding the Academic Management dimension, 77.11% of students reported Agreeing with the information provided for carrying out administrative procedures, while 19.97% responded that they Partially Agree.

**Graphic 1.** Pre-pandemic stage (2019)



Source: Elaborated by the authors based on ITS (2024)

During the confinement period, a moderate and sustained downward trend was observed in six of the ten evaluated items. Between them, it catches the attention of the students' perception of tutor cordiality, it presents a downward of 4.11%, as well as tutor availability which declines 3.44%. In 2020, the implementation of support activities was reported at 74.11%; however, over the course of 2021 and the first half of 2022, this figure showed a decline of 3.10%. On the other hand, access to the ITS platform showed to have increased by 5.96%, and the perceived helpfulness of the ITS for planning academic projects remained stable, only with a slight decline after reaching its peak in 2021 (see table 2).

**Table 2.** Confinement stage (2020/2022-1)

| # Item | 2020  |       | 2021  |       | 2022-1 |       |
|--------|-------|-------|-------|-------|--------|-------|
|        | % DA  | % PA  | % DA  | % PA  | % DA   | % PA  |
| Q1     | 69.17 | 22.75 | 69.27 | 19.78 | 65.83  | 23.53 |
| Q2     | 83.1  | 12.7  | 81.41 | 13.56 | 78.99  | 16.11 |
| Q3     | 69.99 | 20.69 | 68.62 | 18.77 | 63.59  | 21.85 |
| Q4     | 70.07 | 21.1  | 68.74 | 18.35 | 64.29  | 21.99 |

|     |       |       |       |       |       |       |
|-----|-------|-------|-------|-------|-------|-------|
| Q5  | 72.46 | 20.2  | 69.69 | 18.47 | 67.09 | 20.17 |
| Q6  | 56.47 | 26.22 | 60.33 | 22.32 | 58.12 | 24.23 |
| Q7  | 74.11 | 19.79 | 73.65 | 17.41 | 71.01 | 18.21 |
| Q8  | 78.81 | 16.41 | 78.51 | 15.28 | 76.75 | 15.27 |
| Q9  | 79.47 | 15.66 | 84.01 | 12.2  | 85.43 | 11.62 |
| Q10 | 74.28 | 20.28 | 78.57 | 16.58 | 78.01 | 16.67 |

Source: Elaborated by the authors (2024)

# Itm: Question number included in the research instrument.

% DA: Percentage of Agree responses.

% PA: Percentage of Partially Agree responses.

During the return to in-person learning phase, corresponding to the 2022-2 period, a significant recovery was observed, with response levels similar to or even higher than those registered before the pandemic. Moreover, a cordial relationship with the tutor reached 86.04%, while attendance at tutoring sessions demanded by the tutor stood at 79.12% (see Table 3)

**Table 3.** *Return to in-person learning phase (2022-2/2024)*

| # Item | 2022-1 |       | 2023  |        | 2024  |       |
|--------|--------|-------|-------|--------|-------|-------|
|        | % DA   | % PA  | % DA  | % PA   | % DA  | % PA  |
| Q1     | 73.54  | 18.22 | 67.09 | 21.34  | 72.07 | 17.99 |
| Q2     | 86.04  | 9.57  | 81.14 | 13.15  | 81.24 | 11.79 |
| Q3     | 79.12  | 14.23 | 73.78 | 16.45  | 74.93 | 14.77 |
| Q4     | 76.06  | 16.49 | 71.53 | 18.48  | 74.33 | 15.72 |
| Q5     | 77.39  | 16.76 | 72.88 | 17.88  | 73.62 | 15.96 |
| Q6     | 71.28  | 14.89 | 66.34 | 16.6   | 69.68 | 15.6  |
| Q7     | 70.61  | 16.62 | 66.49 | 18.26  | 70.34 | 16.14 |
| Q8     | 62.1   | 21.21 | 58.04 | 21.675 | 61.82 | 20.17 |
| Q9     | 65.39  | 17.98 | 59.71 | 20.36  | 64.50 | 18.22 |
| Q10    | 76.99  | 16.89 | 70.02 | 20.74  | 73.38 | 17.09 |

Source: Elaborated by the authors (2024)

# Itm: Question number included in the research instrument.

% DA: Percentage of Agree responses.

% PA: Percentage of Partially Agree responses.

The accompaniment dimension shows a downward trend in 2023 (70.20%), with a slight recovery of 1.48% in 2024. Regarding the academic management dimension, the lowest approval levels were recorded; although it improved by 2.25% in 2024.

## Conclusion

As a result, academic tutoring at FTYM of UABC demonstrated remarkable operational and pedagogical resilience in the face of the pandemic cycle. Far from being weakened, the ITS adapted, expanded, and strengthened its role through virtual, hybrid, and in-person modalities, maintaining its relevance as a strategic tool for student permanence and academic success. During lockdown, although there were declines in the perception of accessibility and accompaniment, ITS's assessment and functionality increased, particularly in 2021 and 2022-1. The communication dimension remains the most robust across all the stages analyzed. Equally important, a cordial and respectful relationship with the tutor, along with consistent communication, played an important role in sustaining a positive perception of the program, even under adverse conditions. In 2022-2, the item on cordiality reached 86.04% of "Agree" responses, and in 2024 it remained high at 81.24%, being the highest values in the entire series.

Although academic accompaniment showed stable results, this dimension put into focus a decline during 2023, followed by a recovery in 2024. Academic guidance regarding study plans, mentoring, and support programs needs to be clearer, more profound, and sustained. The average percentage of "Agree" responses in this dimension dropped to 70.20% in 2023 and rose to 72.58% in 2024 (still below the 74.89% recorded in 2022-2). Regarding the academic management dimension, it registers the lowest satisfaction levels. In spite of the fact that there was an improvement of 2.25 points in 2024, it remains the main structural challenge of ITS. The average percentage of "Agree" responses in this dimension was only 62.59% in 2023 and 66.57% in 2024. To sum up, the findings of this research confirm that academic tutoring at FTYM of UABC has shifted from a reactive model to one that is proactive, resilient, and strategically adapted to the challenges of a changing educational context.

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# **Proximal composition and potential nutritional value of microgreens (*Rumex acetosa*, *Brassica oleracea* var. *italica*, *Beta vulgaris*) conventionally packaged in Ecuador**

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## **Introduction**

Microgreens, also known as micro vegetables, are gaining popularity among consumers, becoming a culinary specialty due to their wide range of colors, flavors, and textures (Durham, 2016). They are defined as young, tender vegetables grown from seeds of various species of herbaceous plants, vegetables, aromatic herbs, and edible wild plants. They are harvested within a short period, ranging from a few days to a maximum of two weeks after sowing, at which point the cotyledons are fully developed and the first true leaves begin to appear (Agrofy News, 2015).

In the last decade, microgreens have been recognized as a valuable source of complementary nutrients in the diet, thanks to their high content of macro and micro mineral elements, as well as bioactive compounds (Kyriacou et al., 2016; Neves, 2019). Due to their favorable nutritional profile, they have been proposed as one of the new "superfoods" (Choe et al., 2018; Hochmuth & Cantliffe, 2021) and as effective supplements in diets rich in these nutrients (Sharma et al., 2022).

In addition, microgreens are ideal for growing in small, controlled spaces, requiring less water, which promotes more sustainable agriculture. Their nutritional content and potential as a food supplement have been studied for applications in space life support (Kyriacou et al., 2017). It is important to mention that, as freshly harvested products, microgreens have a relatively short

shelf life, not exceeding 10 to 14 days (Xiao et al., 2016). Due to their young tissue composition, are highly perishable, and their deterioration is more related to a stress-induced response than to the natural process of senescence (Mir et al., 2017; Xiao et al., 2016). Pre-harvest treatments, the type of packaging material, and modified atmosphere packaging (MAP) are variables that influence the shelf life of fresh-cut microgreens (Dalal et al., 2019). On the other hand, the use of hypochlorite in post-harvest washing has been shown to improve overall quality (appearance) and reduce microbial load in microgreens such as broccoli during storage at 5 °C (Ghoora & Srividya, 2020). The oxygen transmission rate in packaging, which affects the equilibrium concentrations of CO<sub>2</sub> and O<sub>2</sub>, has also been evaluated, although no significant effects on the shelf life of microgreens have been observed. However, storage temperature has been found to be the factor that most impacts the shelf life of the product (Ghoora & Srividya, 2020).

With this background, the objective of this research is to evaluate the nutritional and bioactive characterization of microgreens (sorrel, broccoli, and beet) stored conventionally.

### Selection, harvesting, packaging, and storage of microgreen varieties

In this study, the main microgreen producers in Ecuador were contacted, and a selection was made based on criteria such as production capacity, openness to culinary trials on farms, as well as the marketing and shipping of microgreens to the city of Manta. Three varieties (sorrel, broccoli, and beet) were chosen based on the commercial demand of the selected producer. These varieties were grown and purchased from the company "Cultiva Ecuador," located in Puenbo, Quito, in the province of Pichincha. Details are presented in Table 1.

**Table 1.** Information on the microgreens under study

| Commercial name | Sorrel                                                                              | Broccoli                                                                            | Beet                                                                                  |
|-----------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| Scientific name | <i>Rumex acetosa</i>                                                                | <i>Brassica oleracea</i>                                                            | <i>Beta vulgaris</i>                                                                  |
| Family          | Polygonaceae                                                                        | Brassicaceae                                                                        | Amaranthaceae                                                                         |
|                 |  |  |  |

Source: Own elaboration

The microgreens were harvested in one full day, following the producer's usual post-harvest and packaging process. This procedure included cutting and collecting the vegetables, followed by washing them with water and draining them properly. They were packaged in plastic PET boxes with quick closures, using paper towels at the bottom to absorb moisture. The microgreens were then packaged, labeled, and shipped to the city of Manta. During transport, the microgreens were stored at a temperature of 7-8°C, with a relative humidity of 85-89%, for a period of thirteen days. Sampling was carried out on days 1, 7, and 13 of storage, considering the day of harvest and shipment to the destination city as day zero.

## Experimental design

The statistical model used was ANOVA with a two-factor arrangement A×B, where: Factor A was the microgreen varieties: sorrel, broccoli, beet; and Factor B was the days of storage: 1, 7, and 13; with 3 replicates, resulting in 9 treatments (Table 2) and a total of 27 experimental units. To determine the significant differences between the means of the treatments, a Tukey test with a p-value < 0.05 was applied using the Statgraphics and InfoStat programs. The dependent variables were the proximal and sensory analyses, where n=3 and n=5, respectively.

**Table 2.** *Research treatments.*

| Treatments | Factor A: microgreen varieties | Factor B: days of storage |
|------------|--------------------------------|---------------------------|
| T1         | Sorrel                         | 1                         |
| T2         |                                | 7                         |
| T3         |                                | 13                        |
| T4         | Broccoli                       | 1                         |
| T5         |                                | 7                         |
| T6         |                                | 13                        |
| T7         | Beet                           | 1                         |
| T8         |                                | 7                         |
| T9         |                                | 13                        |

## Proximal composition

From each variety of microgreens selected and harvested for storage, 25 boxes of each variety were used and three samples were randomly separated from each, which were divided into two fractions. The first fraction was used immediately for analyses requiring fresh samples: % dry matter; chlorophylls,

antioxidant capacity, and anthocyanin . The other fraction was subjected to deep freezing (-40 °C) for use in metal analysis.

For the proximate composition of the different samples, the corresponding analyses were applied as detailed below. Moisture content was determined on a fresh weight (FW) basis using the AOAC 964.22 procedure. The protein content ( $N \times 6.25$ ) was determined by the Kjeldahl nitrogen method following AOAC 955.04. The lipid content was determined after Soxhlet extraction according to AOAC 920.39C. Total dietary fiber was determined using the enzymatic-gravimetric procedure according to AOAC 991.43. The ash content was determined using a muffle furnace according to AOAC 923.03. Finally, total carbohydrates were determined by difference.

### **Macroelement and microelement mineral content**

The macro and micro mineral content was determined in the certified "LASA" laboratory, where the samples were prepared according to the AOAC 2015.06 reference method. The samples were deep-frozen to prevent loss of their properties and were later used for the analysis of macro minerals (Ca, K, Na, Mg, P) and microelements known as trace elements (As, B, Co, Cu, Fe, Mn, Mo, Zn, Ag, Al, Ba, Be, Cd, Cr, Hg, Li, Ni, Pb, Sb, Se, Sn, Sr, Ti, Tl, V) by ICP-MS (AOAC, 2019). To determine the characterization of the mineral elements in the microgreens, the analysis was performed on day 7 of storage, as this is the average number of days of consumption.

### **Analysis of bioactive compounds**

The bioactive compounds were analyzed in the certified "LASA" laboratory, where chlorophyll a and b, beta-carotene, and anthocyanins were evaluated on day 7 of storage to determine the characteristics of the microgreens, as there is currently no characterized profile for them. For these analyses, 1 g of fresh weight (FW) of the samples was mechanically processed and homogenized with a mixture of acetone-hexane (2:3) for 2 minutes until a uniform mass was obtained. The samples were then centrifuged (Eppendorf 5810 R) and determined with a UV spectrophotometer- Vis and the equations mentioned in Branisa et al., (2014). In addition, the antioxidant power was analyzed and determined according to Acharya et al., (2021), who used the FRAP spectrophotometry method with results expressed in mg ASA (ascorbic acid equivalent) / l.

### **Sensory evaluation**

Sensory evaluation was carried out on days 1, 7, and 13 of storage in order to observe changes in the microgreens throughout their shelf life. A trained panel

of 20 people who consume microgreens and/or fresh cut vegetables performed this evaluation. It focused on aspects such as visual quality, texture, and flavor, using a 5-point scale (Table 3), similar to that used in the study by Paradiso et al. (2018).

**Table 3.** *Details of the scale for sensory evaluation of visual quality, texture, and flavor in microgreens.*

| Rating | Description                                                                                                                                                                         | Visual quality, texture, and flavor |
|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
| 5      | Free of defects, freshly harvested. No visible defects. Pleasant flavor and texture, characteristic of the variety.                                                                 | Excellent                           |
| 4      | Minor defects, not objectionable. Physical damage < 10% (wrinkled cotyledons). Not wilted. Pleasant, mild flavor. Slight changes in texture.                                        | Good                                |
| 3      | Moderately objectionable defects, marketable threshold. Slight chlorosis (yellowing). Physical damage < 25% (dry and wilted). Changes in texture and noticeable variation in flavor | Suitable                            |
| 2      | Excessive defects, unsaleable. Chlorosis in cotyledons >25% and wilting >50%. Little characteristic flavor of the variety.                                                          | Poor                                |
| 1      | Degraded and unusable product, rotten. Presence of bad odor. Apparent physical degradation (liquid present). No flavor.                                                             | Very poor                           |

## Proximal composition of the microgreens studied

Table 4 shows the results obtained for: moisture, protein, fat, total carbohydrates, total dietary fiber, and ash in the nine treatments among the microvegetable varieties (sorrel, broccoli, and beet) + storage days (1, 7, and 13).

In the analysis of moisture content, significant differences were observed between the treatments evaluated. Treatment T9, corresponding to beet (*Beta vulgaris*), on day 13, had the lowest moisture content at 92.87%. In contrast, treatment T6, which consisted of broccoli (*Brassica oleracea var. italica*) on the same day, showed the highest moisture content at 96.20%. These results are consistent with the findings of Kowitcharoen et al. (2021), who reported moisture values for varieties of the Brassicaceae family on day zero, ranging from 91.88% for purple radish (*Raphanus sativus*) to 94.67% for red cabbage (*Brassica oleracea var. capitata*), while broccoli had a moisture content of 94.07%.

On the other hand, treatment T7, which corresponded to beetroot on day 1, showed a moisture content of 93.57%, which is lower than the 95.10% reported by Xiao et al. (2015) for freshly harvested beetroot. In terms of protein content, significant differences were recorded between the species studied. Treatment T1, which evaluated sorrel (*Rumex acetosa*) on day 1, reached 2.41%, the highest value compared to the other treatments. This result is in line with that found by Kowitcharoen et al. (2021), who reported a protein content of 2.23% in their research on the bioactive composition and nutritional profile of microgreens.

In relation to lipid composition, a significant difference ( $p < 0.05$ ) was observed, determining that treatment T2 (sorrel, day 7) had the highest lipid content, with 0.73%, compared to T6 (broccoli, day 13), which had the lowest fat content with 0.27%. This lipid content behavior is similar to that reported by Paradiso et al. (2018), who found fat contents between 0.30% and 0.66% for broccoli and radish, emphasizing that they controlled the temperature and relative humidity during the process (20 °C and 85%). Kowitcharoen et al. (2021) also reported a content of 0.49% for broccoli microgreens grown under controlled conditions.

In terms of total carbohydrates, treatment T9 (beet, day 13) had the highest content at 3.53%, which was significantly higher than the 1.87% recorded in treatment T4 (broccoli, day 1). These results are consistent with those reported by Kowitcharoen et al. (2021), who found total carbohydrate contents ranging



from 3.70% to 2.32% in their study on the bioactive composition and nutritional profile of microgreens, focusing on purple radish and red cabbage.

Regarding total dietary fiber, treatments T1 (sorrel, day 1) and T2 (sorrel, day 7) showed a content of 1.81%, higher than the 0.60% recorded in treatment T5 (broccoli, day 7). These findings are consistent with the reports of Ghoola et al. (2020), who studied various species of microgreens, including spinach (*Spinacia oleracea*) and French basil (*Ocimum basilicum*), and obtained values of 2.36% and 1.41%, respectively. In terms of ash, the results are similar to those reported by Bafumo et al. (2022), who obtained results of 0.90% in radish and 0.70% in arugula (*Eruca sativa*)

**Table 4.** Proximal analysis of selected microgreen varieties.

| Treatment          | Moisture            | Protein           | Fat                | total carbohydrate | Dietary fiber total | Ash               |
|--------------------|---------------------|-------------------|--------------------|--------------------|---------------------|-------------------|
| Day 1 sorrel       | 93.40 <sup>BC</sup> | 2.41 <sup>H</sup> | 0.73 <sup>G</sup>  | 2.80 <sup>E</sup>  | 1.81 <sup>G</sup>   | 0.79 <sup>E</sup> |
| Sorrel day 7       | 93.67 <sup>D</sup>  | 2.30 <sup>F</sup> | 0.63 <sup>F</sup>  | 2.63 <sup>D</sup>  | 1.81 <sup>G</sup>   | 0.70 <sup>D</sup> |
| Sorrel day 13      | 93.90 <sup>E</sup>  | 2.11 <sup>R</sup> | 0.57 <sup>EF</sup> | 2.50 <sup>C</sup>  | 1.70 <sup>F</sup>   | 0.60 <sup>C</sup> |
| Broccoli day 1     | 95.57 <sup>F</sup>  | 1.71 <sup>C</sup> | 0.43 <sup>BC</sup> | 1.87 <sup>A</sup>  | 0.80 <sup>C</sup>   | 0.50 <sup>B</sup> |
| Broccoli day 7     | 95.83 <sup>G</sup>  | 1.51 <sup>B</sup> | 0.37 <sup>B</sup>  | 1.93 <sup>AB</sup> | 0.69 <sup>B</sup>   | 0.40 <sup>A</sup> |
| Broccoli day 13    | 96.20 <sup>H</sup>  | 1.41 <sup>A</sup> | 0.27 <sup>A</sup>  | 2.00 <sup>B</sup>  | 0.60 <sup>A</sup>   | 0.39 <sup>A</sup> |
| Beetroot day 1     | 93.57 <sup>CD</sup> | 2.41 <sup>H</sup> | 0.60 <sup>EF</sup> | 3.13 <sup>F</sup>  | 1.20 <sup>E</sup>   | 0.40 <sup>A</sup> |
| Beetroot day 7     | 93.27 <sup>B</sup>  | 2.31 <sup>G</sup> | 0.53 <sup>DE</sup> | 3.27 <sup>G</sup>  | 1.20 <sup>E</sup>   | 0.70 <sup>D</sup> |
| Beetroot on day 13 | 92.87 <sup>A</sup>  | 2.20 <sup>E</sup> | 0.47 <sup>CD</sup> | 3.53 <sup>H</sup>  | 1.02 <sup>D</sup>   | 0.89 <sup>F</sup> |

Different letters in the superscripts indicate significant differences between treatments ( $p < 0.05$ ), where  $n = 3$

### Analysis of macro and micro mineral elements in the varieties studied on day 7

Table 5 shows the macro and micro mineral elements detected in the three varieties studied on the seventh day of storage. Among the macronutrients, potassium (K) stood out as the most abundant mineral in the varieties analyzed. The second macronutrients with the highest content were phosphorus (P) in sorrel (*Rumex acetosa*), with 500.2 mg/kg, and calcium (Ca) in broccoli (*Brassica oleracea* var. *italica*), with 877.4 mg/kg. In comparison, beetroot (*Beta vulgaris*)

showed higher concentrations of magnesium (Mg) and potassium (K), reaching 376.6 mg/kg and 5,580.8 mg/kg, respectively.

According to Teng et al. (2021), microgreens are high in various minerals essential for plant development and human health, including calcium (Ca), magnesium (Mg), iron (Fe), manganese (Mn), zinc (Zn), selenium (Se), and molybdenum (Mo). These authors reported calcium concentrations ranging from 630 to 886 mg/kg and magnesium concentrations ranging from 410 to 600 mg/kg in varieties of arugula (*Eruca sativa*) and radish (*Raphanus sativus*). As for broccoli, the calcium content found was 880 mg/kg. On the other hand, Ghoola et al. (2020) determined potassium concentrations ranging from 381 to 712 mg/kg in fennel (*Foeniculum vulgare*) and spinach (*Spinacia oleracea*).

In terms of microelements, sorrel had the highest levels of aluminum (Al, 47.7 mg/kg), iron (Fe, 22.7 mg/kg), manganese (Mn, 8.25 mg/kg), and zinc (Zn, 4.3 mg/kg). Next, broccoli showed aluminum (Al, 22.5 mg/kg), iron (Fe, 11.5 mg/kg), boron (B, 5.41 mg/kg), strontium (Sr, 7.52 mg/kg), and barium (Ba, 2.44 mg/kg) content. Beets also revealed high concentrations of aluminum (Al, 23.0 mg/kg), iron (Fe, 11.90 mg/kg), manganese (Mn, 5.53 mg/kg), and zinc (Zn, 3.97 mg/kg). It is important to mention that other microelements were found in lower proportions among the microgreen varieties analyzed.

The microelement concentrations recorded in this study exceeded those reported by Xiao et al. (2016), who found 6.7 mg/kg of iron (Fe), 3.7 mg/kg of manganese (Mn), and 3.5 mg/kg of zinc (Zn) in broccoli. Similarly, Teng et al. (2021) documented values of 6.2 mg/kg of iron (Fe), 3.10 mg/kg of manganese (Mn), and 2.9 mg/kg of zinc (Zn) in cauliflower (*Brassica oleracea* var. *botrytis*). Regarding aluminum, Weber (2017) reported 8.0 mg/kg, a value lower than that found in the three varieties studied, emphasizing that these authors grew the microgreens using compost as a natural fertilizer.

The high iron content in sorrel microgreens is attributed to the presence of metabolites characteristic of Polygonaceae species, especially glucosinolates (Mir et al., 2017).

**Table 5.** Analysis of macro and micro mineral elements in microgreens.

| Metals         | Sorrel (mg/kg) | Broccoli (mg/kg) | Beetroot (mg/kg) |
|----------------|----------------|------------------|------------------|
| Aluminum (Al)  | 47.7           | 22.5             | 23.0             |
| Antimony (Sb)  | 0.0028         | 0.00228          | 0.00219          |
| Arsenic (As)   | 0.00571        | 0.00526          | 0.00381          |
| Barium (Ba)    | 1.84           | 2.34             | 1.19             |
| Beryllium (Be) | <0.00100       | <0.00100         | <0.00100         |
| Boron (B)      | 1.62           | 5.41             | 3.54             |

|                      |          |          |          |
|----------------------|----------|----------|----------|
| Cadmium (Cd)         | 0.00293  | 0.00242  | 0.0091   |
| Calcium (Ca)         | 376.5    | 877.4    | 326.4    |
| Cobalt (Co)          | 0.0208   | 0.00751  | 0.0237   |
| e (Cu)               | 0.567    | 0.439    | 0.817    |
| Total chromium (Cr)  | 0.0291   | 0.0167   | 0.0352   |
| Tin (Sn)             | 0.00521  | 0.00296  | 0.00756  |
| Strontium (Sr)       | 3.23     | 7.52     | 0.256    |
| Total phosphorus (P) | 529.2    | 474.5    | 320.5    |
| Iron (Fe)            | 22.7     | 11.5     | 11.9     |
| Lithium (Li)         | 0.0796   | 0.073    | 0.0619   |
| Magnesium (Mg)       | 327.2    | 280.8    | 376.6    |
| Manganese (Mn)       | 8.25     | 2.32     | 5.53     |
| Mercury (Hg)         | 0.000876 | 0.000865 | 0.000945 |
| Molybdenum (Mo)      | 0.103    | 0.0522   | 0.0375   |
| Nickel (Ni)          | 0.182    | 0.285    | 0.168    |
| Silver (Ag)          | 0.00233  | 0.00161  | 0.00212  |
| Lead (Pb)            | 0.0186   | 0.0136   | 0.014    |
| Potassium (K)        | 5,245.5  | 4,069.2  | 5,580.8  |
| Selenium (Se)        | 0.0107   | 0.0135   | 0.00502  |
| Sodium (Na)          | 563.2    | 510.4    | 1,371.6  |
| Thallium (Tl)        | 0.00747  | 0.0658   | 0.0044   |
| Titanium (Ti)        | 1.49     | 0.625    | 0.707    |
| Vanadium (V)         | 0.0645   | 0.0265   | 0.0301   |
| Zinc (Zn)            | 4.3      | 4.0      | 3.97     |

## Bioactive compounds and antioxidant capacity of microgreens

Significant variations were observed in the chlorophyll a and b content, as illustrated in Figure 1. For sorrel (*Rumex acetosa*), the values were 1.53 mg/g FW for chlorophyll a and 0.76 mg/g FW for chlorophyll b. In the case of broccoli (*Brassica oleracea* var. *italica*), the contents were measured at 1.55 mg/g FW for chlorophyll a and 1.81 mg/g FW for chlorophyll b ( ). On the other hand, beetroot (*Beta vulgaris*) had values of 0.64 mg/g FW for chlorophyll a and 0.76 mg/g FW for chlorophyll b.

These results are consistent with those reported by Paradiso et al. (2018) and Ghoola et al. (2020), who found concentrations between 1.30 and 2.15 mg/g FW in microgreens of the Brassicaceae family, which include species such as kohlrabi, mizuna, and mustard, as well as values of 1.41 to 2.53 mg/g FW in lettuce. Chlorophyll is closely related to the freshness and visual quality of

microgreens, and it has been noted that its degradation can occur during storage due to ethylene-induced senescence (Craver et al., 2017).

As for the determination of  $\beta$ -carotene content in microgreens, the analysis was carried out on the 7th day of storage. Figure 1 shows that sorrel had a content of 1.31 mg/g FW, followed by broccoli with 1.20 mg/g FW, while beetroot had a lower value of 0.68 mg/g FW compared to the aforementioned microgreens. The  $\beta$ -carotene concentrations obtained in this study were lower than those reported by Longvah et al. (2017), who documented values of 3.1 to 9.1 mg/100 g in culinary microgreens of the Brassicaceae family, such as radish and mustard. In addition, it is noted that mature leaves of other species, such as fenugreek (*Trigonella foenum-graecum*) and hibiscus (*Hibiscus sabdariffa*), had a significantly higher  $\beta$ -carotene content compared to the microgreens studied. Mueller and Boehm (2011) indicate that  $\beta$ -carotene is the dietary carotenoid found in the highest amounts in yellow-orange fruits and green leafy vegetables. For beets, a content of 0.68 mg/g FW was obtained on day seven, compared to the study by Xiao et al. (2015), which reported 0.38 mg/g FW at harvest.

Significant differences were observed between the species analyzed in terms of anthocyanin content. Sorrel had the highest content, with 9.745 mg/g FW, followed by broccoli with 3.759 mg/g FW, while beetroot had a lower value of 3.052 mg/g FW compared to the other species studied. These values exceed those reported by Paradiso et al. (2018), who found between 0.12 and 0.20 mg/g FW in two varieties of broccoli. Keutgen et al. (2021) reported 0.12 mg/g DM (dry material) in garden cress, also belonging to the Brassicaceae family. It is important to note that in their study, the analyses were performed on microgreens in a dry state.

The sorrel variety (*Rumex acetosa*) had the highest antioxidant power, with 860 mg EAA/l, followed by broccoli (*Brassica oleracea* var. *italica*), which reached 547 mg EAA/l, and beetroot (*Beta vulgaris*), with 210 mg EAA/l. These indices are significantly higher than those reported by Martínez (2016), who documented values of 120 and 205 EAGg/100 g for varieties of the Brassicaceae family, such as turnip (*Brassica napus*) and spinach (*Spinacia oleracea*). It is important to note that microgreens have 4 to 6 times more antioxidant capacity than their adult forms. This is consistent with the findings of Ghoola et al. (2020), who suggest that microgreens rich in antioxidant components can be used as a promising culinary ingredient that promotes health.

## Sensory characterization

In the sensory evaluation of conventionally packaged microgreens, visual quality, texture, and flavor were analyzed based on the metabolic activities observed during the days of storage (1, 7, and 13), as detailed in Table 6. Significant differences were found in the three sensory attributes between the varieties evaluated and the days of storage.

On the seventh day, visual quality showed some defects, although all three varieties remained at an acceptable level. However, by day 13, the differences became more pronounced. Sorrel (*Rumex acetosa*) microgreens showed moderate defects, such as slight yellowing of the cotyledons and a decrease in the intensity of their characteristic flavor. Despite this, they achieved the best rating in appearance, with a score of 3.2, significantly higher than that of broccoli (*Brassica oleracea*) and beet (*Beta vulgaris*), which scored 1.4.

Broccoli microgreens were the first to deteriorate, experiencing noticeable changes in visual quality, texture, and flavor. Over the days of storage, both texture and flavor varied significantly, which was evident to the panelists. According to Keutgen et al. (2021), appearance is critical for the selection and consumption of food products, which explains why microgreens maintained a good appearance until the seventh day. Regarding texture and flavor characteristics, Paradiso et al. (2018) observed that broccoli (*Brassica oleracea*) began to deteriorate on the tenth day of storage due to its respiratory activity and microbial quality. On the other hand, Xiao et al. (2015) highlighted that beet microgreens (*Beta vulgaris*) achieved good visual quality and texture on the third day, which coincides with their position as the second highest-rated variety.

**Table 6.** Sensory evaluation (visual quality, texture, and flavor) of the selected microgreen varieties.

| Treatment | Treatment description | Visual quality    | Texture           | Flavor           |
|-----------|-----------------------|-------------------|-------------------|------------------|
| T1        | Sorrel day 1          | 5.0 <sup>D</sup>  | 5.0 <sup>D</sup>  | 4.8 <sup>C</sup> |
| T2        | Sorrel day 7          | 4.8 <sup>D</sup>  | 4.8 <sup>D</sup>  | 3.8 <sup>B</sup> |
| T3        | Sorrel day 13         | 3.2 <sup>B</sup>  | 2.2 <sup>B</sup>  | 1.2 <sup>A</sup> |
| T4        | Broccoli day 1        | 4.8 <sup>D</sup>  | 4.6 <sup>D</sup>  | 4.8 <sup>C</sup> |
| T5        | Broccoli day 7        | 3.4 <sup>B</sup>  | 3.2 <sup>C</sup>  | 3.2 <sup>B</sup> |
| T6        | Broccoli day 13       | 1.4 <sup>A</sup>  | 1.2 <sup>A</sup>  | 1.6 <sup>A</sup> |
| T7        | Beetroot day 1        | 4.4 <sup>CD</sup> | 4.8 <sup>D</sup>  | 4.8 <sup>C</sup> |
| T8        | Beetroot day 7        | 3.8 <sup>BC</sup> | 4.2 <sup>D</sup>  | 3.8 <sup>B</sup> |
| T9        | Beetroot on day 13    | 1.4 <sup>A</sup>  | 1.8 <sup>AB</sup> | 1.0 <sup>B</sup> |

Different letters in the superscripts indicate significant differences between treatments ( $p < 0.05$ ), where  $n = 3$

## Conclusions

It was observed that the storage time of microgreens significantly influences their proximate parameters, which include protein, fat, total carbohydrate, fiber, and ash content. As time passes, these nutrients tend to decrease considerably, while moisture content increases, which can affect the quality and nutritional value of the product.

For the three varieties of microgreens studied, notable variations in bioactive content and macro- and microelement concentration were recorded on the seventh day of storage. The sorrel variety (*Rumex acetosa*) stood out for having the highest levels of chlorophylls a and b, as well as  $\beta$ -carotene, anthocyanins, and high antioxidant power. In addition, it showed a notable concentration of aluminum, phosphorus, iron, and zinc. On the other hand, broccoli (*Brassica oleracea* var. *italica*) stood out for its boron, calcium, and strontium content, while beetroot (*Beta vulgaris*) was characterized by its manganese, potassium, and sodium levels. These varieties are considered functional foods, as their consumption can provide significant health benefits.

In terms of deterioration, broccoli microgreens were the first to show significant changes in visual quality, texture, and flavor. This deterioration is directly related to their moisture content, which is the highest among the varieties analyzed and tends to increase with storage time. In contrast, sorrel maintained an acceptable appearance, with moderate defects such as slight yellowing of the cotyledons and a decrease in the intensity of its characteristic flavor on the thirteenth day of storage. This difference is statistically significant compared to broccoli and beet varieties, underscoring the importance of choosing varieties suitable for prolonged storage without compromising their quality.

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# Probiotics, functional groups, and their relationship to health status as continuing education for nurses

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## Introduction

Continuing education in the field of probiotics represents an essential update for nursing professionals, keeping them up to date with advances in modern medicine for exceptional performance in their field. This training process allows nurses to explore the most recent and advanced knowledge, enabling them to intervene more effectively in the comprehensive care of patients. Through this specialized academic program, nurses acquire tools to optimize patient care, integrating the most up-to-date knowledge into their daily practice.

Probiotics, which are live microorganisms that provide health benefits when consumed in adequate amounts, have been the subject of growing interest in nutrition research. These microorganisms, which mainly include strains of bacteria such as *Lactobacillus* and *Bifidobacterium*, have been shown to have positive effects on gastrointestinal health by improving the balance of the gut microbiota. This can translate into better digestion, more regular bowel function, and a reduction in the symptoms of irritable bowel syndrome (Martino et al., 2022).

In the human digestive system, *Lactobacillus* bacteria are some of the most abundant and significant microorganisms. These bacteria, known for their ability to ferment sugars into lactic acid, play a crucial role in maintaining gastrointestinal health. Among the main *Lactobacillus* bacteria present in the digestive system are *Lactobacillus acidophilus*, *Lactobacillus rhamnosus*, and *Lactobacillus casei*. These strains are characterized by their ability to colonize the small intestine and colon, where they contribute to digestion and nutrient absorption, as well as competing with potential pathogens (Y. Liu et al., 2022; López et al., 2023; Ruiz-Sánchez et al., 2024).

Within the human digestive system, microorganisms of the genus *Bifidobacterium* are essential for maintaining proper balance in the gut microbiota and contributing to gastrointestinal well-being. Among the main strains of the genus *Bifidobacterium* present in the digestive tract are *Bifidobacterium longum*, *Bifidobacterium bifidum*, and *Bifidobacterium breve*. These strains are known for their ability to ferment indigestible carbohydrates, such as dietary fiber, producing short-chain fatty acids that provide energy to intestinal epithelial cells and promote intestinal health (Pachacama López et al., 2021).

*Bifidobacterium longum*, one of the most prevalent species within the *Bifidobacterium* genus, has been associated with various gastrointestinal health benefits. This particular strain is found in significant amounts in the human colon and has been shown to play a key role in modulating the intestinal immune system and protecting against intestinal pathogens. In addition, *B. longum* has been the subject of numerous studies that have demonstrated its ability to reduce intestinal inflammation, improve intestinal barrier function, and alleviate symptoms of irritable bowel syndrome. These findings support the importance of *Bifidobacterium* germs in maintaining digestive health and promoting overall well-being (Turroni et al., 2019; Yao et al., 2021).

The relationship between probiotics and health extends beyond the digestive and immune systems. Recent research (Barba-Vila et al., 2024; Ribera et al., 2024) has suggested that probiotics may also play a role in mental health, influencing mood and cognitive function. The gut microbiota has been found to have a direct connection to the brain via the gut-brain axis, leading to the hypothesis that probiotics may have positive effects on mental health by modulating the gut microbiota. Preliminary studies have found associations between supplementation with certain probiotic strains and a reduction in symptoms of anxiety and depression, although further research is needed to confirm these findings and fully understand the underlying mechanisms (Gómez, 2019).

For a better understanding of the function of the microbiota in the human body, it is divided into different functional groups, where strains of different natures and in various concentrations can be grouped. Given the relevance of the topic, the objective of this work is to provide nurses with a better understanding of the function of the human microbiota, organized into functional groups

with strains of different natures and concentrations. This knowledge is crucial for optimizing patient care and promoting evidence-based interventions.

The results for each selected functional group are discussed below. They contain a representation of the fundamental strains of each group, as well as the mechanism of action by which they exert their beneficial effects on human health, specialized content of significant relevance in the practice of professional nursing

### **Immunomodulatory microbiota**

Immunomodulatory probiotic strains are live microorganisms that, when consumed in adequate amounts, can confer health benefits by modulating the host's immune response. These strains are characterized by their ability to interact with the host's immune system, both locally in the intestine and systemically throughout the body. Among the key strains included in this group are *Lactobacillus rhamnosus* GG, *Bifidobacterium lactis* Bb12, and *Lactobacillus casei* Shirota. These strains have been extensively studied and have been shown to exert their optimal effect at specific concentrations, generally in the range of  $10^8$  to  $10^{10}$  CFU (colony-forming units) per dose. These concentrations are critical to ensure the efficacy of immunomodulatory probiotics, as doses that are too low may be insufficient to induce a significant immune response, while doses that are too high may not be beneficial and, in some cases, may even be counterproductive by causing imbalances in the gut microbiota. Therefore, selecting the right strain and appropriate dose are crucial aspects to consider when using probiotics for immunomodulatory purposes (Logroño, Abarca, et al., 2021; Peláez et al., 2023).

The choice of immunomodulatory probiotic strains should also be based on their ability to survive the conditions of the gastrointestinal tract and effectively colonize the intestine, where they can exert their beneficial effects on the immune system. In addition, it is important to consider the stability of the strains during storage and formulation of the final product, as well as their safety for use in the target population, especially in immunocompromised individuals or those with underlying medical conditions. On the other hand, it has been observed that some strains of immunomodulatory probiotics may have synergistic effects when combined in multi-nutrient formulations, which may further enhance their beneficial effects on immune health. However, further research is needed to fully understand the underlying mechanisms and optimize formulation strategies to maximize the therapeutic benefits of these probiotics (Logroño, Macías, et al., 2021).

The immunomodulatory mechanism of *Lactobacillus rhamnosus* GG,

*Bifidobacterium lactis* Bb12, and *Lactobacillus casei* Shirota strains involves a series of complex interactions between these microorganisms and the host's immune system. In the case of *Lactobacillus rhamnosus* GG, it has been observed that this strain can modulate the immune response by stimulating the production of anti-inflammatory cytokines, such as tumor necrosis factor alpha (TNF- $\alpha$ ) and interleukin-10 (IL-10), which help regulate inflammation and promote immune tolerance. In addition, *L. rhamnosus* GG can strengthen the intestinal epithelial barrier by increasing the expression of tight junction proteins and reducing intestinal permeability, which helps prevent pathogen translocation and excessive activation of the immune system (X. Liu et al., 2022; Szajewska & Hojsak, 2020).

On the other hand, *Bifidobacterium lactis* Bb12 has been shown to have immunomodulatory effects by increasing the activity of natural killer (NK) cells and improving T cell response, which strengthens innate and adaptive immunity. This strain can also modulate the production of pro-inflammatory and anti-inflammatory cytokines in the gut, contributing to maintaining an appropriate balance in the immune response and reducing susceptibility to inflammatory bowel diseases and allergies (Kathayat et al., 2022).

As for *Lactobacillus casei* Shirota, it has been observed that this strain can modulate the immune response by regulating the activity of dendritic cells and the production of cytokines, such as interferon gamma (IFN- $\gamma$ ) and IL-12, which promote T cell activity and the adaptive immune response. In addition, *L. casei* Shirota can increase mucin production and strengthen the intestinal mucosal barrier, which helps prevent pathogen colonization and intestinal inflammation (Macnaughtan et al., 2020).

## Protective microbiota

Protective microbiota refers to the community of microorganisms that reside in the human body and play a critical role in protecting against the colonization and proliferation of potential pathogens, as well as regulating the immune system and promoting overall health. Among the strains that perform this function are some species of *Lactobacillus*, such as *Lactobacillus acidophilus* and *Lactobacillus plantarum*, as well as some species of *Bifidobacterium*, such as *Bifidobacterium bifidum* and *Bifidobacterium longum*. These strains are capable of colonizing the intestine and competing with pathogens for nutrients and binding sites, which helps prevent infections and maintain a healthy microbial balance (Calderón, 2023; Diaz & Lara, 2024).

For the effects of protective microbiota to be optimal, an adequate concentration of these strains in the intestine is required. In general, a

concentration of at least  $10^8$  to  $10^{10}$  CFU per dose is considered necessary to ensure effective colonization and functional activity of these beneficial bacteria in the intestine. Therefore, it is important to adjust the dose of probiotics consumed to optimize the effects of the protective microbiota and promote intestinal health and immunity (Diaz & Lara, 2024). The strains *Lactobacillus acidophilus* and *Lactobacillus plantarum* exert their protective effects mainly through several key mechanisms that contribute to maintaining intestinal health and strengthening the immune system. First, these strains have the ability to compete with pathogens for nutrients and binding sites in the intestinal mucosa, making it difficult for harmful bacteria to adhere to and colonize the intestine. This helps prevent infections and reduces the risk of gastrointestinal diseases (Gao et al., 2022; Huang et al., 2021).

In addition, *Lactobacillus acidophilus* and *Lactobacillus plantarum* produce antimicrobial compounds, such as organic acids and bacteriocins, which inhibit the growth of pathogens and contribute to maintaining a healthy microbial balance in the gut. These compounds help control the proliferation of harmful bacteria and promote the growth of beneficial bacteria, thereby improving gut health and immune function. Furthermore, these strains can also modulate the host's immune response by interacting with immune cells in the intestinal mucosa and stimulating the production of anti-inflammatory cytokines, such as interleukin-10, which helps regulate inflammation and promotes immune tolerance (Divyashree et al., 2021).

### **Muconutritive microbiota**

The muconutritive microbiota comprises a variety of bacterial strains that play a key role in the fermentation of complex substrates, such as dietary fiber, to produce beneficial metabolites that contribute to intestinal and systemic health. Among the notable strains in this category is *Bifidobacterium breve*, an anaerobic bacterium that predominantly colonizes the human colon and has a broad capacity to degrade polysaccharides and dietary fiber, producing short-chain fatty acids (SCFAs) and B vitamins. These SCFAs, particularly butyrate, have anti-inflammatory properties and are important for maintaining the integrity of the intestinal barrier, as well as for regulating the immune system (*Probiotic Bifidobacterium Breve Prevents DOCA-salt Hypertension*, n.d.; Solito et al., 2021).

Another relevant strain in the muconutritive microbiota is *Bacteroides thetaiotaomicron*, which is found in the human intestine and specializes in breaking down complex polysaccharides present in the diet. This strain produces a variety of enzymes capable of degrading indigestible polysaccharides, releasing simple sugars that can be absorbed by the host or

used by other bacteria in the microbiota. In addition, *B. thetaiotaomicron* plays a crucial role in regulating energy metabolism and adipose tissue homeostasis by modulating hormonal signaling and nutrient absorption. Together, these strains and other muconutritive bacteria contribute significantly to the digestion of dietary fiber and other complex substrates, producing metabolites that promote the intestinal and systemic health of the host (Ndeh et al., 2020; Ye et al., 2021).

*Faecalibacterium prausnitzii* is an anaerobic bacterium that forms part of the human gut microbiota and performs various key functions in maintaining the health of the host. One of the main functions of *F. prausnitzii* is the production of butyric acid, a short-chain fatty acid with anti-inflammatory properties and benefits for gut health. Butyrate is an important energy substrate for colonic epithelial cells and helps maintain the integrity of the intestinal barrier, reducing permeability and preventing bacterial translocation and inflammation (Leylabadlo et al., 2020).

In addition to its role in butyrate production, *F. prausnitzii* also has the ability to modulate the host's immune response. This bacterium has been shown to reduce the production of proinflammatory cytokines, such as tumor necrosis factor alpha (TNF- $\alpha$ ) and interferon gamma (IFN- $\gamma$ ), and increase the production of antiinflammatory cytokines, such as interleukin-10, which helps regulate inflammation and promotes immune tolerance. In addition,

*F. prausnitzii* has been associated with improvement in various inflammatory bowel diseases, such as Crohn's disease and ulcerative colitis, highlighting its importance in gastrointestinal health and its therapeutic potential (Maioli et al., 2021).

*Akkermansia muciniphila* is an intestinal bacterium that has gained considerable attention in scientific research due to its diverse functions and potential impact on human health. This bacterium is predominantly found in the mucous layer of the intestine, where it plays an important role in the degradation of mucin, a protein that lines the intestinal wall and serves as a protective barrier. Through its specialized enzymes, *Akkermansia muciniphila* is able to break down mucin, releasing simple sugars that can be used as nutrients by both the bacterium and other species in the intestinal microbiome (Effendi et al., 2022).

In addition to its role in mucin degradation, *Akkermansia muciniphila* has been associated with several health benefits. This bacterium has been found to be inversely correlated with obesity and insulin resistance, suggesting a possible role in regulating energy metabolism and preventing metabolic diseases.

Furthermore, *Akkermansia muciniphila* has been shown to have anti-inflammatory and antioxidant properties, making it a promising candidate for the treatment of inflammatory bowel diseases and other conditions related to chronic inflammation. Together, these functions make *Akkermansia muciniphila* an important component of the gut microbiota and a potential target for therapeutic interventions aimed at improving metabolic health and preventing inflammation-related diseases.

## Saccharolytic microbiota

The saccharolytic microbiota is composed of a variety of bacterial strains specialized in fermenting complex carbohydrates, such as dietary fiber and polysaccharides, to produce beneficial metabolites that contribute to intestinal and systemic health. Among the key strains that make up this microbiota is *Bacteroides vulgatus*, an anaerobic bacterium that has a broad capacity to degrade polysaccharides and ferment carbohydrates, producing short-chain fatty acids (SCFAs) and other metabolites that are important for gut health. *B. vulgatus* has been shown to have a beneficial effect on the regulation of energy metabolism and immune response, and its presence in the microbiota has been associated with improved metabolic health and the prevention of inflammatory bowel diseases (Wang et al., 2022).

Another relevant strain in the saccharolytic microbiota is *Prevotella copri*, an anaerobic bacterium found in the human intestine that has the ability to degrade a wide range of complex substrates, including plant-derived polysaccharides. *P. copri* produces SCFAs and other metabolites that are important for gut health, and its presence in the microbiota has been associated with greater microbial diversity and improved glucose tolerance. Regarding the optimal concentrations of these strains, it is estimated that a population of at least  $10^7$  to  $10^9$  CFU per gram of intestinal content is necessary to ensure their proper function and contribute significantly to carbohydrate fermentation and the production of beneficial metabolites (Abdelsalam et al., 2023). Together, these strains and other saccharolytic bacteria play an important role in the digestion of dietary fiber and other complex carbohydrates, and optimizing their presence and activity in the microbiota can have beneficial effects on the host's intestinal and metabolic health.

*Bifidobacterium adolescentis* is a bacterial strain that exhibits significant saccharolytic functions in the human intestine, meaning it has the ability to break down and ferment complex carbohydrates, especially those derived from dietary fiber. This ability allows *B. adolescentis* to actively contribute to the digestion of fiber and other non-digestible substrates in the gut, producing



short-chain fatty acids and other metabolites that are beneficial to gut and systemic health. Fiber fermentation by *B. adolescentis* generates SCFAs, such as acetic acid, propionic acid, and butyric acid, which are absorbed by the intestine and used as an energy source for epithelial cells, thereby promoting intestinal barrier integrity and reducing inflammation (Chen et al., 2021; Qian et al., 2022).

In addition to their role in fiber fermentation, *Bifidobacterium adolescentis* and *Ruminococcus bromii* may also have beneficial effects on energy metabolism regulation and metabolic health. It has been suggested that these strains may influence nutrient absorption and appetite regulation, which may contribute to the prevention of obesity and other metabolism-related diseases (Rangarajan et al., 2022). In addition, *B. adolescentis* has been shown to have antioxidant and anti-inflammatory properties, suggesting potential for the prevention and treatment of diseases related to chronic inflammation (Long et al., 2021).

## Neuroactive microbiota

The neuroactive microbiota is composed of a variety of bacterial strains that play a crucial role in the bidirectional communication between the gut and the brain, known as the gut-brain axis. Among the strains that make up this microbiota are *Bifidobacterium longum*, *Lactobacillus helveticus*, *Lactobacillus rhamnosus*, *Bifidobacterium adolescentis*, and *Lactobacillus plantarum*, among others. These strains have been shown to have the ability to modulate the activity of the enteric nervous system and the production of neurotransmitters, such as gamma-aminobutyric acid (GABA) and serotonin, which play a key role in regulating mood and behavior. In addition, these bacteria can produce bioactive peptides, such as opioid peptides and anxiolytic peptides, which have calming effects and can help reduce anxiety and stress (Chelladurai et al., 2023; Chiang et al., 2021; Krieger-Weber et al., 2020; Yao et al., 2021). Two-way communication between the gut and the brain, known as the gut-brain axis, occurs through several complex mechanisms involving neural, hormonal, and immunological signals. First, enteric neurons in the gut are able to detect and respond to signals from the brain via the vagus nerve, which connects the gut to the brainstem. These signals can influence intestinal motility, hormone and neurotransmitter secretion, and intestinal barrier permeability. On the other hand, the intestine also sends signals to the brain through the release of hormones and neurotransmitters, such as serotonin and GABA, which can influence mood, cognition, and behavior (Castillo-Álvarez & Marzo-Sola, 2022; Diaz & Lara, 2024).

The gut microbiota plays a fundamental role in modulating the gut-brain axis, as the bacteria present in the gut are capable of interacting with epithelial

cells, the immune system, and enteric neurons, producing metabolites and mediators that can influence communication between the gut and the brain. For example, certain strains of bacteria can produce neurotransmitters such as GABA and serotonin, which can influence neuronal activity in the gut and brain. In addition, the microbiota can also modulate the gut immune response and cytokine production, which can affect brain function and mood (Castillo-Álvarez & Marzo-Sola, 2022).

### Proteolytic microbiota

The proteolytic microbiota is composed of a variety of intestinal bacteria that have the ability to break down and metabolize complex proteins present in the diet and intestinal contents. Among the strains that make up this microbiota are bacteria such as *Clostridium*, *Bacteroides*, and some species of *Escherichia coli*. These bacteria produce proteolytic enzymes that break down proteins into simpler amino acids, which can be absorbed by the small intestine and used as a substrate for the synthesis of the body's own proteins or for other metabolic processes. In addition to protein degradation, some strains of proteolytic microbiota can also produce secondary metabolites such as ammonia, hydrogen sulfide, and biogenic amines during the fermentation of amino acids, which can have implications for intestinal and systemic health. An imbalance in the composition of the proteolytic microbiota can lead to excessive production of toxic metabolites such as ammonia and hydrogen sulfide, which may contribute to intestinal inflammation and the development of gastrointestinal disorders such as irritable bowel syndrome (Cheng et al., 2022; Guo et al., 2020; Martinson & Walk, 2020; Zafar & Saier, 2021). In addition, some strains of *Clostridium* can also produce proteolytic toxins, such as botulinum toxins and perfringolytic toxins, which have pathogenic effects on the host by interfering with cell function and causing tissue damage (Guo et al., 2020).

### Another composition of the microbiota

The fungi that make up the human microbiota include a variety of fungal species, the most common being those of the genus *Candida*, *Saccharomyces*, and *Malassezia*. These fungi are an integral part of the microbial ecosystem that inhabits different parts of the human body, such as the skin, mouth, gastrointestinal tract, and genitals. For example, *Candida albicans* is a commensal fungus normally found in the intestinal microbiota and oral mucosa, although it can become pathogenic under certain conditions, causing infections such as oral or vaginal candidiasis. On the other hand, *Saccharomyces cerevisiae* is a yeast commonly used in the food industry and is also found in the human gastrointestinal tract, where it can have beneficial effects, such as the production of lactic acid and competition with pathogens

for nutrients and space (Álvarez et al., 2021; Calderón, 2023; Vásquez, 2024). As for the viruses that make up the human microbiota, it has been discovered that the human body hosts a diversity of viruses, mainly bacteriophages that infect bacteria, such as those of the *Enterobacteria phage* and *Bacteroides phage* genera. These bacteriophages can influence the composition and function of the bacterial microbiota, either directly through the lysis of specific bacteria or indirectly through horizontal gene transfer between bacteria. In addition, RNA viruses such as noroviruses and astroviruses have been identified, which can colonize the gastrointestinal tract and cause gastrointestinal infections in humans (Castillo-Álvarez & Marzo-Sola, 2022; Dhar & Mohanty, 2020; Diaz & Lara, 2024).

## Conclusions

For nursing practice, it is crucial to recognize the diversity of probiotic functions and their impact on patient health. Continuing education in this field allows nurses to integrate this knowledge into daily care, thereby optimizing clinical outcomes and patient well-being. In addition, understanding microbiota and probiotics facilitates interdisciplinary collaboration with other healthcare professionals. Based on the specific functions that human microbiota perform on the host, seven functional groups of probiotics were defined: immunomodulatory microbiota, protective microbiota, muconutritive microbiota, saccharolytic microbiota, neuroactive microbiota, proteolytic microbiota, and other microbiota composition. In general, scientific literature describes an adequate concentration of  $10^8$  to  $10^{10}$  CFU per gram, with the exception of the fungus *Candida albicans* and the yeast *Saccharomyces cerevisiae*, which must be maintained in low concentrations in a state of eubiosis, depending on the individual variability of the host.

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# Argumentation management in the mathematics class for future teachers

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## Introduction

Costa Rican education and in particular the teaching of mathematics has presented serious difficulties in the last decade. An international reference is the PISA tests, in which, in 2022, Costa Rica obtained a score of 385 in the main domain, while the average of the OCDE countries was 472 (Martínez, 2023). Furthermore, in Costa Rica, only 28.1% of students achieved at least level 2 proficiency in mathematics, significantly less than the average for OCDE countries (OCDE average: 68.9%) (OCDE, 2023). Although the mathematics programs of the Costa Rican Ministry of Public Education (MEP) incorporate the "reasoning and argumentation" process, among others, the results that are being achieved show a poor development of these skills and low literacy in the area of mathematics, both in national (Consejo Nacional de Rectores, 2023) and international (OCDE, 2023) test results. The question that arises is what factors influence low promotion? It is not an easy question to answer, since the problem is most likely multifactorial, but one of those factors, which evidently affect, is the initial and continuous training of teachers.

Mathematics teachers working for the Ministry of Public Education or private secondary institutions are responsible for developing five fundamental processes in their classes to achieve mathematical competence in students. However, it has been observed that teachers do not have the knowledge and skills related to the process of mathematical reasoning and argumentation (Ramírez-Oviedo, 2024); therefore, how do they develop this process in their lessons? The most likely answer is that they do not adequately mediate this process. This coincides with the results obtained by secondary school students in the PISA tests and reflected in the ninth State of Education report (Consejo Nacional de Rectores, 2023).

From a survey applied to 20 practicing teachers during a workshop (Ramírez-Oviedo, 2024) it was determined that 15 of them did not receive instruction on argumentation in their initial training, but two of the teachers who said they received instruction on argumentation clarified that it was implicit through mathematical demonstrations. This raises questions about the argumentative practices of teachers during the development of their lessons and how they

promote this skill in students. Although most of the teachers interviewed agree that argumentation depends on a structure, very few identify which elements compose an argumentative process, which suggests that the teachers' argumentative practices do not have a clear structure. From the surveyed teachers' perception of argumentation and their inability to structure the argumentative practice on mathematical tasks, questions arise: how do teachers develop and enhance reasoning and argumentation in their students? Importantly, how to improve teachers' discursive practices related to argumentative processes in the mathematics classroom? For Solar & Deulofeu (2016), argumentation in mathematics can be promoted by encouraging participation, in particular, through error management and generative questions, as well as through open mathematical tasks and planning activities that anticipate argumentation.

In the Costa Rican context, three moments can be considered to develop the processes of reasoning and argumentation in mathematics teachers. First, in those students of Mathematics Teaching or related courses, from their initial courses and in an integrated manner; second, through a course or workshop with advanced students of this career to connect the processes of reasoning and arguing with their future teaching role; or, through training to practicing teachers as part of their continuing education. In this research, we mainly consider the first moment: we intend to incorporate the processes of reasoning and arguing in an introductory course of Mathematics, since, as Crespo *et al.* (2010) point out, students should build the significance of argumentation and teachers should favor scenarios where the objective of arguing is achieved through their classroom practices.

The term argumentation has different approaches; however, from a general perspective, argument is understood as "reasoning through which one tries to prove or disprove a thesis, convincing someone of its truth or falsity" (Ferrater Mora, 1964, p. 127). Since ancient Greece, arguments have been analyzed and classified in a broad sense according to their nature: on the one hand, analytical arguments based on formal-logic, while on the other hand, there are dialectical arguments based on accepted opinions and framed in rhetoric. Immanuel Kant makes a distinction between inference, proof and demonstration, understanding inference as a reasoning process that allows to derive judgments from others, proof is a reasoning process that allows to obtain certainty about certain knowledge and finally demonstration is a type of proof based on intuition and deduction (Martínez, 2022). Since the 1950s, the formal study of argumentation was taken up again and philosophers such as Chaïm Perelman, Lucie Olbrechts-Tyteca and Toulmin presented major works such as *The Uses of Argument* (Toulmin, 2003) and *Traité de l'argumentation*:

La nouvelle rhétorique (Perelman and Olbrechts-Tyteca, 1958). For Durand-Guerrier *et al.* (2012) these philosophers saw argumentation as a reasoned (and reasonable) form of discourse on a subject under debate, in which appeals to emotion are excluded, but in which rationality need not be conveyed solely through deductive reasoning which prompted a debate on the relationships between exploration, argumentation, proof, explanation and justification in mathematics. In Mathematics Education, some authors such as Balacheff (2000), Duval (1993), Toulmin *et al.*, (1984) Weston (2006) present several notions about argumentation, which have elements in common and at the same time present important differences, which do not allow achieving a consensual definition of argumentation.

According to Balacheff (2000) there are important differences between the terms: explanation, proof and demonstration. In explanation, the subject who provides it establishes and guarantees the validity of his propositions, based on his knowledge and his own rationality. On the other hand, proof is seen as an explanation recognized and accepted by a community, i.e., there are elements in the explanation that go beyond the rationality of the subject who provides it, there are external elements recognized by the community that provide validity, there is then a social process that provides validity to the given propositions. Finally, proof is a type of proof that follows a structure and a logical process that gives it rigor, but at the same time it is a social process that must be accepted by the mathematical community. In the case of Balacheff, the definitions of proof and demonstration coincide with Kant. For Duval (1999), Balacheff's work proposed a more detailed perspective on the beginning of proof, through the exploration of problems, and it is from this proposal that interest in the forms of argumentation that appear in the resolution of problems began, which in turn figured a possible scenario of the route from argumentation to demonstration. However, for Duval, this continuity can only occur in a mathematical and not a cognitive framework; moreover, the notion of argumentation is closely associated with that of justification of an assertion or a thesis. But in the justification of an assertion, it is important to separate two operations: the production of reasons or arguments, and the examination of the acceptability of the arguments produced. For Duval, this acceptability is based on demonstration and not on argumentation. He defines arguing as an activity closely related to the justification of an assertion or thesis (Duval, 1993).

### **Argumentation management in the mathematics classroom**

The way in which teachers approach argumentation or should approach it in their mathematics lessons is fundamental to develop this mathematical skill or

process in students. For the specialist ES1, a first aspect to consider in order to promote argumentation is "the choice of mathematical tasks" and a second factor for ES1 is the management of these mathematical tasks in the classroom "one way in which I consider that argumentation has to be approached is in modeling. And it is in modeling in classes, both at the teacher level and at the student level." While for ES2 it is through problem solving that students' reasoning is activated "because I believe that, through problem solving, for example, when you are working at levels, even from basic to engineering careers, in problem solving there has to be a process of argumentation."

In addition to problem solving as a methodological strategy, according to ES2, the process of argumentation is activated through classroom discussion "in this process, argumentation plays a fundamental role because the student, when sharing with classmates and with the teacher, has to argue about the solution or about the attempted solutions that he/she put into play". For ES3, problem solving is a strategy that encourages argumentation "when a student is solving a problem, one way to validate what he is doing is through argumentation, so there is a connection between these two competencies" however he also highlights abduction in the mathematics class "I would believe that it is part of the process, to let students conjecture, test hypotheses, establish conclusions and then they can be validated in the framework of a class discussion, a collective discussion".

## Error management

Errors linked to mathematical content can be used as a resource to obtain relevant information that contributes to the improvement of various aspects of didactic planning (González *et al.*, 2015). For ES3 the error is fundamental for learning mathematics "when we talk about the error, the teacher, depending on his epistemological position, must make decisions, one of them is to correct the error, it would be wasting a great opportunity if only the correction is made". The error has the potential to show the student's reasoning, as ES3 points out:

In many occasions when you go to ask him and try to trace where that comes from that which for us is an error, there is always a sense that he gave that allows you to follow a line of his thinking and that is very interesting because by following that line one can discover that one undoubtedly has knowledge.

Particularly in the line of argumentation, it has a preponderant value in contrasting chains of reasoning among students.

ES3: In the framework of argumentation, the ideal would be for the teacher to first try to make them aware of their statements, if the student has said something that is wrong, not to tell them you are wrong, but to raise some elements that lead them to question their own statement, so that the student realizes the error and with the teacher's mediation can overcome this difficulty.

For ES3, in addition to encouraging argumentation, the error has a formative evaluation role, which allows the student to advance in the construction of his knowledge.

For ES1, ES4 and ES5, posing mathematical situations to students who intentionally have errors for analysis and discussion is a way of encouraging argumentation in the mathematics class.

ES4: yes, for example, in the workshop that I tell you about logic it is full of that, it is designed precisely to make them, that is to induce them in errors and once I tell you they realize or that they do not realize and I tell them, they start discussions of what happened.

## Evaluation

The evaluation of learning is inherent to every educational process and one of its main objectives is to improve the teaching-learning process and as Trelles et al. (2017) point out, that is why the information collected should serve to reflect on the methodology used by the teacher, the resources used, the teacher-student relationship, the relationship of students with their peers, the communicative process, the curricular planning, the interests of the students.

At the diagnostic, formative and summative levels, evaluation allows teachers and students to reflect on their practices. In the mathematics class it is no different, and classroom practices involving argumentation can be evaluated and reflected upon in the same way. For ES1 and ES5, argumentation can and should be evaluated, but from both formative and summative perspectives, ES1: "I believe that, within the evaluative perspective, it must necessarily be done in both ways. And if it is only done in one way, it loses importance in the other" and also emphasizes that it should be done with more flexible tasks, which allow accepting less traditional or algebraic data and guarantees. On the other hand, for ES2 the evaluation of argumentation has a more formative role, it consists of characterizing students' arguments and their progress. For ES3 the evaluation is also commonly formative, it is analyzed by the teacher during class, but traditionally it is not recorded, although he considers that it should be. However, for ES4 it can be recorded through instruments such as

checklists. "Yes, yes, of course. Well, one could make an instrument, couldn't one? Like this, a checklist, right? What do you expect and see if, how much progress has been made, right, in these arguments?"

## Conclusions

Mathematics lesson planning is a fundamental element of teaching practice. In this planning, an adequate selection of the mathematical tasks or activities that the teacher intends to develop becomes necessary, so that on the one hand, students and future teachers can visualize the classroom model developed by the teacher through his argumentative practices and classroom management, and can internalize and adapt it for their future professional practices, and on the other hand, both teachers and students can exploit the resources they have, whether didactic such as problem solving or technological such as dynamic software that facilitates the generation and verification of mathematical conjectures and discussion among peers about the solutions to problems.

Mathematical tasks involving errors should also be planned, so that students must analyze them and mobilize justifications to argue where the error is and how it affects the solution from a mathematical point of view. It is also necessary to manage those errors that are not planned, but that appear in practice so that future teachers can learn to mobilize the errors that appear on a daily basis as part of the learning process through argumentation.

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# Educational Quality in the Chilean School System: Key Dimensions, Measurement, and Current Challenges

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## Introduction

Educational quality has been a widely debated and redefined concept in the fields of public policy, educational research, and school management. In Chile, this notion has taken on particular relevance since the structural reforms initiated in the 1980s, which established a strongly market-oriented education model that conditioned the way quality is conceived, measured, and managed in the school system. Since then, the concept has moved from approaches focused on efficiency and standardized results to more comprehensive approaches that consider contextual, pedagogical, cultural, and structural factors. Talking about educational quality in Chile necessarily implies recognizing the complexity of the concept. Multilateral organizations such as UNESCO and the OECD have proposed reference frameworks that emphasize dimensions such as equity, relevance, effectiveness, and efficiency of the system. However, their application in the Chilean context has generated tensions and debates, particularly due to the overvaluation of standardized measurements such as the SIMCE and international tests, which have limited a holistic view of learning. This perspective has been widely criticized by various authors (Bellei, 2015; Falabella & de la Vega, 2016), who have argued that such instruments do not capture the diversity of experiences and conditions that influence educational processes.

Likewise, in recent years, methodological approaches have been developed that seek to broaden the understanding of quality from multidimensional perspectives. These approaches incorporate elements such as school well-being, coexistence, educational community participation, pedagogical innovation, and educational leadership, among others. Along these lines, research (Yancovic *et al.*, 2016). In the context of Chilean educational policy, recent regulatory milestones such as the School Inclusion Law (Law 20.845, 2015), the creation of the Public Education System (Law No. 21.040, 2017), and

the implementation of the Framework for Good Teaching (2021) and the Framework for Good School Management and Leadership (2015) have contributed to reconfiguring quality criteria from a more equitable and inclusive perspective. However, significant territorial, socioeconomic, and ethnic-cultural gaps persist, hindering the full realization of the right to quality education for all.

This study, therefore, aims to advance the understanding of educational quality as a multifactorial phenomenon influenced by institutional, pedagogical, socioeconomic, and technological variables. Based on a review of recent academic literature, both Chilean and international, we seek to identify the key factors that shape quality in the Chilean school system, as well as the most commonly used methodologies for its evaluation and monitoring. In addition, we analyze the main challenges facing the country in its efforts to move toward a more equitable, inclusive, and student-centered education system.

The relevance of this discussion is twofold. On the one hand, it allows us to problematize dominant conceptions of educational quality, opening the way for more contextualized and subject-centered approaches. On the other hand, it offers inputs for the design of evidence-based public policies capable of responding to the real needs of school communities. In a post-pandemic scenario marked by the urgent need to reactivate learning, reduce gaps, and strengthen teacher training, rethinking educational quality in Chile is an ethical and political imperative. The objectives of our study seek to critically analyze the concept of educational quality in the Chilean school system, identifying key factors and current challenges in its measurement and implementation, based on a systematic review of recent literature.

## **Conceptual approaches to educational quality**

One of the main findings is the coexistence of multiple conceptual approaches to educational quality in the Chilean case. Although the dominant paradigm since the 1990s has focused on a logic of results mainly associated with academic performance measured by standardized tests such as the SIMCE, the most recent literature proposes a more holistic understanding of the concept. Authors such as Bellei (2015), Falabella (2016), and Quiroz (2020) point out that educational quality cannot be reduced to test achievement indicators but must incorporate elements such as socio-emotional well-being, equity in access, and active participation of school stakeholders. In this sense, there is a transition from a technical-productivist model to a more comprehensive one, aligned with the notions of educational justice proposed by Ibáñez (2010) and Nussbaum (2011).

## Key factors influencing educational quality

### a) Institutional factors

- Effective school management: The role of pedagogical leadership as a catalyst for improvements in school culture and learning outcomes is highlighted (Murillo & Hernández-Castilla, 2014).
- Infrastructure and resources: The gap in material and technological conditions remains a critical determinant in vulnerable schools.

### b) Pedagogical factors

- Student-centered classroom practices: Greater impact on deep learning is reported when active strategies, formative feedback, and assessment for learning are implemented.
- Teacher training and professional development: The quality of teaching is closely linked to the level of expertise and pedagogical updating of teachers (UNESCO, 2025).

### c) Contextual factors

- Socioeconomic conditions of the environment: The structural segregation of the Chilean education system continues to reproduce inequalities of origin that affect the quality of learning (Bellei *et al.*, 2021). Rural schools face greater challenges in terms of access to resources, teacher training, and digital connectivity.

## Interaction between public policy and quality measurement

A relevant finding is the strong influence of educational policy on the operational definition of "quality." For example, the Education Quality Agency has established a School Performance Evaluation System that includes indicators of academic results, management, climate, coexistence, and participation. However, academic critics (Falabella & Zincke, 2019) warn that there is still an overreliance on SIMCE results in decision-making. It is also noted that instruments such as the Framework for Good Teaching (MBE) and the Framework for Good Management (MBD) have been key to guiding educational improvement from a more professionalizing perspective. However, their implementation presents practical difficulties and requires systematic support for their appropriation by teachers and administrators.

## **Emergence of new critical dimensions. (post-2020).**

- Well-being and mental health: In the wake of the pandemic, various studies have incorporated socio-emotional well-being as an essential dimension of quality (Cabezas *et al.*, 2022; Vallejos Silva & Cortés Rojas, 2023).
- Inclusive education and territorial equity: The need to consider territorial, ethnic-cultural, and gender contexts in the evaluation of educational quality has become apparent (Venegas-Ramos & Sánchez, 2024).
- Student participation: Some research is beginning to incorporate the voice of students in quality assessments through surveys, interviews, and narrative analysis (Villalobos *et al.*, 2021).

These new dimensions challenge traditional frameworks and open the debate on the need for more sensitive, participatory, and contextualized indicators. Based on the discussion, this section aims to interpret these findings by considering three interrelated levels: (1) the evolution of conceptual frameworks and their institutional translation, (2) the tensions and contradictions between measurement and educational improvement, and (3) the contemporary challenges for advancing toward a more contextualized, inclusive, and transformative notion of quality.

## **From quality as performance to quality as educational justice**

Historically, the Chilean model has been strongly influenced by a technical and market-based rationale, where educational quality was understood as synonymous with "good academic results," generally measured by standardized tests such as SIMCE or international PISA assessments. This paradigm, based on approaches of efficiency, accountability, and standardization, has its roots in the economistic view of education as an investment in human capital (Hanushek & Woessmann, 2011). However, since the 2010s, and with greater force after the crisis of the neoliberal model evidenced in the student mobilizations of 2006 and 2011, a critical vision has gained strength that proposes rethinking quality from a rights-based approach. Authors such as Bellei (2015) and Falabella (2016) have been key in showing how the emphasis on external evaluation has had unintended effects, such as narrowing the curriculum, putting pressure on schools, and producing rankings that reinforce segregation. Thus, it is recognized that quality is not an isolated attribute of the school but a systemic phenomenon that plays out at the intersection of the pedagogical, institutional, and social spheres.

## **Assessment, measurement, and improvement: An ambivalent relationship**

A second tension interpreted in the results is the ambivalence in the relationship between evaluation and educational improvement. On the one hand, there is recognition of the need for robust evaluation systems to monitor progress, identify critical issues, and guide decision-making. In this regard, the efforts of the Education Quality Agency to include broader dimensions than academic achievement, such as the school climate and student participation, are valued. However, the literature also warns that when evaluation is reduced to punitive or comparative instruments, its transformative potential is diluted. As Navarra *et al.* (2021) and Falabella (2025) point out, evaluation can become a form of control that disconnects educational actors from their educational purpose. This is especially problematic in highly vulnerable contexts, where schools require technical support, resources, and collaborative networks rather than sanctions or incentives based on performance indicators.

## **School factors, leadership, and teacher professionalism**

One of the most robust contributions of the studies reviewed is the identification of school factors that positively influence educational quality, including pedagogical leadership, teacher collaboration, and the implementation of student-centered practices. These findings are consistent with the research of Leithwood *et al.* (2019), who emphasize that effective school leaders create cultures of sustained improvement, support innovation, and strengthen the capacities of their teams. In this sense, quality is not achieved simply by the presence of standards or regulatory frameworks but by the ability of school actors to critically appropriate them and adapt them to their reality. Here, teacher professional development emerges as a strategic variable: it is not just a matter of increasing training hours but of creating professional communities that reflect on practice, share knowledge, and build contextualized solutions. However, this idea faces significant structural barriers in Chile, such as work overload, fragmentation of school networks, and the devaluation of the teaching role in public culture. On this point, the results agree on the need to move toward a more horizontal pedagogical support system that replaces the logic of oversight with the logic of institutional learning.

## **Structural inequalities: a persistent obstacle**

This phenomenon has been widely documented by Morales *et al.* (2022), who argue that the institutional architecture inherited from the 1980s continues to segment educational opportunities. Thus, public schools in rural or vulnerable

areas face multiple challenges with fewer resources and lower levels of institutional support (Muñoz *et al.*, 2021). In this context, quality cannot be understood as a universal standard but rather as a situated horizon that requires differentiated strategies according to the context. This implies advancing affirmative action policies, strengthening Local Public Education Services (SLEP), and greater pedagogical autonomy for school communities.

### **The emergence of new dimensions: well-being, participation, and meaning**

A particularly innovative aspect of recent literature is the incorporation of new dimensions that complicate the idea of quality. Socio-emotional well-being, the mental health of students and teachers, student participation, and the meaning of learning appear as key elements for meaningful and transformative education. In this sense, the epistemological shift proposed by the notion of "comprehensive education" is key to overcoming the dichotomy between content and affectivity, between academic achievement and citizenship. As authors such as Ponce *et al.* (2020) and Biesta (2015) argue, education is not only about transmitting knowledge but also about forming autonomous, critical individuals who are committed to the world.

### **Conclusions**

The conclusions corroborate that the debate on educational quality cannot be reduced to standardized indicators. Understanding the complexity of the Chilean school system requires considering the country's structural conditions, regulatory frameworks, school cultures, and the voices of communities. Only from a comprehensive, situated, and participatory perspective is it possible to move toward a truly transformative education.

### **Educational quality is a multidimensional construct.**

One of the central findings of this research is that educational quality cannot be understood as a univocal construct or reduced to standardized test results. On the contrary, it is a multidimensional phenomenon that involves not only academic performance but also institutional, pedagogical, emotional, contextual, and cultural factors. This comprehensive view is in line with the frameworks proposed by UNESCO, which maintain that quality education must be inclusive, equitable, relevant, and focused on the full development of students. In the case of Chile, this broadening of the concept of quality has been driven both by critical research and by regulatory changes in the context of the Educational Reform of the last decade.

## **Tensions persist between assessment, accountability, and school improvement.**

Although the quality assurance system in Chile has incorporated important advances, such as the formative approach of the Education Quality Agency and the Framework for Good Teaching, tensions still exist between the logic of control and the logic of continuous improvement. Assessment tools, especially the SIMCE, continue to be used as school ranking mechanisms, which can have adverse effects such as curriculum narrowing or the stigmatization of vulnerable communities.

## **Pedagogical leadership and teacher collaboration are strategic pillars.**

A robust conclusion derived from the evidence is that distributed pedagogical leadership and collaboration among teachers are necessary conditions for the development of a school culture oriented toward quality improvement. Schools that manage to build professional learning communities based on joint reflection, pedagogical innovation, and critical appropriation of regulatory frameworks generate better conditions for student learning. In this sense, quality cannot be imposed from outside schools. However, it must be built from within through teacher professional development processes that value situated pedagogical knowledge, promote autonomy, and strengthen institutional capacities.

## **Structural inequalities continue to condition quality.**

Despite regulatory advances in school inclusion and the strengthening of public education, the Chilean school system continues to reproduce deep inequalities associated with socioeconomic status, geographic location, and the type of administrative dependence of schools. These structural gaps have a direct impact on the material conditions of teaching, school retention, and learning opportunities for children and young people. Therefore, talking about educational quality without considering the social and territorial context is methodologically insufficient and ethically problematic.

## **The incorporation of new dimensions and technologies is both an opportunity and a challenge.**

The most recent studies have highlighted the need to expand traditional quality indicators to include dimensions such as socio-emotional well-being, mental health, student participation, and school-community relations. Likewise, the development of analytical technologies offers promising tools for more sophisticated and personalized assessment. However, these opportunities also



pose ethical, technical, and pedagogical challenges. Technology alone does not guarantee quality, and its use must be at the service of learning and educational justice.

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# Kingdom, power and glory. Teaching a scientific ontology for international analysis through a TV series

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## Introduction

In the field of Social Sciences, we understand a scientific ontology as a system of conceptual references to the type of entities that can be validly used to construct a theory or a story with explanatory pretensions. A scientific ontology, rather than a simple catalog of objects, offers a repertoire of entities that, by their clarity, sharpness, and boundedness, allow the scientific construction of valid and parsimonious explanations that are centrally composed of conceptual and theoretical elements.

According to Jackson and Nexon (2013), an important part of the theories referred to the international field would be given by the development of scientific ontologies (Jackson, 2008), which would allow us to map better the social phenomena that are addressed in the international field (Jackson & Nexon; 2013) Such theories would be composed of concepts such as actors, processes, systems, and mechanisms, thus providing a conceptual framework that allows us to address international phenomena.

More specifically (Jackson & Nexon, 2013) points out actors such as States, international organizations, and multinational corporations (although also individuals), as well as various contexts in which they are situated and developed and especially the type of processes they develop (behaviors, actions, decisions, communications, relationships, interactions, practices, etc.).

## How can a Scientific Ontology be taught in the International Relations?

In order to evaluate the potential of a scientific ontology and thus be able to teach something like the above, one possibility is to present a real or fictitious case from which, using a scientific ontology, some explanations with scientific

aspiration can be constructed. What is relevant is that when it is taught, it allows the learner to experience the dilemmas, uncertainties, and complexities faced by the protagonists of a case, which can be constituted by a news item, a movie, a TV series, or other similar media.

The use of diverse fiction, science fiction, and fantasy films for teaching politics and international relations already has a specific tradition (Nexon & Neumann, 2006; Gokcek & James, 2021; Campbell & Gokcek, 2019), which facilitates the learning of abstract concepts and theories of a certain complexity, using fictional universes in which conceptual and analytical frameworks provided by the theory are applied (Ayhan, 2019). This exercise enables the transfer of acquired abstract knowledge to various situations and specific environments, resulting in the development of higher-order analytical and synthetic cognitive skills (Gokcek & James, 2021). An important aspect of this is reflected in the work of Moïsi (2017), who directs his gaze to the power contained in contemporary TV series, disseminated mainly through streaming technologies, to teach theory.

### **Borgen: Kingdom, power, and glory as a staging of a case**

In tune with what Moïsi (2017) pointed out, Chow, Waade, and Sanders (2020) highlight the series *Borgen* as an excellent case that combines fiction with an important share of realism and feasibility (Nitsch, Jandura & Bienhaus (2021), which is particularly useful for the teaching of international political analysis (Stenberg & Switek, 2023) as it is built in a narrative that does not elude the complexity and multidimensionality of the facts (Hochscherf, 2019).

In its initial three seasons, the series *Borgen* (Egholm, 2010-2013) focuses on Danish politics, providing an excellent overview of the functioning of the Danish parliamentary system. The fourth season, nine years after the third, entitled "*Borgen: Kingdom, Power, and Glory*" (*Borgen - Riget, Magten og Æren* - 2022) (Foldager Sørensen, 2022), is a good testing ground to preliminarily test specific performances of a scientific ontology combining systems, institutions, and actors. This is the last season of the original series *Borgen* (Egholm, 2010-2013), which has been broadcast and explores, in eight chapters, the global implications of the fictitious fact that new oil sources are discovered in Greenland, ready for exploitation. This is a high-level geopolitical upheaval in the Arctic, a scenario in which, in addition to Greenland, Denmark, the USA, China, and Russia play significant roles.

In its version of the year 2022 (4th season), the series gives continuity and depth to a theme that was already mentioned in chapter # 4 of the first season (Hammerich, 2010), and that has to do with the complex relationship between

Greenland and the Kingdom of Denmark in matters of sovereignty, within the framework of the alliance between Denmark and the USA, and in the context of the global fight against terrorism led by the American state. In this chapter, in addition to the geopolitical and diplomatic tensions, a section raises the question of how the relationship between Greenland and Denmark would be strained if new oil sources were found on the island. In *Borgen: Kingdom, Power, and Glory* (2022), this topic is developed and deepened in an interesting level of complexity throughout eight chapters, developing a hypothetical (but very probable) case of what could happen/had happened if any of the hydrocarbon prospections on the island were finally able to find oil in exploitable conditions (see Nielsen, 2024). In this respect, although fictional, this hypothesis dialogues interestingly with the fact that even though in 2009, Greenland acquired autonomy in the exploitation of natural resources, in 2021, it suspended any new exploration for hydrocarbons (gas and oil), alleging the negative impact that the eventual extraction of this type of resources would bring in the context of global warming. (Associated Press, 2021) In this regard, it should be noted that Nielsen (2024) refers to an interview with the creator of the series (Adam Price) in which he evokes the thesis put forward by the former Minister of Foreign Affairs of Denmark, Martin Lidegaard, and refers us to No. 10 of the Act of Greenland Home Rule Act, especially about relations between Greenland and Denmark and the regulation of income derived from the extraction of raw materials, and specifically to the repercussions of an eventual case in which the subsidies provided by Denmark to Greenland would be reduced to zero by the island's revenue generation, which would open a platform to discuss its eventual independence. (see also Boukes, Aalbers & Andersen, 2022).

## **Systems and Actors**

About the case referred to above, it should be noted that the understanding of international processes requires a view that articulates both the functionally differentiated systems and institutions of world society (Politics, Economics, Science, etc. Luhmann, 2006; Roth & Schutz, 2015) that cross national borders (Albert, Buzan & Zurn, 2013) as well as the role of the organizations that operate in its context in which, international politics opens beyond the States, incorporating diverse actors that interact strategically through the symbolically generalized medium of power (Baraldi, Corsi & Esposito, 2021; Guzzini, 2000; Luhmann, 2005). The progressive differentiation of systems at the global level has promoted the development of specialized institutions and organizational actors, which do not correspond to individuals but to organized systems that process decisions in tune with the different functional systems. Willke (2006) and Drepper (2005) emphasize that these actors—be they companies, NGOs,

government bodies, or social movements—must operate in structurally differentiated environments while maintaining relative autonomy, linking to each other through complex networks that give rise to constellations of interaction (Mascareño, 2000; Scharpf, 1997).

In this context, organizational actors are not mere recipients of institutional rules provided by systems but rather active shapers of their interests and strategies within dynamic networks framed by normative and institutional contexts (Aguilera, Geppert, & Jackson, 2019). Therefore, the observation of contemporary international politics requires considering both systemic logic and organized agency in a permanent co-constitution between global functional differentiation and strategic action.

### **Strategic Interactions: Tale of an Eskimo Roll**

In the context of the Borgen series, *Kingdom*, *Power*, and *Glory*, the strategic interactions between actors are numerous and varied and occur at different levels. They range from the family level to the level of interaction between governments, passing through a wide range of intermediate levels. For the exercise that this paper aims to develop, we will focus our attention almost exclusively on the international sphere and how Denmark and Greenland interact in terms of their prerogatives and duties in the scenario of the discovery and eventual exploitation of fossil fuels on the island. In fact, except for the account of the indispensable communicating vessels between the national and the international, the development of the counterpoint and the repercussions of foreign policy actions on Danish domestic policy is omitted.

To this end, a schematic narrative can be constructed, drawing freely on the proposal of analytical narratives (Levi, 2002; Bates et al., 1999). This methodological approach is consistent with a scientific ontology such as Mansouri (2024) calls institutional individualism, in which strategic actors are understood as basic explanatory units, whose actions are framed by systemic, and institutional structures that shape their frameworks of action. This hybrid basis allows for a productive tension between formal modeling and narrative contextualization, as actors narratively interpret rules, norms, and contexts.

The diagrams included below attempts to metaphorically reflect the tangled "Eskimo roll" of the Danish Minister of Foreign Affairs at a moment in which she loses her personal and political compass, which leads her to make a 360° turn from her initial environmentalist position, moving to a moderate position promoting responsible exploitation, to return to her original position. The curious aspect of the case is that, beyond the position regarding the

exploitation of hydrocarbons, the ultimate background concerns the sovereignty of Greenland and its relationship with Denmark.

#### Diagram No. 1: Story of an Eskimo Roll (part I)

##### First moment: The commitments of an Environmental Alliance (Progressivism)

- a) Greenland announces oil discovery on the island by "Canadian" company
- b) The tension is generated by whether to proceed with the exploitation of this new resource:
  - i) Greenland Government in favor of opportunities
  - ii) Danish government against over campaign commitments
    - **A conflict between nations opens up**
- c) Danish government incorporates information from "undesirable" Russian controller in the Canadian company, which would allow it to veto exploitation for security reasons
- d) The US asks the foreign minister to temporarily withhold this information for intelligence reasons; offers in exchange to support his nomination to the UN
  - **Negotiation / Quid Pro Quo**
- e) Minister accesses
  - **Commitment and Collaboration with the USA**
- f) Foreign Affairs Committee questions Minister about information
  - **Executive and Legislative Tension → Ambush**
- g) TV1 investigates the case of the information of the Russian controller
  - **Pressure grows**
- h) Minister questioned by members of her party, and by the prime minister
  - **Pressure grows again**
- i) Nyborg seeks support from opposition leader, in exchange for oil support
- j) TV1 foresees minister's resignation in on-screen interview
- k) Instead, the Minister changes her position (politics) on oil
  - **Lowers Pressure; Ambush Escape**

#### Diagram No. 2: Story of an Eskimo Roll (part II)

##### Second Moment: A Green and Democratic Oil (Realistic Moderation)

- a) She is once again questioned by the Prime Minister and her party
- b) It is reported that the Russian company has been bought by Chinese capital
  - **Low Internal Pressure**
- c) Nyborg reproaches Eliassen for being unrealistic in achieving independence.
- d) Eliassen ends negotiations and returns to Greenland
  - **Negotiation Failure→Conflict Remains**
- e) Prime Minister is aligned with Nyborg
- f) Kirkegaard reports sale of land to Chinese to build port
- g) U.S. Secretary of State Pushes for Chinese Exit from Greenland
  - **Commitment and Collaboration with the USA**
- h) Minister of Justice reports impossibility of avoiding contract with Chinese
  - **Governmental Conflict/Dilemma**

- i) Nyborg offers a trilateral company: Denmark Greenland China
  - i) Liking the USA
  - ii) Resignation on the part of China
    - **Negotiation**
- j) The Minister of the Environment resigns from the party and the government.
  - **Coalition Conflict**
- k) Sirius Patrol Border Incident After Chinese Military Drone Crash
  - **Restlessness; Military Pressure**
- l) U.S. reports soldiers were from a Russian submarine
- m) Greenland offers Denmark 25% of the profits of the joint venture
- n) Party pressure on Nyborg renewed
- o) Neutralizes pressure by a narrow margin
  - **Conflict is controlled, but remains in the making**
- p) Minister of Finance propose 50% and 50% and trilateral company, to Greenland.
- q) The US also asks to set up its own port
- r) Arctic Ambassador conveys this offer to Greenlandic Foreign Minister
- s) Berthelsen warns Nyborg he will challenge his leadership at party congress
- t) PM Instructs Nyborg to Travel and Sign Triple Company Agreement
- u) The deal is threatened by intense U.S. (jets) concerns about China
  - **Trilateral Company is signed**
- v) After the signing and conversation with the Minister of Greenlandic, doubts arise
  - i) Geopolitics between Denmark and Greenland is revealed
- w) Nyborg speaks with Kragh and says the agreement is unsatisfactory to all parties. It's a very sub-optimal arrangement. He proposes to go backwards.
  - **Disappointment →Setback**
- x) Nyborg draws on the special environmental situation of the Arctic and the impact on whale food (Krill, Plankton, etc.) to evict what was agreed
- y) A new position is consolidated in the presence of both prime ministers.
  - i) New route to increase Greenland's autonomy
  - ii) Original environmentalist position is recovered

## Conclusions

In its preliminary application, the proposed scientific ontology tested offers interesting results in terms of illustrating concepts such as systems, institutions, organizations, actors, and strategic interactions in the development of the case provided by the Borgen series, which acquires special importance in the realism of its story and the particular feasibility of the central premises of its story in terms of international politics. The series is vibrant due to the exercises carried out. The analyzed story narrates and applies strategic game theory (Scharpf, 1997) and the logic of mechanisms (Little, 2019) by illustrating conflicts, negotiations, compromises, collaborations, coalitions and even ambushes; all of them devices typical of international politics. However, such



strategic interactions do not take place in a vacuum, but in meso and macro contexts provided by institutional frameworks and functional social systems. The scheme developed integrates the narrative of the series into a global analytical narrative, based on micro elements, which allows us to construct explanations for highly complex situations such as those that characterize the contemporary dynamics of international relations. In the context of this work, the high intelligibility component that the combination of formal conceptual apparatuses acquires using narrative devices such as a TV series should be highlighted. This is particularly important in the context of the development of a didactic tool for students of International Relations, as it facilitates the incorporation of abstract concepts through a highly successful audiovisual narrative. In terms of strategic interaction, and beyond schematically recording and graphing the presence of dynamics of collaboration, competition, and conflict, the story shows us how the political system can rely on the knowledge generated by the scientific system, whether it is part of the natural or social sciences, to support the change of political position. In this sense, the semantics of democracy, human rights, or environmental protection are instrumental (hence the centrality of a *techno-spin doctor* in the series), opening up possibilities for new types of analysis.

Beyond the macro level analysis, the TV series also opens up the possibility of addressing other topics of particular importance today at other levels (meso, micro), such as female leadership in complex organizations and the multilevel ubiquity of the power environment. Finally, whoever believes that the exploitation of oil drives the central conflict has overlooked a final level of depth, and that is the one that reveals the indispensability of the unity of the kingdom and its sovereignty in the face of the complex global geopolitical tensions affecting the Arctic.

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# **From design to validation: a model for impact assessment of teacher training in Chilean universities with current curricular innovation processes**

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This text arises in the context of a doctoral research project related to the evaluation of the impact of teacher training in Chilean state universities with current curricular innovation processes, through the implementation of a proposed model for this purpose.

## **Introduction**

Higher education institutions have promoted curricular innovation processes in response to social, economic, and technological changes that demand more relevant and high-quality professional training. These processes have involved transformations in curricula, integration of technologies, adoption of a competency-based approach, and renewal of pedagogical practices. These trends have been particularly evident in Latin America, where curricular reforms reflect broader demands for educational relevance, technological integration, and the development of professional competencies (Riveros, 2025).

Within this framework, university teacher training has been consolidated as a strategic pillar, conceived as a continuous and comprehensive process aimed at developing pedagogical, digital, and research competencies (Aramburuzabala et al., 2013). Strengthening faculty capabilities in these areas is essential to sustain curricular transformation and to align teaching practices with contemporary educational demands.

International organizations have emphasized the need for training policies that go beyond content updating to also foster inclusive and innovative learning environments (UNESCO, 1998; Reinoso et al., 2024). However, these transformations require rigorous evaluation mechanisms capable of demonstrating their actual impact. As noted by Feixas et al. (2015) and Gairín (2010), it is essential to implement models that assess not only satisfaction or

immediate learning outcomes but also the transfer of knowledge to teaching practice and broader organizational changes.

## Teacher Training

University teacher training is a continuous and strategic process that enhances pedagogical, digital, research, and socio-emotional competencies, directly impacting educational quality and essential university functions such as teaching, research, and institutional management. This training must align with the contemporary challenges of higher education, fostering comprehensive professional development that responds to technological, social, and epistemological transformations of the 21st century (Imbernón, 2017; Salinas & De Benito, 2020; Zabalza, 2011). Furthermore, it promotes a culture of continuous improvement and academic excellence (Zabalza, 2013). International organizations such as the ILO (2021) highlight the need for systematic evaluation systems, promoting models with holistic and transformative approaches (González, 2021).

These models are based on stakeholder-centered approaches and diverse organizational structures, where integrated programs stand out for their collaborative and systemic effectiveness (Zabalza, 2007; Aramburuzabala et al., 2013). In response to current challenges, training in active methodologies, digital technologies, inclusion, and diversity is prioritized, which in turn demands robust and multidimensional evaluation systems to assess both processes and their impacts (Pineda, 2000).

## Evaluation Context

In higher education, teacher training impact evaluation models make it possible to analyze the effects of training actions beyond immediate satisfaction or knowledge acquisition. These models integrate broader dimensions such as transfer to professional practice, institutional transformation, and student learning outcomes (Carrasco & Farías, 2023). As conceptual representations, they encompass the different stages of the evaluation process—from design to results—facilitating the understanding of complex educational phenomena (Sabarwal, 2014). Among the most influential approaches are those of Scriven (1991), Kirkpatrick (1998, 2006), Guskey (2000), Brinkerhoff (2006), Phillips (2006), Patton (2008), and the CIPP model developed by Stufflebeam and Zhang (2017), oriented toward continuous institutional improvement. Despite their broad application in universities, these models require contextual adjustments to address the specificities of Latin American systems, particularly regarding equity and institutional quality.

## Context Description

From a complementary perspective, the evaluation of teacher training can be approached at three interconnected levels: implementation processes, immediate outcomes, and long-term impact, as suggested by Scriven (1991), Chen (2015), and Rossi et al. (2019). Impact evaluation, in particular, enables the identification of causal relationships between training interventions and observed changes (Bamberger et al., 2019; Gertler et al., 2011; OECD, 2017). This type of evaluation is essential to understanding the real effects of teacher training on pedagogical practices, student achievement, and institutional culture. Moreover, it provides solid evidence to support decision-making, promote continuous improvement, and strengthen accountability within higher education institutions.

## Proposed Model

The impact evaluation model for teacher training in higher education proposed in this study constitutes a theoretical and methodological framework that allows for a systematic analysis of the effects of professional development programs on faculty, students, and the institution. Unlike approaches that focus exclusively on satisfaction or short-term learning, this model incorporates dimensions such as pedagogical transfer, student learning impact, and institutional change (Carrasco & Farías, 2023). Adopting a comprehensive perspective, it covers all phases of the training cycle—planning, implementation, monitoring, and evaluation—and seeks to enhance academic quality and institutional management.

Its application enables a rigorous and contextualized assessment of the relevance and sustainability of teacher training programs, aligning their outcomes with institutional strategic objectives. The model promotes an ethical and participatory approach, supported by methodologies such as triangulation, instrument validation, and results analysis, fostering a critical and collaborative evaluation culture. It draws on key principles such as comprehensive and contextualized assessment (Stufflebeam & Zhang, 2017), evidence-based learning (Guskey, 2000), continuous improvement (Stufflebeam & Coryn, 2014), practical utility (Patton, 2008), and the theory of change (Kirkpatrick & Kirkpatrick, 2006), which links training initiatives with verifiable transformations in professional practice and institutional outcomes. Its structure comprises five interrelated levels, each defined by descriptors, evaluation aspects, suggested techniques, key informants, and strategic relevance.

**Figure 1.** *Impact Assessment Model for Teacher Training in Higher Education in the Context of Curricular Innovation.* **Source:** Own elaboration.



Designed specifically for Chilean universities undergoing curricular transformation, the model integrates international frameworks from Kirkpatrick (1998), Guskey (2000), and Gairín (2010). Its five analytical levels are:

1. Institutional Action: Evaluates organizational commitment to faculty training.
2. Satisfaction: Captures participants' perceptions of program quality and relevance.
3. Learning: Assesses the acquisition of knowledge, skills, and attitudes.
4. Transfer/Innovation: Evaluates the application of learning in pedagogical practice.
5. Outcomes: Measures the impact on student learning, faculty development, and institutional advancement.

With a comprehensive and contextualized approach, the model seeks to overcome reductionist frameworks, contributing to the continuous improvement of teaching and reinforcing quality in Chilean higher education (Zabalza, 2011; Pineda, 2000).



## Content Validity Analysis (CVR Index)

The analysis of the instrument's content validity using the CVR index yielded highly favorable results. A total of 86% of the items (18 out of 21) achieved a CVR of 1.000, indicating full consensus among the six expert judges regarding their essentiality. Three items obtained a CVR of 0.667, a value below the critical threshold established by Tristán (2008) for panels of six experts ( $\text{CVR} \geq 0.99$ ). These results suggest the need to review the wording or content of these items to improve their clarity and alignment with the construct being evaluated.

When the results were disaggregated by dimension, a high degree of consistency was observed in expert assessments. The dimensions of Clarity and Understandability and Relevance and Coherence achieved an average CVR of 1.000, reflecting strong conceptual and linguistic validation. The remaining dimensions also exceeded the conventional acceptance threshold, with average CVR values of 0.917 for both Applicability and Feasibility and Conceptual Rigor and Theoretical Foundation, and 0.933 for Usefulness for Continuous Improvement. These findings support the internal consistency and theoretical robustness of the proposed model.

**Table 1.** *Content Validity Index (CVR) by Dimension and Items with Critical Scores.*

| Dimension                                   | CVR Average |
|---------------------------------------------|-------------|
| Clarity and Understandability               | 1.000       |
| Relevance and Coherence                     | 1.000       |
| Applicability and Feasibility               | 0.917       |
| Conceptual Rigor and Theoretical Foundation | 0.917       |
| Usefulness for Continuous Improvement       | 0.933       |

**Note.** Items with CVR values below 0.80 should be revised to improve clarity or reformulated. A second round of validation is recommended with additional expert reviewers.

## Analysis of the Achievement Percentage by Dimension

In addition to the CVR, the percentage of achievement (% Achievement) was calculated for each dimension by summing the scores assigned by the expert judges (on a five-point Likert scale) and comparing them to the total possible score. This complementary metric provided a practical indicator of the model's level of acceptance among evaluators.

**Table 2.** *Percentage of Achievement by Dimension.*

| Dimension                                   | Maximum Score | Score Obtained | % Achievement |
|---------------------------------------------|---------------|----------------|---------------|
| Clarity and Understandability               | 120           | 116.0          | 96.67%        |
| Relevance and Coherence                     | 120           | 119.0          | 99.17%        |
| Applicability and Feasibility               | 120           | 113.0          | 94.17%        |
| Conceptual Rigor and Theoretical Foundation | 120           | 115.0          | 95.83%        |
| Usefulness for Continuous Improvement       | 150           | 148.0          | 98.67%        |

The results indicate that all five dimensions achieved over 94% of the desired scores. The “Relevance and Coherence” dimension stood out with 99.17%, followed by “Usefulness for Continuous Improvement” (98.67%) and “Clarity and Understandability” (96.67%). These high values reinforce the robustness of the model from a practical standpoint and confirm its alignment with the evaluation needs of the university context.

The percentage analysis supports the validation process by enabling: (1) a quick understanding of expert consensus, (2) preliminary evidence of internal consistency, (3) anticipation of future reliability tests such as Cronbach’s alpha, and (4) triangulation of results with CVR scores. This strengthens the methodological rigor of the evaluation and facilitates transparent and well-founded reporting.

The overall findings demonstrate strong expert agreement regarding the model’s relevance, clarity, and applicability. The content validity index (CVR) reached optimal levels for most items and dimensions, while the complementary percentage analysis further substantiated these results. As emphasized by Escudero (2003) and Stufflebeam and Coryn (2014), the integration of pedagogical orientation, institutional context, and evidence-based decision-making is fundamental for the development of effective formative evaluation models.

Moreover, the participation of experts from diverse areas of higher education—teaching, student support, research, and community outreach—

enriched the validation process by incorporating multiple perspectives. This diversity enhances the adaptability and contextual feasibility of the proposed model.

The results support the conclusion that the model possesses strong content validity and empirical grounding for use in real-world contexts. Nevertheless, it is recommended that the items with lower CVR values be reviewed to improve their wording and ensure optimal formulation in future iterations.

## Conclusions

The proposed model for assessing the impact of teacher training in higher education, particularly in the context of curricular innovation, provides a solid theoretical and methodological foundation for evaluating both individual and institutional outcomes. The validation process confirms that the model exhibits high internal consistency, conceptual clarity, and practical feasibility. Its five-level structure enables a comprehensive analysis of institutional engagement, participant satisfaction, knowledge acquisition, pedagogical transfer, and educational outcomes.

The results of this preliminary validation support its use as a tool for decision-making, quality assurance, and continuous improvement in teacher development programs. Furthermore, the model aligns with current trends in educational evaluation by incorporating multidimensional, participatory, and context-sensitive approaches.

Future studies should focus on implementing the model in real university settings, gathering empirical data to assess its predictive capacity and operational utility. Additionally, further rounds of expert review and pilot testing are recommended to refine specific items and enhance the instrument's reliability and generalizability.

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# Authentic Voices: Integrating Slang, Jargon, and Taboo in L2 Spanish via Virtual Coaching

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## Introduction

The acquisition of a second language (L2) entails more than mastering grammatical rules and a core vocabulary; it involves the development of intercultural communicative competence (ICC), which emphasizes the ability to understand, relate to, and interact effectively with people from diverse cultural backgrounds (Byram, 1997). Successful communication in an L2 goes beyond the accurate exchange of information; it depends on the learner's ability to interpret meaning within cultural contexts and to establish meaningful social relationships (Byram & Wagner, 2018). Intercultural language learning, therefore, must integrate both language and cultural understanding, viewing culture as the lens through which meaning is created and interpreted (Liddicoat & Scarino, 2013). In this process, technology plays a pivotal role, offering learners direct access to authentic language and cultural practices in real-time (Abrams, 2020).

In the context of Spanish as a foreign language, particularly in an online course centered on Spanish/English translation, engaging with the diverse lexicon of the Hispanic world, including dialectal variation, register, euphemisms, idioms, and taboo expressions, is essential for developing authentic communicative competence (Mayo Martín, 2023; Bradford, 2010). However, traditional pedagogical approaches, often grounded in textbook content, tend to treat culture as static and homogeneous, overlooking the rich complexity of real-world language use (Liddicoat & Scarino, 2013). Colloquial and taboo language, in particular, are frequently excluded, leaving learners unprepared to navigate informal, emotionally charged, or culturally sensitive interactions (Bradford, 2010; Mayo Martín, 2023). This omission can hinder learner's ability to communicate effectively and appropriately in diverse Spanish-speaking settings.

This classroom-based study addresses this pedagogical gap by examining how virtual exchanges (i.e., structured online conversations with native speakers) can enhance both linguistic and intercultural competence among L2 Spanish learners. Through guided interactions and exposure to real-world media, this study explores how students acquire culturally embedded expressions and

navigate language in context. Virtual exchanges offer rich exposure to authentic input and provide opportunities for learners to engage directly with diverse Spanish-speaking interlocutors (Sevilla Pavón & Haba Osca, 2016). Authentic resources, defined as materials created by and for native speakers, help learners see how language operates within its cultural context (Abrams, 2020), while live interactions foster reflection and real-time adaptation.

A central component of this study is the inclusion of a specialized module on lexical variation, which uniquely incorporates the explicit study of taboo language, a subject rarely addressed in traditional instruction due to its sensitive and complex nature (Mayo Martín, 2023). Yet, scholars argue that teaching taboo expressions is crucial for developing the pragmatic competence necessary for informal or emotionally charged interactions (Mohammadi, 2022). This includes recognizing the social functions and implications of such language, thereby equipping learners to make contextually appropriate communicative choices. The *Instituto Cervantes'* Plan Curricular also acknowledges that learners at various proficiency levels should be prepared to handle taboo-related situations (Mayo Martín, 2023).

Despite growing awareness, learners often struggle to use colloquial or taboo expressions appropriately without explicit instruction. For example, Fernández (2018) found that students exposed to *lunfardo* (Buenos Aires slang) lacked the metapragmatic awareness to discern when and with whom such expressions were appropriate, leading to either misuse or avoidance.

By integrating authentic voices and socially embedded language into instruction, this study responds to recent calls for language education to move beyond sanitized and overly normative models of language learning (Abrams, 2020). It proposes a pedagogical model in which virtual exchanges serve as a meaningful intervention to promote both linguistic flexibility and intercultural sensitivity, enabling learners to become reflective and socially aware communicators (Schön, 1987).

This research aims to achieve the following objectives:

1. To examine how virtual interactions facilitate the understanding and appropriate use of culturally specific expressions across Spanish-speaking countries
2. To explore how real-world materials, such as popular media, support students in connecting their own culture with those of Spanish-speaking communities, thereby fostering intercultural understanding



By pursuing these objectives within a curriculum that emphasizes both linguistic and cultural variation, the study contributes to a more inclusive and contextually grounded approach to L2 pedagogy.

The study was conducted in Spanish 3510, an online introductory course in Spanish/English translation at Iowa State University. A key module of the course focuses on lexical variation influenced by speaker variables such as gender and emotion (Pizarro Chacón, 2015). Notably, the course also includes instruction on informal and culturally marked language, including slang, idiomatic expressions and taboo language. Given the rarity of such content in conventional curricula, this module offers a unique opportunity for students to expose linguistically rich, socially nuanced language essential to authentic communication.

To support this instruction, students participated in weekly virtual exchanges with native-speaking coaches via LinguaMeeting, a professional platform offering structured, one-on-one conversations with trained speakers from various Spanish-speaking countries. In this study, 23 students engaged in guided conversations with coaches from Colombia, Ecuador, Guatemala, Honduras, Panama, and Peru. Each session focused on a specific task that encouraged the use and discussion of idiomatic, colloquial, and taboo language in authentic contexts. These personalized interactions enabled students to move beyond formulaic textbook Spanish and experience language as a living, dynamic form of cultural expression.

Unlike virtual collaborations arranged between university professors, often referred to as telecollaborations or virtual exchanges partnerships, third-party platforms such as LinguaMeeting, TalkAbroad and Conversifi offer logistical and pedagogical advantages. While university-led exchanges can foster deep intercultural dialogue, they often face barriers such as scheduling conflicts, time zone differences, uneven student engagement, and the added coordination burden for instructors. In contrast, third-party providers ensure consistent access to trained native speakers, offer flexible scheduling, and manage the technical infrastructure, making them especially well-suited for asynchronous and online learning environments. By outsourcing the interaction component, instructors can focus on curriculum development while ensuring that students engage in meaningful, authentic conversations with speakers from diverse Spanish-speaking backgrounds.

## **Facilitating the understanding and use of culturally specific expressions through virtual interactions**

To address the first research question, data from three pre-survey and two post-survey items were analyzed. The pre-survey collected information on participants' definitions of intercultural competence in translation, previous experiences with cultural challenges in translation, and expectations for working with native coaches on LinguaMeeting, while the post-survey asked students to describe significant cultural learnings gained through LinguaMeeting and to provide concrete examples of how these learning were applied to solve translation challenges. The focus includes colloquial language, slang, and swear words, as well as vernacular expressions and idiomatic language.

The pre-survey results indicate that students most frequently associate intercultural competence in translation with understanding cultural differences, which accounted for 25% of responses. Other prominent themes included adapting language to context and understanding slang or regional variation, each comprising 17% of responses. Being culturally sensitive in translation was identified by 13% of participants, while respecting other cultures was cited by 12%. Smaller proportions of students highlighted the importance of using cultural elements in translation and communication and mutual understanding, each representing 8% of responses. These findings suggest that students view intercultural competence as a multifaceted concept, with particular emphasis on cultural awareness, contextual adaptation, and sensitivity to linguistic variation.

Open-ended responses on cultural challenges in translation revealed a diverse range of student experiences, with many participants describing more than one difficulty. The most frequently cited challenge was navigating regional language differences, such as dialects, slang, and regional word a usage, mentioned by 54.5 % of respondents. Cultural sensitivity, including issues related to respecting cultural norms, idiomatic expressions, and tone, was identified by 31.8% of respondents. General translation challenges, such as grammar, comprehension, or giving directions, were noted by 9.1% of students. Additionally, 22.7% of participants indicated that they had not yet encountered such challenges, often indicating limited exposure to real-world translation situations or direct interaction with native speakers. The qualitative data also illustrate that some students' experiences stem from travel, work, or study abroad, while others have not faced these challenges due to a lack of immersion or practical translation opportunities. These findings underscore not only the complexity and variety of obstacles students face when translating,

but also the importance of authentic intercultural engagement in developing translation competence.

Analysis of students' open-ended responses about their hopes for learning from native speaker coaches on LinguaMeeting revealed several key themes. The most prevalent aspiration was to improve speaking skills, mentioned by 50% of students. Developing better understanding of native speakers and increasing overall fluency were each cited by 22.7% of respondents. Hopes for enhanced confidence in using Spanish and for improved translation skills were each expressed by 4.5% of students. Goals related to pronunciation, cultural knowledge, and speed or comprehension were each mentioned by 9.1% of participants, while 13.6% hoped to strengthen their grammar and writing abilities. These findings indicate that students are primarily motivated by the desire to become more effective and confident communicators, with particular emphasis on speaking proficiency, understanding authentic language use, and achieving greater fluency in Spanish.

An examination of students' reflections on cultural learning gained through LinguaMeeting highlights several recurring themes. The most frequently noted takeaway, reported by 43.5% of students, was the recognition of regional variation in language use, such as differences in slang, phrases, and word meanings across Spanish-speaking countries. Approximately 21.7% of responses emphasized the importance of understanding cultural context and connotations, particularly how literal translations can lead to misunderstandings due to differing cultural backgrounds. About 17.4% of students highlighted exposure to diverse cultural perspectives and practices, noting that interactions with coaches from various countries deepened their appreciation for cultural diversity and challenged generalizations. Additionally, 13% of students referenced discussions of specific cultural topics, including humor, LGBTQ+ issues, religion, and healthcare, as important learning moments. Finally, 8.7% of responses focused on the value of real-life communication with native speakers in building conversational skills and cultural awareness. These findings demonstrate that LinguaMeeting sessions provided students with meaningful opportunities to engage with authentic language variation and cultural practices, fostering a deeper and more nuanced intercultural understanding.

Analysis of students' responses to how they applied cultural learning from LinguaMeeting to solve translation challenges reveals several distinct strategies and outcomes. The most common approach, reported by 26.1% of students, was consulting dictionaries or native speakers to verify connotative meanings and avoid literal translations that could lead to misunderstandings. About 21.7% of students described adapting or substituting cultural references, such

as modifying brand names or idiomatic expressions, to ensure the translation resonated with the target audience. Another 21.7% highlighted the use of culturally appropriate humor, drawing on feedback from coaches to adjust jokes, metaphors, or slang so they would be understood and appreciated in different Spanish-speaking contexts. Additionally, 17.4% of responses emphasized the importance of distinguishing between personal and national perspectives when discussing sensitive topics, such as gender identity or religion, to maintain respect and accuracy in translation. Finally, 13% of students noted the value of expanding their vocabulary and cultural knowledge through ongoing engagement with native speakers, which enabled them to produce more nuanced and contextually appropriate translations. These strategies reflect growing awareness of how cultural context informs linguistic choices.

### **Connecting cultures and fostering intercultural understanding through real-world media in Spanish language learning**

Analysis of LinguaMeeting recordings and students' written reflections on the guided activity showed that integrating real-world media, particularly popular media, into the Spanish language classroom is a highly effective pedagogical strategy. These materials supported both linguistic development and intercultural competence by linking students' lived experiences to those of Spanish-speaking communities. Throughout the sessions, all 23 students referenced slang, idiomatic, or taboo expressions, and engaged with authentic language drawn from widely consumed contemporary media, including television series such as *"Élite"*, *"La Casa de Papel"* [*Money Heist*], and *"Euphoria"*, as well as music by artists like Bad Bunny, Rosalía, Karol G, and J Balvin. Student responses frequently included spontaneous references to these sources, demonstrating that popular media not only captured students' interest but also anchored learning through relevant and emotionally resonant content.

A prominent theme that emerged from both written reflections and recorded interactions was students' increasing awareness of the cultural and regional and contextual nuances embedded in informal Spanish. About 70% of student responses included references to specific regional variations in expressions or idioms. For example, students discussed how terms such as *"qué chido"* (México, [how cool]), *"chévere"* (Colombia, [awesome]), *"chilero"* (Guatemala, [cool]), and *[qué guay]* (Spain, [cool]) all function to express enthusiasm or approval but differ in regional usage and cultural resonance. Participants demonstrated a nuanced understanding that the same term may carry different connotations across regions. For instance, the expression *"qué chimba,"* commonly understood as positive in Colombia, meaning [how cool] or

[awesome], was acknowledged by students as potentially vulgar or inappropriate countries such as Peru. These discoveries were often deepened through dialogues with native-speaking coaches, who clarified the appropriateness, regional specificity, and tone-dependent meanings of terms such as “*cabrón*” (which can range from [badass] to [bastard,] depending on context), “*chingadera*” Mexican slang for [nonsense] or [crap]), and “*no des papaya*” (a Colombian idiom meaning [don’t make yourself an easy target]).

In addition to linguistic exploration, all students engaged in cultural reflection by drawing explicit comparisons between Spanish and English slang. All students referenced English-language expressions encountered through social media platforms such as TikTok and Twitter, or in popular U.S. series like *Stranger Things* and *Outer Banks*. Frequently mentioned English terms included *low key*, *no cap*, *spill the tea*, and *you ate that up*. Students not only explained these expressions in English but also attempted to identify Spanish equivalents or near-equivalents. For instance, *low key* was associated with understated behavior or quiet enthusiasm, prompting students to explore whether Spanish conveys similar subtlety through expressions like “*más o menos*,” [more or less] “*cabal*” ([exactly] or [spot on] in Central American usage), or other regional specific idioms. These comparative discussions fostered metalinguistic awareness but highlighted how slang encodes generational identity, group belonging, and social norms in both languages.

Moreover, 63% of students reported that encountering slang and idiomatic expressions in familiar cultural contexts significantly increased their motivation and sense of relevance in learning Spanish. The authenticity of the language presented in popular music and series, especially when consumed voluntarily outside the classroom, served to validate students’ linguistic identities while reinforcing their perception of Spanish as an accessible, evolving language. 44.3% of student responses expressed heightened engagement upon recognizing phrases in Spanish media that mirrored those used within their own linguistic communities. For instance, Maluma’s lyric “*Felices los cuatro*,” [Happy the four of us] sparked discussions regarding romantic norms and humor in Latin American cultures. Likewise, expressions such as “*vamo’ a romper*” [let’s tear it up] from Bad Bunny’s music and “*chaval*” [kid] or [boy] in Peninsular Spanish) from “*La Casa de Papel*” [Money Heist] prompted students to reflect on the generational and emotional nuances embedded in such terms.

Popular media also served as a lens for observing how language evolves across time and social groups. 52.17% of students commented on the generational variation in slang, particularly after watching series like *Stranger Things*, which features 1980s expressions unfamiliar to Gen Z audiences. This led to

discussions about how slang operates as a temporal marker and how meanings shift over time. While 34.78% of students acknowledged that media provided initial exposure to informal expressions, they also recognized that full understanding often required clarification from native speakers. For example, the distinction between humorous versus offensive uses of “*cabrón*” [badass] was clarified by coaches who contextualized its meaning within local norms and relationships. These intercultural dialogues significantly contributed to students’ sociolinguistic awareness and deepened their understanding of how culture, identity, and communication intersect.

This dynamic was also evident in real-interactions between students and LinguaMeeting coaches. In one exchange, coach Daniela Madrid, who is not part of Generation Z, searched online to better understand the age range of Gen Z, highlighting how generational identity can influence language use and comprehension. Despite her experience as a language coach, Daniela encountered difficulty interpreting slang like “low key”. A student attempted to explain it, noting that some expressions are so context-specific that even native speakers struggle to define them clearly. This moment emphasized how slang not only marks generational boundaries but also resists straightforward translation, reinforcing the importance of intercultural dialogue in developing sociolinguistic awareness.

## Conclusions

Students entered the Spanish/ English translation course with a conceptual awareness that translation is not just linguistic, but deeply cultural. Before LinguaMeeting sessions, students had limited or inconsistent experience navigating cultural nuances in translation. They were motivated to bridge the gap between classroom Spanish and real-world, culturally grounded communication. LinguaMeeting provided authentic, diverse cultural exposure that deepened students’ understanding of Spanish-speaking communities. Students demonstrated practical intercultural competence by applying cultural insights to improve the accuracy and appropriateness of their translations. Virtual intercultural exchanges, like those in LinguaMeeting, effectively bridge the gap between theoretical knowledge and practical application. They help students understand the cultural depth behind language, adapt their communication to diverse audiences, and translate not just words, but meaning, tone, and context. The integrated analysis of video-recorded sessions and students’ written reflections affirms the pedagogical value of real-world materials, particularly popular media, in fostering intercultural awareness and communicative competence. By presenting rich, culturally embedded expressions that are often absent from textbooks, these materials provide

students with opportunities to interpret meaning dynamically, reflect on cultural values, and engage in comparative linguistic analysis. The combination of authentic media exposure and real-time conversation with native speakers created a learning environment that promoted critical thinking, emotional engagement, and cultural empathy. Ultimately, this approach not only enriched students' linguistic repertoires but also equipped them with the tools to navigate intercultural communication with nuance and confidence. Future research should explore the reciprocal of virtual exchanges by examining how Spanish native-speaking coaches learn English from American students, particularly through discussions of English slang initiated by the students during LinguaMeeting sessions. Such interactions offer coaches opportunities to engage in mutual interpretation and reflection on contemporary Anglophone youth culture, highlighting the bidirectional nature of intercultural learning that these exchanges promote. This line of inquiry shifts the focus from the traditional view of language exchanges as benefiting only the language learner, instead recognizing the intercultural speaker as a mediator who facilitates understanding in both directions. By analyzing instances where students explain English slang, researchers can gain insight into how coaches not only improve their language skills but also deepen their understanding of American cultural references and youth perspectives, thus enriching the overall intercultural experience for all participants.

These findings align with Abrams' (2020) framework, emphasizing authentic, real-time intercultural engagement in language pedagogy. The use of virtual exchanges and popular media in this study reflects Abrams' assertion that technology can bridge the gap between classroom instruction and real-world communication.

By engaging with native speakers and culturally embedded materials, students developed not only linguistic proficiency but also the intercultural communicative competence described by Byram (1997) and Liddicoat & Scarino (2013). This pedagogical approach validates the importance of integrating dynamic, socially situated language practices into the curriculum, supporting learners in becoming reflective, adaptive, and culturally aware communicators.

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# Citizenship Education: essential competences for initial teacher training in Portugal

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## Introduction

Citizenship Education (CE) is understood as an educational response aim at promoting competences that are fundamental to the consolidation of democratic societies. In Portugal, it is implemented through the Citizenship and Development curriculum component, using a transdisciplinary approach from preschool through the end of compulsory education, and includes a specific academic subject in the 2nd and 3rd cycles of basic education (5th to 9th grade). This framework implies that all teachers, regardless of their area of expertise, should contribute to the promotion of citizenship within the school context.

Given this requirement, initial teacher training is identified as a strategic context for developing these competences, considering the responsibility assigned to future teachers in implementing CE. However, recent studies point to significant gaps in initial teacher training regarding citizenship education. It is therefore evident that this topic is not sufficiently integrated into curricula, that future teachers do not receive adequate preparation to address it in the classroom, and that the competences necessary for its implementation are not developed during training (Estellés *et al.*, 2021; Fischman & Estellés, 2019; Lourenço, 2021).

The Council of Europe (2025) emphasized that greater efforts are still required to ensure the integration of democratic culture competences in vocational training and higher education. In Portugal, teachers report that factors such as cultural diversity, lack of student motivation, subject complexity, unpredictable classroom debates, interdisciplinary challenges, and limited knowledge of legal

frameworks hinder the effective implementation of citizenship education (Pina *et al.*, 2023).

Given this context, the present study aimed to address the following question: what essential competences should be developed in initial teacher training to enhance future teacher's capacity, commitment, and confidence in promoting citizenship education, in accordance with national and international guidelines? Thus, the study seeks to identify and organize these competences to better prepare future teachers to foster citizenship education and strengthen democratic culture.

The results suggest that the proposed competences provide a solid foundation for teachers in training to experience, reflect on, and mobilize learning to promote CE. This study contributes to ongoing discussions on citizenship education in initial teacher training, with a particular focus on the Portuguese context, where there is a legal requirement to address the topic in compulsory education.

There is a well-established tradition in the literature of connecting democracy with education, as it recognizes the educational potential to foster mutual respect and promote fundamental values that strengthen democratic culture (Estellés *et al.*, 2021). It is understood that democracy can only be effective if it is rooted in democratic values, attitudes, and practices, that is, in a culture of democracy.

According to Dewey (1997/1916), democracy should be seen as a model of community life rather than a form of government. In his view of school as an embryonic community, the author advocates the implementation of a set of practices that encourage participation and, with that, the incorporation and experience of democratic values through initiation into democratic life, enabling the exercise of citizenship and the development of competences essential to democracy.

In this sense, it is essential to understand citizenship as active and critical, where individuals participate and take responsibility towards others for a more just and sustainable society (Waghid, 2023). The dialectic between the local and the global, existing in the diversity of approaches to the concept, is important for understanding that citizenship, in the exercise of rights and responsibilities, is mostly experienced locally, by each individual and group in their territory (Fischman & Estellés, 2019).

However, it is also essential to consider that the world of the 21st century is increasingly closer and undergoing rapid transformations and, for this reason,

the concept of global citizenship contributes to the importance of citizens who angle their actions beyond national borders in the context of an interconnected and multicultural world (Lourenço, 2021). Although it is still an open and divergent concept, global citizenship contributes to the deconstruction of a citizenship restricted to nationalist discourses that promote romanticized views of patriotism (Fischman & Estellés, 2019).

In this context, citizenship education (CE) is an educational response to promoting the skills needed to strengthen democratic societies at national, European and international level. According to Estellés *et al.* (2021), the inclusion of CE in many European curricula was inspired by the model promoted by the European Commission and the documents produced by the Council of Europe, which influenced citizenship and human rights education in Europe.

According to the Council of Europe (2018b), citizenship education is based on the personal development of competences, that is, the development of specific individual resources such as values, attitudes, capacities and knowledge that are mobilized and employed in an active and adaptive way in different situations, in order to act effectively for the democratic culture in society.

Therefore, the role of teacher education institutions (units) is [...] to equip them [teachers] with a set of competences necessary for living together as democratic citizens in diverse societies (the "substantial" side). Teachers who themselves act successfully in the everyday life of democratic and culturally diverse societies will best fulfil their role in the classroom. (Council of Europe, 2018b, p. 77)

Teachers, then, must be prepared to act as models of democratic life, developing in themselves the competences necessary for democratic citizenship. It is up to teacher training institutions to create training conditions that foster the experience of these competences. Only in this way will future teachers be able to promote these same competences with their students (Council of Europe, 2018b). It is therefore necessary to identify, systematize and organize the essential competences for initial teacher training based on the guidelines and recommendations established for the Portuguese context.

The methodology adopted consisted of analyzing eight Portuguese and European documents, focusing on identifying relevant competences for citizenship education. Documents were selected that establish curricular and professional references designed to guide teacher training and promote

educational practices in line with democratic principles.

Produced by national and international organizations, these documents reflect political-educational contexts and express guidelines and expectations in the field of citizenship education, thus serving as natural sources of contextualized information (Kripka et al., 2015). Their analysis makes it possible to identify the essential competences for teacher training to accomplish citizenship education.

A synthesis was made of the main guidelines for the development of competences for citizenship education in the educational process. In Portugal, the following documents were considered: The Basic Law of the Portuguese Education System (BLES), Decree-Law 240/2001, Decree-Law 9-A/2025, the Profile of Students Leaving Compulsory Education (PSLCE) (Martins et al., 2017), and the National Strategy for Citizenship Education (NSCE) (Monteiro et al., 2017). At the European level, the documents from the Council of Europe regarding the Reference Framework of Competences for Democratic Culture were also considered.

### **Basic Law of the Portuguese Education System (BLES)**

The law establishes the general framework of the Portuguese education system, presenting democracy as an ethical project fostered through citizenship competences that incorporate personal, social, scientific, and pedagogical training. It emphasizes civic awareness, democratic responsibility, lifelong learning, and critical thinking. Pedagogically, it highlights the need for students to develop know-how, cooperation, and community participation, requiring teachers to acquire competences that enable this learning.

### **Decree-Law 240/2001, of August 30 - Approves the general professional performance profile for kindergarten teachers, primary and secondary school teachers**

The document sets out the competences expected in teacher training and professional practice. It reinforces the cultural and civic dimensions of teaching by defining four key areas in the professional profile of nursery, primary, and secondary school teachers: professional, social and ethical; development of teaching and learning; participation in the school and relationship with the community; lifelong professional development. These dimensions establish the individual resources that teachers must mobilize in personal, relational, and didactic-pedagogical domains.

## **Decree-Law 9-A/2025 - Approves the legal framework for professional qualifications for teaching in pre-school education and basic and secondary education and the legal framework for continuous teacher training**

The decree defines that training in the general educational area should develop a set of competences common to all teachers for the exercise of their function, which involves research, analysis and articulation between theory and practice for critical, investigative and grounded performance. This is supported by the area of supervised teaching practice, which has had its number of credits increased compared to the original 2014 decree.

The decree also inserts citizenship education, along with other subjects, into the general education area and defines for this area a lower number of credits than for the other areas of education. It also maintains the social, cultural and ethical area without its own established credits, despite indicating that the area should promote the valorization of the ethical and civic dimensions of teaching activity.

## **Profile of Students leaving Compulsory Education (PSLCE)**

This document describes the vision, principles, values and competences expected of Portuguese students at the end of compulsory education, aiming at their individual qualification, exercise and training for democratic citizenship. Established on a humanist foundation, it places human dignity as a fundamental value and sustainable and inclusive development as intentions. It reinforces the need to acquire competences for acting in a world in constant transformation, such as adaptability and flexibility, autonomy and responsibility.

PSLCE also defines competences related to teaching practice, based on planning and developing learning contextualized within the students' daily lives and the social and geographical environment. In this manner, integrating cooperative methodologies, critical use of information sources and technologies, and the promotion of spaces that encourage initiative, autonomy and conscious decision-making by the students.

## **National Strategy for Citizenship Education (NSCE)**

The NSCE establishes the Citizenship and Development curriculum component as a transversal or autonomous component at all levels of compulsory education. It defines citizenship education as being approached from the axes of individual civic attitudes (citizen identity, individual autonomy, and human

rights), interpersonal interactions (communication and dialogue) and social and intercultural relations (interdependence, cultural diversity, peace and conflict management). It establishes that students' education must include practical experiences of citizenship, and that teachers must develop the necessary competences for this purpose.

It also establishes the desired professional profile for promoting citizenship, including the ability to recognize cultural diversity, engage with the community, foster critical and collaborative thinking, and master project methodologies and technologies. Accordingly, it recommends integrating the subject and related pedagogical training into both initial and ongoing teacher education.

### **Council of Europe documents - Reference Framework of Competences for Democratic Culture**

At the European level, three key documents from the Council of Europe, an influential international organization for the promotion of democracy and human rights, were analyzed. These documents, which influence Portuguese educational policies, present the Reference Framework of Competences for Democratic Culture. The first document (2016) introduces the model, which organizes twenty key competences into four interconnected dimensions, contemplating fundamental principles of democratic societies. The second document (2018a) proposes how to operationalize the model, using descriptors to observe and monitor the development of these competences. The third document (2021) presents a self-reflection tool for teachers, based on competence-oriented questions, to support their professional development. It reinforces the Council of Europe's focus on educational practice and helps teachers align personal values with pedagogical approaches to coherently promote democratic citizenship.

### **Analysis of the documents**

After reading the documents, the most recurrently emphasized competences were identified and grouped into two categories: citizenship competences and didactic-pedagogical competences. This organization reflects the understanding found in both the guiding documents and the literature that personal development is essential for the effective operationalization of these competences in teaching practice.

Below there is a definition of the set of competences systematized and organized based on the synthesis and analysis of the guiding documents:

**Table 1.** *Set of citizenship and didactic-pedagogical competences for promoting citizenship education*

| Citizenship competences                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Didactic-pedagogical competences                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• Respects human rights, social justice, equity and democratic values.</li> <li>• Participates democratically in the school environment, recognizing it as a place for citizens to live together.</li> <li>• Demonstrates civic commitment, respecting the rights, duties and norms of democratic life.</li> <li>• Are aware of their role as a model of democratic conduct.</li> <li>• Values cultural diversity, recognizing its importance in a democratic society.</li> <li>• Identifies and recognizes the impact of stereotypes, exclusions and generalizations in society.</li> <li>• Demonstrates attitudes of respect, solidarity, inclusion and empathy.</li> <li>• Uses critical thinking to understand life in society and social, political and environmental phenomena.</li> <li>• Adopts a reflective and proactive stance towards the real challenges of the school and social context.</li> <li>• Demonstrates collaborative attitudes and active involvement in knowledge-building processes.</li> <li>• Recognizes the importance of encouraging students' autonomy and initiative in the</li> </ul> | <ul style="list-style-type: none"> <li>• Articulates disciplinary content with Citizenship Education.</li> <li>• Establishes and strengthens school and community partnerships, promoting networking as an educational strategy.</li> <li>• Active listening and dialog with students, families and the community.</li> <li>• Promotes learning environments that encourage teamwork, cooperation and mutual respect.</li> <li>• Plans and develops pedagogical practices that favor intercultural dialogue.</li> <li>• Creates inclusive educational environments, valuing different identities and backgrounds.</li> <li>• Develops learning contexts that encourage reflective, critical and creative thinking, favoring conscious decisions.</li> <li>• Applies practices aimed at understanding and solving real problems.</li> <li>• Plans and implements participatory, investigative and collaborative methodologies.</li> <li>• Uses educational strategies that encourage students to act with initiative and take responsibility.</li> <li>• Critically evaluates and adapts the use of educational resources and technologies.</li> <li>• Mediates the construction of knowledge in an informed manner based on the critical</li> </ul> |

| Citizenship competences                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Didactic-pedagogical competences                                                                                                                                                                                                                                                                                                                                                                                               |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>educational process.</p> <ul style="list-style-type: none"> <li>• Reflects critically on the use of educational resources and technologies, considering their pedagogical and social impact.</li> <li>• Mobilizes multiple literacies to interpret different sources of information.</li> <li>• Recognizes the local, in its socio-cultural, geographical and community dimensions, as an educational context.</li> <li>• Knows the principles of the Sustainable Development Goals (SDGs), of sustainability and positive peace.</li> </ul> | <p>analysis of different sources, perspectives and opinions.</p> <ul style="list-style-type: none"> <li>• Incorporates local and current situations into the process of building knowledge.</li> <li>• Adapts teaching strategies according to the socio-cultural context.</li> <li>• Integrates the Sustainable Development Goals (SDGs), sustainability and positive peace as central axes of teaching practices.</li> </ul> |

The competences identified in the documents appear either explicitly, as stated competences, or implicitly, through principles, objectives, and guidelines that reflect training expectations for teachers and students. Citizenship competences (personal and social dimensions) and didactic-pedagogical competences (linked to teaching practice) are interconnected, highlighting the teacher's role as a model of democratic life and the need to mobilize these competences so that students become committed to building a democratic culture. Thus, "becoming a globally competent teacher is a complex process, requiring a deep personal and professional transformation, a «metamorphosis» that allows teachers to reconceptualize their role as citizens and educators in an uncertain world" (Lourenço, 2021, p. 15).

The set of competences defined in this study is in line with the literature, which proposes that a competency-oriented approach to citizenship education is more effective than one focused solely on content. Lourenço (2021) points out that the development of competences was essential for teachers to feel prepared to lead CE at local, national and global levels, reconciling it with curricular requirements.

According to studies, participatory methods, critical approaches, and contextualized learning, including experiential learning, project-based teaching, research tasks, and simulations, effectively promote participant engagement. It is essential that these practices are connected to a critical understanding of social challenges, the responsible use of technologies and



information, and the concrete realities of future teachers' lives. Community experiences through collaborative networks are also essential (Lourenço, 2021; Waghid, 2023).

Thus, it is highlighted the need for initial training courses to promote training experiences that mobilize these competences, so that they are reflected in teachers' pedagogical practices. The set of competences listed in this study provides a solid basis for future teachers to experience, reflect on and mobilize this learning throughout their training.

## Conclusions

The conclusion drawn is that the documents analyzed provide a foundation which, through critical analysis, allows us to propose a profile of citizenship and didactic-pedagogical competences aligned with educational guidelines and consistent with the existing literature. These competences are essential for initial teacher training, as they help prepare future teachers to serve as models of citizenship and pedagogical practice committed to the promotion of a democratic culture. This is particularly relevant in the Portuguese context, where there is a legal requirement for both an autonomous subject — Citizenship and Development—and a cross-curricular approach to the topic.

The study's main limitation is that the proposed set of competences has not yet been validated by experts. Future research could explore how pre-service teachers perceive and appropriate these competences, as well as guide curricula and training practices.

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# Implementation of artificial intelligence tools to support asynchronous learning in mobile application development students

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## Introduction

In recent years, higher education has undergone rapid transformation thanks to the incorporation of emerging technologies, particularly artificial intelligence (AI). Tools such as virtual tutors and content recommendation systems have begun to redefine the landscape of asynchronous learning, offering more personalized, accessible, and efficient experiences. These AI-based solutions allow content to be tailored to individual student needs, providing real-time feedback, fostering autonomy in learning, and improving knowledge retention (Cairo & Ramírez Echavarría, 2023).

Their impact has been particularly significant in asynchronous environments, where flexibility in study time and pace represents both an advantage and a challenge. In this context, AI-based tools such as virtual tutors, content recommendation systems, and code assistants have demonstrated their ability to improve the student experience by offering personalized feedback, progress tracking, and resources tailored to individual needs (Zhao, 2025).

In fields such as mobile application development, where constant updating and independent practice are essential, these tools are even more relevant. Technologies such as virtual tutors based on natural language processing allow for real-time interaction, detect student emotions and difficulties, and adjust explanations according to their level of understanding, which encourages autonomous and sustained learning (Rathika et al., 2024). Likewise, content recommendation systems can optimize study time by prioritizing materials according to the user's performance, preferences, and learning style (Drouet et al., 2024).

Despite their potential, the implementation of these technologies is not without challenges. In specific contexts such as Ecuadorian universities, factors such as technological infrastructure, teacher training, student acceptance, and possible algorithmic biases must be considered. In addition, ethical concerns arise related to data privacy, equity in access to technology, and the transparency of automated systems (Zhao, 2025).

Several studies have shown that interactive virtual tutors, through the use of natural language processing and emotional analysis algorithms, can significantly increase student engagement and academic performance (Rathika et al., 2024). In addition, content recommendation systems dynamically adjust educational resources based on user progress and preferences, optimizing the learning experience in virtual environments (Drouet et al., 2024).

However, the implementation of these tools also poses significant challenges, such as the need to preserve data privacy, avoid algorithmic bias, and ensure equity in access to technology (Zhao, 2025). Despite these barriers, evidence suggests that well-planned integration can enhance the quality of asynchronous learning, especially in highly technical disciplines such as mobile application development.

This chapter analyzes how these AI-based tools are influencing the quality of asynchronous learning at an Ecuadorian university in 2024, focusing on the mobile application development program. Based on a specific research question, four thematic areas are explored: the transformation of asynchronous learning through AI, specific tools applied to mobile development, the challenges of the Ecuadorian context, and the evaluation of educational impact. Through this exploration, we seek to contribute useful evidence and reflections for teachers, institutional leaders, and educational technology developers.

In summary, the integration of AI into higher education presents a unique opportunity to improve the quality of asynchronous learning, provided that it is done in an ethical, inclusive, and contextualized manner. Its application in technical fields such as mobile development can be a key driver for more personalized, effective, and motivating training (Cairo & Ramírez Echavarría, 2023).

In this context, this research seeks to analyze how the implementation of artificial intelligence-based tools influences the quality of asynchronous learning for mobile application development students at an Ecuadorian university in 2024. Understanding this impact is essential for designing more effective, inclusive, and student-centered educational strategies.

## **The evolution of online education and the role of AI**

Over the last decade, online learning has undergone a significant evolution, initially driven by the need for flexible access to education and subsequently accelerated by the COVID-19 pandemic. This transformation has consolidated asynchronous learning as an effective modality, especially for students who

require autonomy and adaptability. In this context, artificial intelligence (AI) has emerged as a key tool for improving personalization, real-time feedback, and continuous student support (Gaoture, 2023).

AI has enabled educational platforms to evolve from passive environments to interactive and adaptive systems capable of adjusting content and pedagogic strategies to each student's profile. This advance has been fundamental to the development of more effective asynchronous learning systems, where students can receive personalized support without depending on the constant presence of a teacher. Recent studies highlight that AI-driven systems improve academic performance by providing personalized learning paths, immediate feedback, and content aligned with individual needs (Sarnato et al., 2024).

In addition, AI has significantly improved the quality of interaction in virtual environments. Through intelligent tutors, conversational agents, and automated assessment systems, students can now interact with the platform dynamically and receive constant guidance. This contrasts with traditional asynchronous environments, where feedback was often delayed or limited. According to Rakya (2023), AI-based systems encourage more active student participation by offering immediate corrections and enabling discovery learning (Rakya, 2023).

Another relevant dimension is the impact of AI on the equity and accessibility of asynchronous learning. While challenges related to technological infrastructure still exist, AI-based adaptive learning platforms have proven capable of supporting students with different learning styles, prior knowledge levels, and even language barriers (Willis, 2024). This advance represents a valuable opportunity for diverse contexts such as Latin America, where student heterogeneity is a constant.

In short, the evolution of online education has been marked by the growing integration of artificial intelligence, which has transformed not only asynchronous environments, but also the way we understand personalized, student-centered teaching. This process, still underway, poses significant ethical and technical challenges, but also opens the door to more efficient, inclusive, and human learning.

### **Advantages of personalizing learning in technical environments**

One of the most notable advances in asynchronous learning has been AI-driven personalization. This personalization allows the content, methods, and pace of teaching to be adapted to the individual needs of each student, which is especially valuable in technical environments such as programming or

software development. In these areas, where complexity and diversity of learning styles are high, AI becomes a strategic tool for facilitating autonomous and effective student progress (Zhao, 2024).

AI enables the construction of adaptive learning environments capable of analyzing student performance, preferences, and frequent errors, dynamically adjusting content and feedback. This not only improves understanding but also strengthens motivation by avoiding the frustration associated with overly difficult or irrelevant content. For example, AI-based generative tutors, such as personalized GPT systems, have already been implemented in technical courses at the university level, showing preliminary positive results in terms of retention and learning autonomy (Bonde, 2024).

In addition, personalization facilitates differentiated instruction in diverse contexts. In countries where students may have prior knowledge gaps, AI offers the possibility of designing individualized learning paths, adjusting both the pace and complexity of the material on a case-by-case basis. This has been validated in studies showing how intelligent platforms allow teachers to adapt content in real time, improving effectiveness in STEM subjects even at the elementary school level (Zhang et al., 2024).

However, significant challenges have also been identified. Although the potential is great, not all students are equally prepared to take an active role in their personalized learning process. Recent research suggests that a significant proportion of university students do not yet feel fully ready to interact with AI-based systems without direct teacher supervision, highlighting the need for parallel pedagogical support (Sysoyev, 2025).

Ultimately, the personalization of learning through AI represents a transformative opportunity for technical environments, enabling more tailored, motivating, and effective teaching. However, its success depends on a balanced implementation that combines the best of technology with human support, preparing students not only to consume content but also to learn how to learn.

## **Comparison between traditional methods and AI-assisted approaches**

For decades, traditional teaching methods have relied on face-to-face classes, textbooks, periodic assessments, and constant interaction between students and teachers. These approaches have offered proven benefits, such as the development of social skills, collaborative learning, and personalized guidance from the teacher. However, their structural rigidity and difficulty in addressing

individual differences among students have been persistent limitations, especially in asynchronous environments.

In response to this, artificial intelligence (AI)-assisted approaches have emerged as an alternative capable of overcoming some of these barriers. AI-based tools allow for the personalization of learning pace, content, and assessments according to each student's profile, interests, and performance. A study conducted with graphic design students showed that those who used platforms with AI-based feedback improved their grades by an average of 31.5%, compared to a 20% improvement in the group that followed the traditional approach, in addition to reporting greater creativity and satisfaction with the training process (An, 2024).

Similarly, research in the field of nursing education showed that students who learned through AI-assisted immersive methods not only achieved better theoretical results but also expressed higher levels of motivation and satisfaction than those who followed the traditional method (Xin & Huiping, 2021). These results reinforce the idea that AI-assisted approaches can enrich asynchronous learning, not only in cognitive terms, but also in affective terms.

However, there are not only advantages. The integration of AI also presents risks, especially when students become overly dependent on these tools, which can affect the development of critical thinking and problem-solving skills. A recent study found that intensive use of AI tools, without adequate pedagogical mediation, can diminish students' capacity for autonomous reasoning, despite improving their efficiency in repetitive tasks (Çela et al., 2024).

Compared to traditional methods, AI-assisted approaches offer greater flexibility, personalization, and scalability. But they also require new digital skills on the part of students and teachers, as well as ethical and critical oversight of their use. Therefore, various studies agree that the most promising approach is not replacement, but balanced integration: a hybrid model that combines the adaptability of AI with human guidance, thus ensuring more comprehensive, contextualized, and meaningful learning (Yusuf et al., 2024).

### **Virtual tutors and educational chatbots: Features and use cases**

In modern technical education, virtual tutors and educational chatbots have become a key tool for facilitating asynchronous learning. These technologies, powered by artificial intelligence, offer personalized support, 24/7 availability, and immediate feedback, which are especially valuable in fields such as mobile application development, where the pace of learning and constant practice are



crucial. Virtual tutors can guide students through coding exercises, detect common errors, and tailor explanations to their level of competence (Setiawan et al., 2024).

A notable example of this implementation is the "e-JAVA" chatbot, designed to support Java programming learning. This interactive tool allows students to resolve common questions about syntax, control structures, and basic programming concepts ( ), and has proven to be particularly useful as an alternative tutor in post-pandemic contexts. The results show significant improvements in students' understanding and willingness to practice independently (Daud et al., 2020).

In terms of functionality, educational chatbots can be integrated with learning management systems (LMS) and used as course assistants, helping with tasks such as reminders, formative assessment, links to personalized resources, and technical interview simulations. In the case of the NAJEH chatbot, developed in Tunisia, more than 80% of students reported using it daily, highlighting its ease of use and usefulness as a virtual tutor integrated into the academic app (Abid et al., 2024).

In addition, the design of these systems allows teaching to be scaled up to large groups without losing quality. Thanks to natural language processing and machine learning, chatbots can progressively adapt to frequently asked questions and respond with contextualized accuracy. This frees up teaching time and reduces the administrative burden, while offering students ongoing support in their learning process (Adewole et al., 2025).

However, the implementation of virtual tutors also requires consideration of user perception. According to Fuligni et al. (2025), although students tend to view AI tutors favorably, full acceptance depends on their ability to provide useful and contextually relevant explanations. In addition, teachers and educational administrators must be involved in the design and evaluation of these systems to ensure their pedagogical relevance (Fuligni et al., 2025).

## **Adaptive content recommendation systems**

In the field of asynchronous learning, adaptive content recommendation systems based on artificial intelligence have emerged as essential tools for personalizing the educational experience. These platforms use algorithms that analyze student behavior, performance, and preferences to suggest relevant content tailored to their level of understanding. In technical areas such as web development and mobile application development, where mastery of multiple languages, frameworks, and design patterns is essential, these tools allow

students to be guided on their own learning path, optimizing time and maximizing knowledge retention (Sari et al., 2024).

Recent studies show that these types of systems significantly improve academic performance. For example, the use of adaptive platforms such as Smart Sparrow or IBM Watson Education increased course completion rates and raised students' average grades from 68.4 to 82.7 points, according to reports in technical and higher education settings (Sari et al., 2024). These results suggest that adaptive recommendations are not only useful as automatic guides, but also promote greater motivation and engagement by presenting content that feels more useful and achievable.

In technical training contexts, such as programming or software design, recommendation systems also function as virtual mentors, suggesting practices, exercises, and resources based on the student's level of progress and most frequent errors. The study by Ikhsan et al. (2024) highlights how the integration of adaptive feedback into LMS platforms allows for the creation of personalized learning paths, the identification of interaction patterns, and the proposal of materials before cognitive blocks occur, resulting in a more fluid and efficient education (Ikhsan et al., 2024).

Another innovative example is the use of generative models in recommendation systems, which allow suggestions to be created not only based on previous data, but also by anticipating the student's future needs. This type of approach was successfully tested in e-learning environments, where generative algorithms provided not only links to existing content, but also personalized explanations and dynamic recommendations built in real time (Son et al., 2024).

Despite their benefits, these systems also face challenges, such as the need for robust technological infrastructure, clear data privacy policies, and teacher training to interpret and intervene on the data generated by the algorithms. Nevertheless, evidence suggests that, with ethical and pedagogically oriented implementation, adaptive recommendation systems represent a key opportunity to personalize technical learning and improve the quality of teaching in higher education.

### **AI-based code assistants (GitHub Copilot, Amazon CodeWhisperer) and their impact on autonomous learning.**

The emergence of AI-based code assistants, such as GitHub Copilot and Amazon CodeWhisperer, is revolutionizing the way programming is learned, especially in asynchronous contexts. These tools generate code snippets in real

time from natural language descriptions or partial commands, facilitating immediate understanding and resolution of technical problems. For mobile development students, this represents a valuable opportunity to practice autonomously, receive direct feedback, and build real projects without the constant need for teacher supervision (Erizo, 2025).

Studies show that these tools not only increase productivity but also boost student motivation. GitHub Copilot, for example, has been shown to reduce the time spent on repetitive tasks such as writing code base, generating tests, and documentation by up to 50%, allowing learners to focus more on logic and complex problem solving (Pandey et al., 2024). This efficiency not only improves academic performance but also strengthens confidence in independent learning.

In addition, tools such as Copilot have been specifically studied for their impact on the experience of novice developers. A qualitative and quantitative study showed that their use generates greater satisfaction, facilitates the learning of good coding practices, and accelerates familiarization with new languages and APIs (Gonçalves & Gonçalves, 2024).

However, autonomous learning assisted by these tools also presents new challenges. On the one hand, there is a risk of excessive dependence on the assistant, which can limit the development of critical thinking if conscious reflection on the generated code is not encouraged. On the other hand, code assistants still have flaws in complex tasks and can introduce subtle errors or security issues, so human judgment remains essential (Yetistiren et al., 2023).

Together, GitHub Copilot and Amazon CodeWhisperer represent promising advances in facilitating autonomous learning in technical careers such as mobile development. When combined with thoughtful pedagogical strategies and formative supervision, these tools have the potential to become virtual mentors, promoting a more fluid, autonomous, and personalized educational experience.

## **Factors influencing the adoption of AI in Ecuadorian universities**

The adoption of artificial intelligence (AI) in Ecuadorian universities is progressing at an uneven pace, influenced by structural, technological, pedagogical, and cultural factors. One of the main drivers has been the recognition of AI's potential to improve educational quality, optimize teaching processes, and strengthen research. However, the effective implementation of these technologies is limited by various institutional and contextual challenges.

One of the most decisive factors is the availability of technological infrastructure. Many higher education institutions lack the necessary equipment or sufficiently robust systems to integrate AI-based tools. This creates a gap between academic interest and actual operational capabilities. According to a study conducted in universities on the Ecuadorian coast and highlands, advances in AI are concentrated in institutions with a higher level of digitization, while others face serious difficulties due to a lack of connectivity, equipment, or adequate platforms (Rojas Espinoza & Mármol Córdova, 2024).

Another critical issue is the lack of clear university policies on the use and regulation of AI. Although there is a positive perception among teachers about the benefits of these tools, many do not use them in their classes due to the absence of specific institutional guidelines and regulations. Recent research in public universities in Guayaquil revealed that only a minority of teachers use AI systematically, and they do so mainly for administrative tasks or data analysis, not as an integral part of the educational process (Aparicio-Izurieta, 2024).

In addition, the country's socioeconomic conditions play an important role in the adoption of these technologies. Inequality in access to digital resources among students and regions limits equity in the implementation of AI. A national study identified that, although the technological approach has the greatest influence on adoption, the pedagogical approach continues to lag behind, reflecting the need to better integrate AI into curriculum design and teaching methodologies (Taipicaña Vergara et al., 2024).

Finally, teacher training in digital skills is an indispensable condition. Without adequate training, educators cannot take full advantage of AI tools or teach their students to use them critically. Recent research indicates that, while many university teachers demonstrate average levels of digital competence, weaknesses persist in key areas such as content creation and the pedagogical use of technology (Zambonino Torres et al., 2025).

In summary, the adoption of AI in Ecuadorian universities depends on a combination of infrastructure, institutional policies, social equity, and teacher training. As these factors are addressed in a coordinated manner, the path will be paved for a more effective, inclusive, and sustainable integration of artificial intelligence into the country's higher education system.

### **Perceptions of students and teachers about these technologies**

The perceptions of university teachers and students in Ecuador regarding artificial intelligence (AI)-based technologies are mostly positive, although tempered by concerns related to training, infrastructure, and ethics. Among

teachers, there is recognition of the value of AI in transforming teaching and learning processes, but also a sense of lagging training and a lack of clear policies for its implementation. A study conducted at three public universities in Guayaquil showed that, although most teachers recognize the educational potential of AI, few actively use it, largely due to the absence of institutional guidelines and specialized training (Aparicio-Izurieta, 2024).

Similarly, another study at a private university in Ecuador found that, although many teachers still do not consider AI to be an essential tool in their practice, they do agree on the urgent need to receive training in its use, revealing an ambivalent attitude: caution in the face of novelty, but openness to change when the right context is provided (Mejía Marín & Gómez Rivero, 2024).

As for students, the general perception of the use of AI in learning is favorable. A survey of 665 students at the Universidad Estatal Península de Santa Elena revealed that the majority value these tools positively as support for autonomous learning, although they also identify challenges, such as a lack of training in digital skills and the superficial use of some available tools (Laínez Quinde et al., 2024).

In the area of teaching English as a foreign language, the use of AI-based resources such as videos generated by Fliki has also been well received. Students at a private university highlighted that these tools improve their comprehension, promote personalized learning, and increase their level of participation in class, demonstrating that, when properly integrated, AI technologies can enrich the educational experience (Cabrera-Solano et al., 2024).

In summary, both teachers and students in Ecuador perceive the transformative potential of artificial intelligence in higher education, but agree that its use depends largely on training, institutional planning, and ethical and pedagogical support.

### **Technical, pedagogical, and ethical challenges**

As artificial intelligence is integrated into Ecuador's university environments, significant technical challenges arise that hinder its full and equitable adoption. One of the main obstacles is the digital divide between institutions. Universities with greater access to technological resources and connectivity show more noticeable advances, while those located in rural areas or with limited budgets face serious difficulties in implementing AI platforms and ensuring their proper maintenance (Rojas Espinoza & Mármol Córdova, 2024).

On the pedagogical level, another fundamental challenge lies in teacher training. Although AI promises to personalize learning and automate processes, its effective use requires educators to reconfigure their methodologies, integrate new platforms, and develop advanced digital skills. However, research has shown that the pedagogical approach has the least influence on the implementation of AI in Ecuadorian universities, due to the lack of specific training and the limited inclusion of these technologies in the current curriculum design (Taipicaña Vergara et al., 2024).

From an ethical standpoint, universities face the challenge of regulating the use of AI without violating fundamental principles such as equity, privacy, and transparency. The use of algorithms for automated assessment or personalized learning raises questions about algorithmic bias and the processing of students' personal data. Despite enthusiasm for educational transformation, regulatory frameworks are still in their infancy and do not clearly address the ethical implications of using AI in the classroom (Airaj, 2024).

In addition, a significant risk related to technological dependence has been identified. While AI-based systems can increase efficiency, there is also the possibility that students will rely too heavily on these tools, affecting their capacity for critical analysis and independent thinking. Therefore, it is urgent to integrate education in artificial intelligence ethics into university programs, promoting conscious, critical, and responsible use of these digital tools (Han et al., 2023).

In conclusion, the technical, pedagogical, and ethical challenges in the use of AI in Ecuadorian higher education are complex but manageable. They require investments in infrastructure, comprehensive teacher training, and the creation of clear institutional policies that guarantee fair and equitable use in line with the country's educational values.

### **Metrics for measuring effectiveness (academic performance, retention, student satisfaction)**

Assessing the impact of artificial intelligence (AI) on educational quality requires accurate metrics to measure the effectiveness of technological interventions in the classroom. Among the most relevant are academic performance, student retention, and student satisfaction. These variables allow us to observe not only quantitative results, such as grades and pass rates, but also qualitative aspects related to the learning experience.

Recent studies show that the integration of virtual tutors and AI assistants in university courses significantly improves these metrics. For example, at a

private university in Lima, the implementation of an AI-based virtual assistant raised academic performance, increased on-time submissions, and improved satisfaction and retention levels compared to groups that did not use the tool (Llanos et al., 2024).

Similarly, the use of AI predictive models has made it possible to identify risk factors and personalize support, reducing student dropout rates and improving the educational experience. In a study of more than 250 university students, it was found that personalized learning and data-driven guidance contributed to higher retention and an increase in positive perceptions of the quality of educational services (Torres-Gutiérrez et al., 2024).

Student satisfaction, as a subjective dimension of educational quality, is also impacted by AI. A study in Saudi Arabia, based on the information systems success model, revealed that the perceived usefulness of AI systems and their technical quality directly influence student satisfaction, which in turn improves academic performance (Alsulami, 2024).

Likewise, the use of AI to provide automated and personalized feedback has been shown to improve student engagement and motivation. According to Segovia-García (2024), educational chatbots have transformed academic support by offering immediate responses and personalized recommendations, which optimizes the student experience and their relationship with the institution (Segovia-García, 2024).

In conclusion, performance, retention, and satisfaction metrics are fundamental pillars for evaluating the impact of AI in higher education. Current evidence suggests that when these technologies are implemented in a planned manner and aligned with pedagogical objectives, they can contribute significantly to improving the quality of learning and the student experience.

### **Preliminary results of implementations in 2024**

During 2024, several universities around the world have reported positive preliminary results after implementing artificial intelligence (AI)-based tools in their educational processes. These initial findings show that, although still in the exploratory phase, AI has a tangible impact on academic efficiency, student experience, and pedagogical transformation.

In the case of international studies, the implementation of AI in higher education has significantly improved student data management, the design of personalized learning paths, and the automation of administrative tasks, allowing teachers to focus on more human aspects of the educational process.



According to Leffia et al. (2024), these advances have contributed to a substantial improvement in the student experience by offering them more relevant resources and continuous support, particularly through adaptive systems and sentiment analysis to assess their emotional and academic progress (Leffia et al., 2024).

Another study focused on active methodologies reveals that the use of AI in project-based learning has increased student motivation, creativity, and autonomy. Kyselova's (2024) research concludes that the incorporation of AI not only automates repetitive tasks for teachers, but also strengthens students' critical thinking and collaborative work skills, thus improving the overall performance of the group (Kyselova, 2024).

Likewise, recent experiences in Latin American universities indicate that, although the adoption of AI has been slow, institutions are beginning to define collaborative implementation strategies. A regional workshop with leaders from 19 universities showed that one of the main challenges is the lack of clear institutional strategies, but it was also recognized that the pressure to adapt to emerging patterns of AI use is generating positive change in academic and administrative policies (Vázquez-Villegas et al., 2024).

In terms of curriculum, universities implementing AI tools are beginning to reconfigure their programs to respond to labor market needs. This translates into a better alignment between acquired skills and professional demands, which improves the employability of graduates and raises the perception of educational quality (Melnyk & Pypenko, 2025).

Taken together, these preliminary results suggest that the implementation of AI in 2024 has begun to effectively transform higher education, provided that it is accompanied by a solid institutional strategy, teacher training, and an ethical approach. Although much research remains to be done, the first steps show a promising horizon.

## **Recommendations for future applications in higher education**

Process management has proven effective in linking strategic planning with educational quality in Mexican universities. Arjona et al. (2022) demonstrated that such management has a positive impact on quality indicators, although they emphasized that mere planning does not guarantee results without active monitoring. In this regard, it is suggested that continuous monitoring systems linked to academic performance goals be implemented, accompanied by timely adjustments and institutional accountability.



The pandemic exposed pedagogical shortcomings in university teachers, who are often trained more for research than for teaching. Francesc Pedró (2025) identified this gap and proposed professionals trained in teaching, the creation of pedagogical support centers, and evaluation mechanisms that recognize innovation in teaching.

For the future, it is recommended to develop accredited continuing education courses in teaching methodology that are mandatory for doctoral students, in addition to institutionalizing roles linked to teaching excellence with resources and explicit recognition.

In terms of inclusion, during lockdown, students with disabilities benefited greatly from remote access, which reduced the achievement gap between students with and without disabilities. Upon returning to face-to-face modalities, much of this progress was reversed. The recommendation is to institutionalize hybrid modalities and permanently maintain technological adaptations (class recordings, accessible questionnaires, etc.), as well as protocols that guarantee continuous access for students with functional diversity.

Finally, the incorporation of virtual environments enhanced collaborative learning, especially for vulnerable students. Candia et al. (2022) showed that interaction in forums and collaborative tasks significantly improved academic performance, particularly for those who started at a low level.

Therefore, developing and integrating collaborative learning tools and strategies, such as structured forums, team projects, and online dynamics, is a priority recommendation for enriching the quality of university education.

## Conclusion

The main objective of this research is to identify and analyze how the implementation of artificial intelligence (AI)-based tools influences the quality of asynchronous learning in mobile application development students at an Ecuadorian university during the year 2024. The expected contributions of this research are multiple and relevant, both academically and practically, as they will contribute to enriching knowledge in the field of technological education and digital transformation in the Latin American context.

One of the fundamental contributions will be the generation of empirical evidence on the positive impact that AI tools, such as virtual tutors and recommendation systems, have on student motivation, autonomy, and knowledge retention. This will provide a better understanding of how these

technologies can enhance autonomous and personalized learning in higher education settings, which is essential for designing more effective educational strategies tailored to the current needs of students.

The research will also identify the challenges and limitations associated with AI integration, such as technical, pedagogical, and ethical obstacles. This understanding will help educational institutions anticipate and overcome these difficulties, promoting a more inclusive, ethical, and contextualized implementation of artificial intelligence technologies. In this way, it will contribute to establishing best practices and guidelines that facilitate the responsible and balanced adoption of these tools in higher education.

Furthermore, the rationale for this research lies in the pressing need to transform traditional educational models toward more innovative and adaptive approaches that respond to the demands of a digital economy and an increasingly demanding labor market in terms of technological skills. The experience in the Ecuadorian context, particularly in technical careers such as mobile application development, can serve as a model for other similar institutions and regions, promoting an educational transformation aligned with the demands of the 21st century.

Finally, the results of this research have the potential to offer valuable insights to institutional leaders, teachers, educational technology developers, and public policy makers, facilitating informed decisions to integrate AI in an effective and responsible manner into the teaching-learning processes. In short, this study will contribute to consolidating a critical and pedagogically aligned vision of technological innovation that enhances asynchronous learning, improves student retention and satisfaction, and supports the development of digital skills essential for students' professional future.

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# Game design as a learning strategy in industrial engineering: application of technology readiness levels (TRL)

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## Introduction

A key concept in innovation management is that of technology readiness levels (TRL), which measure the maturity of a technology, from the initial idea to its implementation in the real world. Teaching TRL effectively can be challenging if limited to traditional lectures, as students often perceive them as abstract or disconnected from concrete experiences.

In this regard, pedagogical research shows that passive teaching through lectures or slides does not have the greatest impact on learning complex concepts. In fact, a meta-analysis in STEM education revealed that in classes based solely on lecture reading, 55% more students fail compared to classes that incorporate some element of active learning (Gui, et al., 2023). In numbers, average failure rates of 33.8% in traditional classes are reduced to 21.8% when active methodologies are introduced, marking a substantial improvement (Gui, et al., 2023). This confirms that active learning that engages students through discussion, collaboration, experimentation, etc., improves academic performance in engineering (Gui, et al., 2023).

The incorporation of playful strategies in higher education has gained relevance in the training of engineers, as it has become an effective way to develop key skills. In this context, Game-Based Learning (GBL) has established itself as an effective pedagogical methodology for strengthening motivation, active engagement, and knowledge acquisition among engineering students (Fotaris & Mastoras, 2019).

In response to this approach, a teaching experience was designed that focused on the collaborative creation of a board game involving industrial engineering

topics and aimed at the progressive understanding of TRLs. This proposal emerged as an innovative alternative to link innovation management theory with its practical application, allowing students to move from observing basic principles (TRL 1) to validating a functional prototype (TRL 4) through a series of playful and reflective stages developed in the classroom.

This chapter describes how the idea was generated, the game design process, its pedagogical implementation, and peer validation. It also documents the lessons learned, the evidence of learning obtained, and the benefits observed in students in terms of participation, creativity, and critical thinking. In this context, the following research question arises: How does the design and development of a board game based on TRL contribute to the understanding of innovation processes and the strengthening of skills in industrial engineering students?

The conceptual framework underlying the initiative is presented below, followed by a description of each phase of implementation, analysis, and results.

To support this teaching proposal, the concepts of Technology Readiness Levels (TRL) and their teaching in engineering, game-based learning (GBL), and game design as a pedagogical strategy are described below.

## **Technology Readiness Levels (TRL) and their teaching in engineering**

TRL is a measurement scale used to assess the maturity of a technology during its development. It consists of nine levels ranging from the observation of basic scientific principles (TRL 1) to a real system successfully tested in the final operating environment (TRL 9). In simple terms, they describe the journey of a technological idea from initial research, through prototyping and validation, to market or practical use. According to the National Aeronautics and Space Administration (NASA), each level has a precise definition; for example, TRL 1 implies that the basic principles have been identified and reported in basic research, TRL 3 means that proof of concept has been demonstrated at the experimental level, TRL 5 indicates that a component or subsystem has been validated in a relevant environment (simulated or laboratory), TRL 7 involves the demonstration of a prototype of the system in a real operational environment, and TRL 9 represents the actual system fully tested in operations (NASA, n.d.).

In industrial and R&D practice, this scale is used to manage risks and make decisions, which is why it is a widely used concept in innovation management,

technological development, and even in R&D project financing. Likewise, research organizations and companies use TRLs to evaluate the progress of technological projects, determine whether an innovation is ready to be transferred to production or needs further research, and communicate the status of development to stakeholders in a standardized manner. The European Commission's Directorate-General for Research and Innovation (2024), for example, incorporated TRLs as a criterion in innovation funding programs (Horizon 2020/Horizon Europe), and sectors such as defense, aerospace, energy, etc., adopt this nomenclature to align researchers, engineers, and managers. Therefore, an engineering graduate familiar with TRLs will have an advantage in understanding how ideas translate into products and what implications each stage of technological development entails.

In pedagogical terms, introducing TRLs into the curriculum allows technical knowledge to be contextualized within the innovation cycle. Instead of students viewing their academic projects as isolated exercises, they can learn to position them at a level of maturity and visualize what steps would be necessary to take a laboratory prototype to a real product.

### **Game design as a pedagogical strategy**

Game design for educational purposes must go beyond the playful and aesthetic dimensions, adopting an intentional pedagogical approach that prioritizes meaningful learning. In the context of STEM education, it has been shown that the effectiveness of digital games depends largely on the quality of the learning mechanisms that structure them (Gui et al., 2023). This involves designing experiences that not only entertain but also actively facilitate the understanding of complex concepts, the development of higher cognitive skills, and the transfer of knowledge to real-life situations.

Likewise, the integration of a coherent narrative, an authentic context, and events based on real problems is presented as a key condition for achieving such transfer. As pointed out by Jääskä et al. (2022), games must be realistic and closely linked to learning objectives and professional contexts, ideally designed in collaboration with actors from the productive sector. This approach ensures that the dynamics of the game maintain their educational relevance and promote learning that is applicable in real-world scenarios, thus consolidating the potential of game design as a student-centered pedagogical strategy.

In engineering, findings obtained from the implementation of playful strategies in the classroom reflect a high potential for the comprehensive development of

key skills in training. As evidenced by Lluch-Molins et al. (2022), game-based learning promotes intrinsic motivation, collaborative work, and improved academic performance, while also creating an environment of student satisfaction. These benefits are not only linked to the subject matter covered, but also to the dynamics inherent in the game itself, where cooperation, effective communication, creativity, and critical thinking emerge spontaneously (Fernández & Castillo, 2022). In line with this, Jääskä et al. (2022) highlight that game-based learning solutions can prepare students for decision-making in real-world environments characterized by uncertainty, a dynamic typical of innovation projects.

Taken together, this evidence supports the idea that the design and implementation of games in the field of industrial engineering not only improves conceptual understanding but also activates complex collaborative processes, promotes soft skills, and strengthens key capabilities for innovation, such as systemic thinking, adaptability, and creativity, which are essential in training professionals for contexts of rapid change.

### **Design and implementation of the experience**

The pedagogical experience described here is developed within the framework of the Industrial Engineering program at the Technological Units of Santander (UTS), a Colombian higher education institution committed to training well-rounded professionals capable of facing the challenges of an increasingly dynamic and competitive productive environment. The Industrial Engineering program trains professionals with strategic vision and entrepreneurial skills, prepared to lead plans, programs, and projects aimed at improving production systems through innovative, sustainable, and efficient solutions (UTS, n.d.).

The teaching strategy described above was implemented in the Innovation Management course, which is part of the ninth semester of the curriculum. The purpose of this course is to strengthen students' understanding of the processes that enable the generation, structuring, evaluation, and implementation of technological innovations within industrial organizations.

The group of students who participated in the experience was made up of young people nearing the end of their professional training, with a high aptitude for teamwork, complex problem solving, and the practical application of the knowledge acquired throughout their career. The activity was designed with this profile in mind, with the aim of consolidating skills associated with critical thinking, creativity, interdisciplinary collaboration, and informed decision-making, in line with the demands of the productive environment and the training standards of the UTS industrial engineer.

Based on the learning outcomes, teachers are expected to provide clear and structured guidance for the educational experience based on active learning methodologies, specifically Project-Based Learning (PBL), applied to game design (UTS, 2024). This implies that teachers must accurately explain the methodology to be used, as well as clearly establish the dynamics of group work, learning objectives, and the competencies to be developed during the activity. Likewise, they must timely communicate the assigned tasks, evaluation criteria, and instruments that will be used to assess student performance. In addition, the teacher is expected to maintain effective communication throughout the process, responding to students' concerns, providing ongoing guidance, and creating opportunities for formative feedback. This feedback should be aimed at improving the learning process, with specific comments on the work submitted, thus promoting critical reflection, continuous improvement, and the comprehensive development of the intended competencies.

On the other hand, students are expected to take an active, autonomous, and reflective role in their learning process, taking advantage of group and project-based learning methodologies as an opportunity to enhance their individual understanding. This implies that students must organize their time appropriately, plan their assignments, and take a proactive approach to the tasks assigned to them and project-based learning methodology as an opportunity to enhance their individual understanding. This implies that students must organize their time appropriately, plan their assignments, and take a proactive attitude towards the tasks assigned, either by drawing up their own schedules or following those provided by the teacher.

Students are also expected to implement effective strategies to carry out their activities, such as searching for information in complementary sources, participating in tutoring sessions, collaborating with their peers, and asking the teacher questions when necessary. In addition, they must demonstrate self-assessment skills, critically identifying areas for improvement during the development of tasks in order to adjust their actions and achieve the proposed objectives. This active and strategic approach is key to achieving competencies in active learning contexts.

## **Game planning**

The activity began with a clear instruction: each group of four or five students had to select an everyday object (except for stationery items or cell phones) that was not repeated within the same team. Based on these objects, students were challenged to conceptualize, design, and build a board game inspired by formats such as charades, UNO, dominoes, among others. This instruction

required a functional reinterpretation of the selected object, while promoting creativity, collaboration, and team problem-solving.

The game design process was structured according to TRL levels, specifically from TRL 1 (observation of the basic principle) to TRL 4 (validation of the functional prototype in a laboratory environment). To advance between levels, teams had to document their progress on a validation form that recorded evidence and technical justifications, which was then reviewed by another group (as a cross-validation exercise), thus replicating the real dynamics of peer feedback in technological innovation projects.

As final products, students submitted three key outputs: (1) a technical validation sheet of TRL progress with structured evidence, (2) a set of game rules, presented in visual formats such as Canva or PowerPoint presentations, and (3) the functional prototype of the game that would be used in technical validation.

## Execution and development

The premise was simple: if innovation can solve problems, generate value, and connect with people, why not learn to innovate by creating something from scratch... and playing? This gave rise to multiple ideas that were turned into prototypes, including games with varied mechanics, original rules, and themes related to engineering and the world of production. However, the biggest challenge was not only to design something "fun," but also to validate whether it really captured attention, motivated interaction, and generated learning.

**Table 1.** *Structure of the technical data sheet: TRL progress validation*

| Stage of the strategy | Equivalence TRL                                | Actions taken                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|-----------------------|------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Idea and Conception   | TRL 1 – Principles basic observed and reported | <ul style="list-style-type: none"> <li>• Selection of everyday objects to include in the game (except for stationery items or cell phones), no may be repeated within the same team.</li> <li>• Results of preliminary basic and applied research -</li> </ul> <p>Theoretical review (bibliographic references and websites).</p> <ul style="list-style-type: none"> <li>• Generation of the game idea: Initial collaborative design</li> </ul> <p>with students (brainstorming).</p> |

During the game testing day, students presented an initial version of their designs that incorporated the essential functionalities necessary to represent the complete dynamics of the product, its Minimum Viable Prototype (MVP) (Table 2). This version of the game, developed to reach a TRL 4 (validation in a laboratory environment), underwent a validation process with peers, teachers, and other members of the academic community at the IndusLab event during Industrial Engineering Week 2024-2 (Figure 1).

**Table 2.** *Capabilities of games*

| N o. | Game name                         | Number of People per round | Duration      | Number of people in 1 hour |
|------|-----------------------------------|----------------------------|---------------|----------------------------|
| 1.   | Vortex of destinations            | 4                          | 20 min        | 12                         |
| 2.   | Listening and guessing            | 3                          | 20 min        | 12                         |
| 3.   | Operation to safeguard Rosaura    | 5                          | 15min         | 20                         |
| 4.   | Elemental Summit: Wild Mission    | 4                          | 15 min        | 16                         |
| 5.   | Arriving at the subway            | 4                          | 10 min        | 24                         |
| 6.   | <b>Make sense of the industry</b> | <b>2</b>                   | <b>10 min</b> | <b>12</b>                  |

Do you know how inventions are made? That was the question that kicked off this validation experience outside of innovation management classes. Amidst testing, strategizing, discussions, and creativity, students experienced, almost without noticing, the real complexities of bringing an idea to practical validation.

More than a one-off activity, it was a space for active learning, meaningful appropriation of concepts, and direct experience of collaborative work and iteration, so characteristic of the innovation process. What began as a playful exercise became an opportunity to understand, from within, how inventions are built.

Note: Evaluation carried out by the teachers who attended the board game presentation day at the IndusLab 2024-II event of the Industrial Engineering program – UTS.

Based on this validation, 87 responses were collected, including qualitative observations and suggestions for improvement that provided feedback for the

game design and redesign process. Thus, the methodological approach not only promoted the practical application of TRLs in the educational context, but also simulated real scenarios of innovation development and iteration, providing an authentic project-based learning experience.

The recommendations provided by participants during the game validation process are grouped into seven categories that identify opportunities for improvement in different aspects of the design and gaming experience (Table 3). First, there are suggestions related to the design of the board and components, focused on optimizing physical elements such as squares, tokens, timers, and figures to improve interaction and usability. Second, observations about the content and dynamics of the game invite enriching the experience by incorporating more questions, levels, puzzles, and prizes, as well as adjusting the difficulty of the activities. A third group of recommendations emphasizes clarity in the rules and instructions, underscoring the need to explain them adequately to ensure understanding and equitable participation.

Aspects related to the speed and fluidity of the game were also pointed out, suggesting adjustments that would make progress more dynamic, such as the use of two dice. On the other hand, it was proposed to expand participation and scalability, allowing more students to actively participate. In terms of aesthetics and presentation, the importance of visual design as a motivating factor was valued.

Finally, aspects for improving game mechanics were identified, such as optimizing the roulette wheel and controlling question repetition, in order to increase the challenge and maintain player interest. This set of recommendations provides a valuable basis for iterating prototypes and reinforcing their pedagogical impact. In this sense, the validation of the Minimum Viable Prototype (MVP) in the activity allowed students to experience a real process of feedback and improvement, strengthening their understanding of the innovation cycle. By contrasting their designs with real users, they identified opportunities for adjustment and consolidated key skills such as iteration, empathy, and evidence-based decision-making.

In summary, the design of an educational game that incorporates TRLs offers an innovative and effective pedagogical strategy for teaching innovation management in Industrial Engineering. By combining the structure of TRLs with playful elements, it facilitates a practical and in-depth understanding of technological development processes, preparing students to successfully face the challenges of contemporary industry.

The implementation of this teaching strategy based on game design produced



remarkable evidence of learning among students, which supports its effectiveness. The main results and benefits observed are summarized below, contrasting them as far as possible with external sources that report similar findings. After the experience, students demonstrated not only knowledge of the definition of each level, but also an understanding of the implications of moving from one to another. This result coincides with the effect reported by Jääskä et al. (2022), where a playful activity in project-based education made students feel prepared to deal with uncertainty, just as in real-life projects. The students internalized that technological development is neither linear nor guaranteed, and were able to discuss strategies to mitigate risks at each stage (e.g., investing extra time in TRL 3 to ensure a solid foundation before jumping into building prototypes). This type of strategic understanding goes beyond what a traditional written assessment could achieve in isolation.

Throughout the rest of the course, there was a noticeable overall increase in student participation, especially when it came to topics related to technological innovation. The activity acted as a catalyst that sparked their curiosity. Previous experiences have documented that GBL increases student engagement and intrinsic motivation (Jääskä et al., 2022) by offering an immersive and challenging experience. A recent meta-analytic review even found that digital game environments in STEM produce a medium to large positive effect on performance compared to conventional classes (Gui, et al., 2023), attributed in part to students devoting more time and cognitive intensity when motivated by the game. Incorporating games into engineering courses can serve as a bridge between abstract theory and simulated practice. In this sense, the TRL game allowed students to understand the process of technological innovation, not just the definition of its stages. This coincides with other studies that point out that games in engineering help future engineers visualize how to apply their theoretical knowledge in practice (Núñez-Pacheco, et al., 2023). It is recommended to identify in each course those complex concepts or processes that could benefit from a playful simulation.

Although the focus of the learning strategy is on understanding TRLs, a significant collateral benefit was the training of cross-cutting skills. Students practiced teamwork in designing and playing, effective communication (both in creating understandable rules and in debating), and exercised creativity. The latter deserves special mention, as by giving them free rein to come up with challenges and narratives, the students surprised us with original proposals.

Taken together, these findings reaffirm some of the promises of game-based learning reported in the literature: In addition, it was found that including students in the creation process was a success that enhanced learning as much

or more than the actual playing. As co-designers, they went from being consumers to producers of content, which increased their engagement. This is a recommendation that could be made to other teachers, in which involving students in the development of their own learning tools can amplify results. Finally, the need to place greater emphasis on the final TRL levels and to manage time better was identified, modifications to the experience that can be incorporated into future editions of the course.

## Conclusions

The experience described in this chapter illustrates how an unconventional teaching strategy, focused on the design and use of a game, can transform engineering students' understanding of a specialized topic (TRL). Through a narrative and practical approach, students were able to experience the process of technological maturation firsthand, turning theoretical concepts into a series of challenges, decisions, and meaningful learning experiences. This initiative was based on solid principles of active and experiential learning, and its successful implementation went through stages equivalent to the TRLs themselves, from the idea to final validation in the classroom.

Game design as a learning strategy in Industrial Engineering offers numerous benefits, such as improved technical skills, the development of professional competencies, greater motivation, and the practical application of knowledge. However, it is essential to carefully consider the alignment of game design with learning outcomes and evaluate its effectiveness to maximize its educational potential. Involving students in the co-design of the learning tool proved to be a differentiating factor. It will not always be feasible for them to design the game from scratch, but they can be included in content creation (e.g., proposing cases, challenges, or questions for the game). This not only increases their motivation, but, as evidenced, can foster their creativity and give the teacher an opportunity to see how students are understanding the material by proposing the rules or questions themselves. Co-creation turns the class into a collaborative learning community.

As in technological development, there is no need to fear adjusting the strategy as you go along. In this experience, the game design was iterated with student feedback before the functional testing of the prototype by those who attended the IndusLab event. Similarly, at the learning strategy level, the teacher should observe the dynamics and collect feedback to refine the activity for future occasions. Furthermore, documenting and publishing these experiences helps to build a body of evidence that encourages more teachers to innovate and refine techniques.

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# Artificial Intelligence and University Students' Perception in Learning

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## Introduction

Currently, Artificial Intelligence (AI) encompasses all fields of knowledge, particularly at the educational level. Professors from different academic disciplines are changing their methodologies to enhance student learning. Today's students have access to information that previously required significant time to locate, and professors seek to integrate this vast information with pedagogical methods, adapting to current student needs and thereby improving the teaching-learning process (Valencia Tafur & Figueroa Molina, 2023). The current reality is characterized by numerous technological tools that cover multiple information fields and generate innovative strategies for improved evaluation. These tools enable the accumulation of large amounts of data and allow students to generate predictions while achieving high levels of creativity (Moreno-Padilla, 2019).

To improve education, institutions tend to purchase programs and hardware as tools for professors to implement teaching strategies and provide creative information, seeking changes in modality and approaches to reach students. The pandemic abruptly accelerated this transformation through distance education, which used well-crafted videos to enable university teaching to continue while managing academic, operational, and individual data. AI helps simplify teaching processes through intelligent data utilization (Patricio *et al.*, 2022). While AI cannot yet operate as a classroom professor, it offers solutions for students to enhance information access, expand existing knowledge, and enables professors to improve learning monitoring. Professors can personalize content while seeking feedback and data quality for learning applications (Magallanes-Ronquillo *et al.*, 2023). Additional important aspects of AI in education include adaptation to learning styles, creation of educational environments through reflection, and reduction of inequality within social contexts (Merino-Luzón *et al.*, 2023), highlighting the need to integrate AI with learning (Atencio-González, 2023). However, risks exist in using AI for education, as it generates student concerns about privacy invasion and

potentially creates gaps in access to inclusive, quality education. Similarly, professors perceive the threat of being replaced by AI and worry about creating negative ethical characteristics in individuals (Jara & Ochoa, 2020).

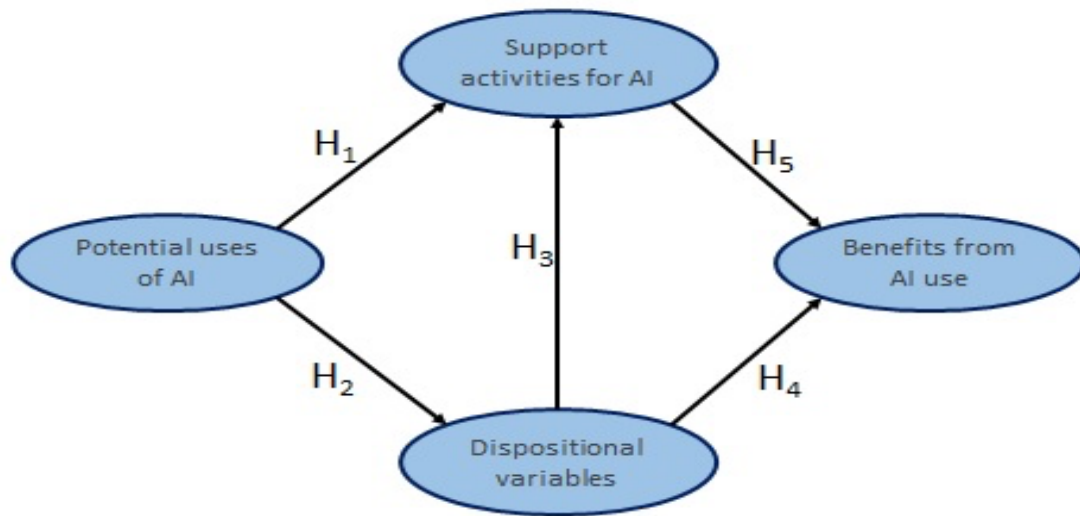
The connection between education and AI represents a crucial factor, serving as a central axis that intersects learning processes, particularly in association with educational platforms, chats, social networks, and learning management systems through which educational work is being transformed and constructed. Current demands have motivated the creation of technological solutions aligned with new educational trends, generating continuous interest in AI use within higher education and projecting a future for learning and knowledge acquisition (Gonzales & Bonilla, 2022). University students perform activities guided by professors' orientations centered on disciplinary principles that promote new competencies, criteria explanation, example usage, and evaluations (Victoria *et al.*, 2014). The didactic integration of performance-based AI establishes a solid foundation for analyzing its influence on educational practices and the time students dedicate to using these tools according to the Interbehavioral Model of Performance (MIDD).

Additionally, the rapid organization and structuring of information aids learning primarily due to data processing speed, but this information carries dual implications. While it efficiently streamlines information access, it may lack accuracy and generate misinformation, causing students to reduce their analytical thinking when attempting to elucidate, clarify, or define concepts (Yeung *et al.*, 2025). This raises questions about the appropriateness of integrating AI with learning.

Despite this dilemma, technology continues advancing and increasingly integrates into academic levels, modifying traditional teaching and directing it toward current technological trends. Therefore, this research aims to explore individual variables regarding how undergraduate university students in Administration programs at campuses somewhat distant from the city perceive AI use for learning, while identifying activities students consider beneficial for their education with AI support.

To identify this research trend, the following hypotheses were proposed: [H1]: Possible AI uses influence AI support activities. [H2]: Possible AI uses influence dispositional variables. [H3]: Dispositional variables influence AI support activities. [H4]: Dispositional variables influence AI use benefits. [H5]: AI support activities influence AI use benefits (Figure 1).

**Figure 1.** Structural model of AI and learning



## Artificial Intelligence and Education

AI has evolved rapidly since the late 19th century. It emerged as a science in 1956 at Dartmouth College in Hanover (United States) through four researchers: John McCarthy, Marvin Minsky, Nathaniel Rochester, and Claude Shannon. Understanding this historical stage is important because it provides a retrospective vision for society and education. Currently, numerous changes have occurred; AI can be defined as the "capacity of machines or software systems to perform tasks that would normally require human intervention, using algorithms and data models to learn, adapt, and make decisions based on patterns and previous experiences." (Toro-Espinoza et al., 2023, p.156).

Since its beginnings, AI has demonstrated relationships and similarities with educational theory and technology, becoming a form of intelligent tutoring (Bond et al., 2024). In educational practices, technologies have driven major advances primarily in learning and cognitive computing processing. Various conversational models have been created among students, achieving nearly automatic feedback and reaching almost personalized learning platforms. These technological advances also raise questions about ethical implications in their utilization (Ho et al., 2021).

This potential has driven educators to explore student learning experiences, improving knowledge outcomes, and in many cases promoting personalized learning (Sun et al., 2025). Despite significant technological advancement, using AI in education within learning processes is not entirely ideal. Observations have shown that students demonstrate negative consequences

from AI teaching because it distances students from critical thinking and directs them toward proper learning attitudes and desires to undertake innovative creative activities, creating regression to cognitive levels (Wang & Li, 2024). This affects students' academic performance and, furthermore, their ability to solve problems in daily life. According to Atencio-Gonzales (2023, p.651):

New technologies can help optimize the teaching-learning process, since education is not a product but a process, where learning extends beyond simple knowledge acquisition. AI as a new technology has strong potential in education, since systems based on this technology can favor personalized learning according to students' needs and interests.

AI could help society overcome many complex problems across various areas, especially those involving actions where communities seek solutions to survival problems, although as human beings, they face challenges regarding their rights and security (Bolaño-García & Duarte-Acosta, 2023).

The study was conducted with university-level students from the Administration program, which maintains campuses in Camaná, Mollendo, Pedregal, and Arequipa. Of the total surveyed, only 157 students from first to fifth year responded to the questions. Campus distribution included: Arequipa 12.7%, Mollendo 19.1%, Camaná 36.3%, and Pedregal 31.8%. Of this total, 63.1% are women and 36.9% are men. Age concentrates in the 18-20 and 21-23 frequencies with 79.6%, indicating that university students are quite young for this study.

**Table 1** *Demographic data*

| Variables       | Category      | Frequency | Percentage % |
|-----------------|---------------|-----------|--------------|
| Gender          | Female        | 99        | 63.1         |
|                 | Male          | 58        | 36.9         |
| Age             | 15 - 17 years | 5         | 3.2          |
|                 | 18 - 20 years | 51        | 32.5         |
|                 | 21 - 23 years | 74        | 47.1         |
|                 | 23+ years     | 27        | 17.2         |
|                 |               |           |              |
| Year of Studies | 1st year      | 19        | 12.1         |
|                 | 2nd year      | 21        | 13.4         |
|                 | 3rd year      | 60        | 38.2         |
|                 | 4th year      | 14        | 8.9          |
|                 | 5th year      | 43        | 27.4         |
|                 |               |           |              |
| Study           | Arequipa      | 20        | 12.7         |

Campus

|          |    |      |
|----------|----|------|
| Camaná   | 57 | 36.3 |
| Mollendo | 30 | 19.1 |
| Pedregal | 50 | 31.8 |

Note: Own elaboration (2025), based on Jamovi 2.6

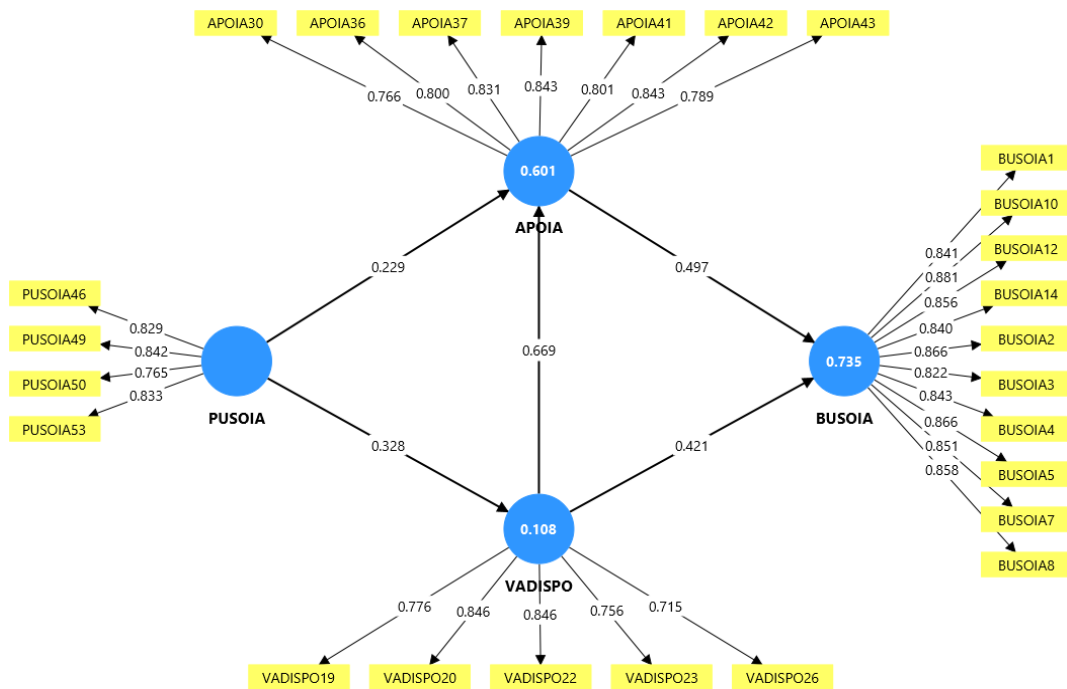
The model presents a general study of four variables: activities with AI support, dispositional variables, consequences of AI use, and benefits of AI use. The coefficient of determination ( $R^2$ ) indicates AI use benefits with a very high level, reaching 73.5% of the variance in perceived benefits from AI use, reflecting excellent value in the educational field. AI support activities show 60.1% explanation through possible AI uses. Conversely, the dispositional variable shows 10.8%, indicating that variance in this variable is explained only by possible consequences of AI use, which requires review.

The latent variables representing research pathways and our hypothesis approach demonstrate that possible AI uses and AI support activities maintain a moderate, positive relationship of 0.229, showing that professor-conducted activities have minimal influence on student activities with AI support. Our second hypothesis regarding the influence of possible AI uses on dispositional variables shows a value of 0.108, determining a moderate relationship with low explanatory capacity. The third hypothesis, where AI support activities and AI use benefits reach 0.601, indicates a strong and significant relationship, reflecting the model's most significant pathway and explaining that student activities with AI achieve substantial benefits from using this tool.

Furthermore, the fourth hypothesis shows that dispositional variables with AI use benefits reach 0.421, representing a moderate relationship where students emphasize that their attitudes, openness, and motivation influence perceived benefits. Factor loadings for each item demonstrate that most exceed 70%, indicating good convergent validity and strong representation of latent variables (Figure 2). The model demonstrates that effective AI use in educational activities constitutes a crucial factor influencing perceived benefits, with usage consequences indirectly affecting benefits, particularly by facilitating AI-supported activities.



**Figure 2.** Structural measurement model



## Cluster analysis

The structural equation analysis model explains perceived benefits from AI usage. AI support activities including time dedicated to studies, research work conduct, resource access, activity and task improvement in class, and effective feedback on learning; all exert strong significant effects on AI use benefits. This suggests that greater student participation in AI-assisted academic activities results in enhanced content usage according to curriculum standards, improved benefits, skills, and opportunities while achieving academic integrity. This finding aligns with previous research on technology application in learning that demonstrates efficiency in results.

In contrast, dispositional variables such as training, education, experience, and openness to perceived AI benefits, while presenting moderate relationships, indicate that personal variables do not significantly influence AI use benefits. Additionally, AI use consequences do not directly affect usage benefits but have indirect implications through support activities and dispositional variables. These perception pathways demonstrate how technologies in academic learning are guided by individual factors and personal usage patterns.

## Conclusions

Technology advancement, particularly after the pandemic, has significantly influenced tasks and activities of university students at Universidad Nacional de San Agustín across its various campuses. Student perceptions indicate substantial benefits and potential in AI tool usage, impacting learning processes by enabling faster information access and problem-solving. Comparative analysis of students from Arequipa, Mollendo, Camaná, and Pedregal campuses revealed approaches to AI perception and methods for improving academic tasks through information searching, writing enhancement, and result analysis.

University students significantly value AI tool usage in academic activities. However, this valuation has resulted in strong dependence on such tools, with students dedicating approximately 80% of their available time to their use. This situation has negatively impacted the development of independent skills such as critical analysis and personal writing, limiting the individual effort essential for deep and autonomous learning.

This research provided insights into how university students from Administration program campuses prioritize AI tool usage in their academic environment, seeking to integrate intelligent technologies into teaching-learning processes while achieving impact on perceived benefits and promoting curricular design that integrates AI use in productivity and daily activities. Professors, meanwhile, require training in pedagogical use of these tools for effective subject monitoring, while considering potential risks to their professional development and harmful effects on ethical principles when addressing various academic learning challenges in professional programs, all stemming from excessive technological tool usage in learning processes.

Currently, technology has become an essential resource by facilitating information access and optimizing analysis time for presenting organizational requirements. In this context, education is considered a fundamental pillar for knowledge transmission and sustainable societal development. AI technology usage requires careful and ethical management. The utilization of AI-generated data can directly influence strategic decision-making affecting educational systems. Thus, education assumes an important role not only in academic formation but also in promoting responsible, critical, and reflective use of new technologies.

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# Teacher training in STEAM Methodologies and its effect on Scientific and Mathematical Learning

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## Introduction

The issuance of the Competency Curriculum Framework (2023) has triggered a transformational shift in Ecuador's curriculum, offering opportunities for innovation in teacher education through STEAM (Science, Technology, Engineering, Art, and Mathematics). This approach promotes participation, interdisciplinary learning, and contextualized education, interweaving artistic and technological competencies with problem-solving and inclusivity. However, challenges persist, such as limited use of new technologies, lack of soft skills development, and insufficient inclusion of interethnic diversity and gender equity in teacher training program design.

Participants from Universidad Laica Eloy Alfaro de Manabí (ULEAM) and Universidad Técnica Particular de Loja (UTPL) attended training from September 16 to 27, 2024, as scheduled during their registration. This period coincided with the start of the new academic year. The program included in-person workshops on robotics, programming, virtual reality, and educational data science, as well as an asynchronous virtual module on STEAM fundamentals. The hybrid format promoted the use of advanced educational technologies and emphasized gender, interculturality, and active learning strategies aligned with Project-Based Learning (PBL).

This article analyses teachers' perceptions regarding the impact of their STEAM training on student learning, particularly in science and mathematics. It also explores how this training influences students' attitudes and motivation toward these disciplines, which are essential for scientific or engineering careers. Using a qualitative methodology, open interviews and inductive coding were applied to construct semantic networks. These networks reveal the key concepts and

relational patterns teachers mobilize in their pedagogical transformations and in the changes they observe in their students.

The study makes a significant contribution to teacher education by providing empirical evidence on how STEAM-based training transforms pedagogical practices and student engagement. Its novelty lies in the use of conceptual semantic networks to analyse teacher perceptions, offering insight into the impact of interdisciplinary training on classroom dynamics. This method reveals how teachers integrate digital tools, PBL, and socioemotional learning. Additionally, the research situates STEAM training within a territorial, intercultural, and gender-inclusive framework, promoting equitable and context-aware educational innovation in Latin America.

### **STEAM Training for teacher**

According to Silva-Hormazábal and Alsina (2023), Soto and Villena (2024) the STEAM training attempts to address the integrated approach to the educational problems of the 21st century. It goes beyond the mere integration of disciplines because STEAM encourages active pedagogy where experimentation, critical thinking, and resolution of complicated issues are done in an interdisciplinary manner. In teacher training, its use promotes the development of skills related to project design in the context, advanced literacy, and a guiding research mindset, which are fundamental in teaching the science and mathematics courses in the classroom

The research of Santillán *et al.* (2019) shows that teacher training utilizing a STEAM framework enables the integration of technical and pedagogical knowledge through PBL and cooperative processes. These strategies enhance the meaningful internalization of content and bolster computational thinking, which is foundational for nurturing engineers and scientists within diverse educational contexts (Soto & Villena, 2024; Vera & Bonilla, 2025). The integration of technologies like educational robotics or visual programming languages such as Scratch also fosters critical digital literacy and the development of immersive experiences that enhance motivation and a positive attitude toward science (Berciano *et al.*, 2021).

The development of conceptual maps, such as the one built in this study, helps to reflect on how teachers understand their STEAM training as a transformative experience that consolidates their professional competencies and diversifies the teaching-learning processes. Berciano *et al.*, (2021) evidence indicates that this framework strengthens with teachers 'ability to design integrative, critical, and innovation-driven educational proposals, instilling in their students a collaborative and creative disposition towards scientific and mathematical

knowledge and, more importantly, towards learning.

### **Student interest in learning science and mathematics**

According to Wu *et al.*, (2024, p. 25744) an “attitude toward scientific and mathematical disciplines is critical for developing constructive thinking and interest in STEM fields. Self-efficacy, usefulness, and the learning climate shaped by the teacher are determinants”. In this regard, teacher preparation with STEAM training goes beyond providing methodological strategies; it means expanding a teacher’s pedagogical toolbox to enable the design of transformative experiences that enhance students’ positive feelings, and thoughts towards learning. Studies such as that of Vázquez, Aguilar and Magaña (2008 cited by Tolentino, 2018) underscore that social self-efficacy are pivotal in fostering interest in the scientific professions at an early age.

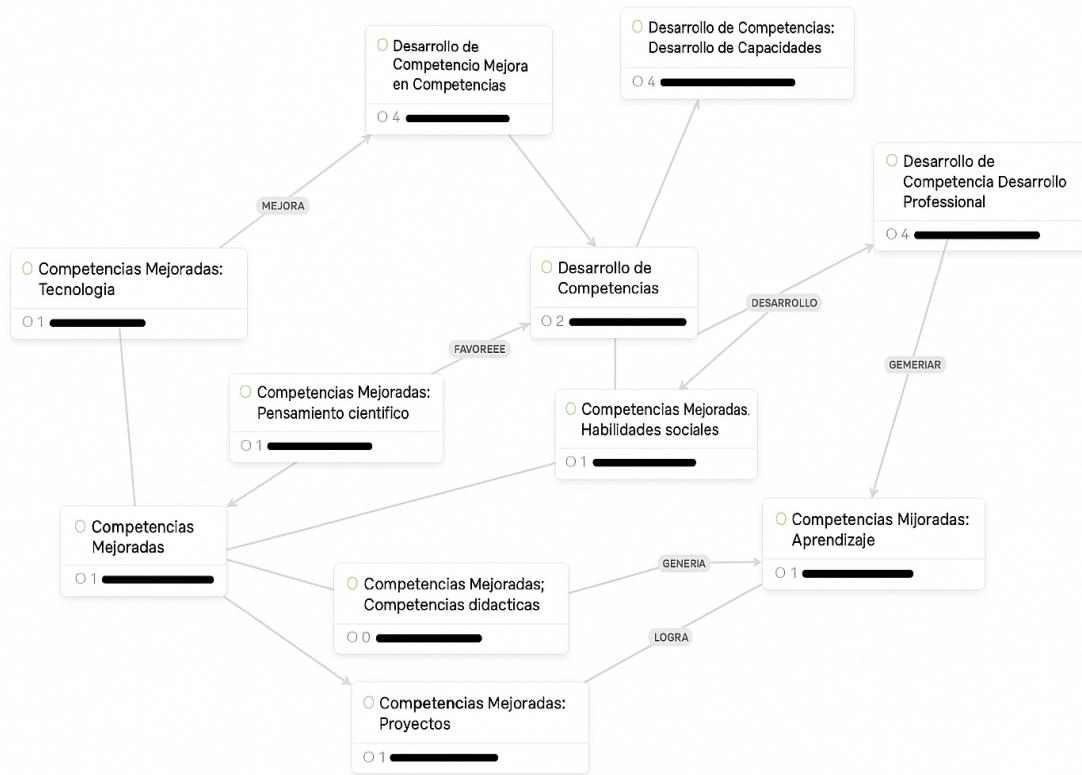
The inclusion of educational tools such as the interactive Phet simulations, as well as active methods like PBL (Figuerola *et al.*, 2018) and gamification (Morocho Palacios *et al.*, 2023; Zambrano *et al.*, 2022), strongly reinforce this process by making classes more dynamic and theory-based practice, playful and participatory learning environments. These approaches not only contribute positively to the active construction of knowledge but also enhance the investigative attitude and appropriation of scientific knowledge within authentic contexts (Amanova *et al.*, 2025). STEAM-trained teachers report marked differences in students' motivation and participation, as students demonstrate increased willingness to engage in challenges, embrace problem-solving, and perceive science and mathematics as valuable to daily life.

### **Transforming pedagogical practices through the STEAM framework: an analysis of the teacher's skills and scientific-mathematical learning.**

The following network diagram is generated from the coding of the responses from the teachers, incorporating their own reflections and perceptions about their pedagogical practices:



**Graphic 1.** Transforming the pedagogical practice through the STEAM approach



Based on the analysis of data collected through conceptual networks in *Atlas.ti*, STEAM-focused teacher training programs offer new opportunities to reshape pedagogical practices. The integration of science, technology, engineering, the arts, and mathematics into a cross-disciplinary curriculum enhances practical problem-solving and critical thinking. The development of pedagogical competencies emerges as a central axis, influencing both professional growth and the acquisition of didactic, digital, and social skills. The centrality of the node *Desarrollo de Competencias* (development of competences) reveals that participants do not simply adopt innovations; they actively transform teaching practices (Castro-Campos, 2023).

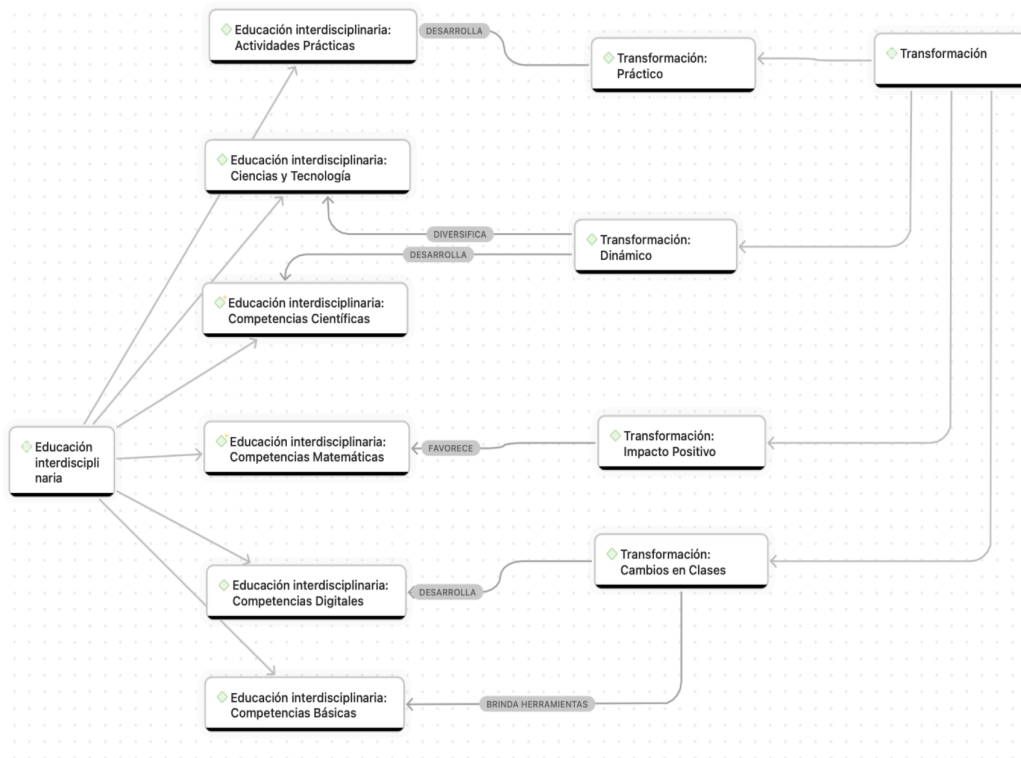
This transformation is reflected in enhanced abilities to create meaningful, context-based learning experiences. The connection between *Competencias mejoradas* (enhanced competences) and *Aprendizaje* (learning) suggests that STEAM-trained teachers foster holistic STEM learning through project-based methodologies (Lam-Byrne, 2023) and digital tools. This pedagogical shift promotes digital literacy, learner autonomy, and socioemotional development—essential elements for inclusive, relevant, and future-ready education in the 21st century.



## Innovative Pedagogy with STEAM: Effects of Teacher Training on Science and Mathematics Learning

Based on the preliminary findings of the study, the second interpretation network is presented:

**Graphic 2: Innovative Pedagogy with STEAM** Source: Own work using Atlas.ti 25



Interdisciplinary education within the STEAM approach moves toward integrating science, technology, and mathematics through constructivist pedagogical practices. It enriches teaching methods and encourages active, collaborative learning. Implementing methodologies like Problem-Based Learning and Phet simulations fosters practical engagement, critical thinking, and inquiry. When students perceive relevance and feel confident, their affective attitudes toward science are more positive. Teachers trained in STEAM show a more optimistic pedagogical outlook, supporting the construction of meaningful knowledge (Galvis, 2007; Vaquer et al., 2019). This is reflected in the increased interaction when addressing science and math challenges.

‘Developing teachers’ basic and digital skills leads to deep changes in classroom dynamics and enhances the use of educational technologies that boost student engagement and motivation (Barberà et al., 2015). Instructional designs rooted in playful, real-life contexts improve students’ self-efficacy and foster scientific literacy from early stages. These transformations involve not only technical skills but also emotional and intellectual shifts. As a result, science and mathematics are revalued as essential aspects of everyday life (Calle et al., 2021). The study confirms the relevance of professional development in STEAM disciplines, especially in improving teaching practices and learning outcomes.

Conceptual networks revealed *desarrollo de competencias* (competency development) — particularly digital, investigative, and collaborative — as central to pedagogical innovation. PBL emerges as a core element of contextualized STEAM lessons (Carmona et al., 2019), and interdisciplinary experimentation supports meaningful learning (Manganelli, 2023). STEAM training also promotes inclusive and adaptive teaching models (Del Pezo Baque et al., 2025), essential to address structural inequities in Latin America. Teachers design transformative, situated learning experiences that build transversal skills like critical thinking and teamwork. As Camacho-Tamayo and Bernal-Ballén (2024) state, STEAM is both a pedagogical and political strategy to democratize knowledge.

## Conclusions

The study revealed that teacher training under the STEAM framework is a powerful tool for transforming pedagogical practices in Ecuadorian education. Participating teachers experienced a significant shift from being content transmitters to becoming learning designers, developing didactic, scientific, technological, and digital competencies. The analysis of conceptual networks identified ‘competency development’ as the central node linking key elements such as PBL, scientific thinking, and digital integration. This indicates that STEAM training fosters a reflective, collaborative, and innovative pedagogical culture, promoting dynamic and context-relevant learning in science and mathematics.

These findings align with Carmona et al. (2019), who highlight PBL as central to interdisciplinary STEAM lessons, and Manganelli (2023), who emphasizes the impact of inquiry-based, technology-enhanced practices on student engagement. Del Pezo Baque et al. (2025) further support the inclusive, adaptable nature of STEAM, especially in multicultural classrooms. The study confirms that integrating emerging technologies—such as robotics, virtual simulations, and gamified platforms—boosts motivation, strengthens self-

efficacy, and enhances knowledge appropriation in traditionally difficult subjects.

The hybrid training model, combining virtual modules with hands-on workshops, proved effective for contextualizing pedagogical tools. Teachers reported improved skills for designing interdisciplinary and creative learning experiences aligned with the national curriculum and responsive to their local realities. This demonstrates the importance of scaling similar programs nationwide, with an emphasis on digital integration, interculturality, and gender equity in STEM.

Given the positive outcomes in teaching practices and student engagement, future research should examine the long-term effects of STEAM training on classroom performance and academic trajectories. It is also crucial to investigate the development of socioemotional and collaborative competencies in STEAM environments. Furthermore, research should address the scalability of these programs in rural or under-resourced settings and conduct intersectional analyses on how ethnicity, gender, and geography shape access to and participation in quality STEM education.

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# Systematic Review of Educational Reengagement: Factors, Programmers and Strategies under the PRISMA Framework

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## Contextualization of School Dropout and the Importance of Educational Re- engagement

School dropout, or "dropout", represents a complex educational phenomenon of global concern, characterized by the premature termination of studies by students (González García et al., 2024). This problem has significant implications at both individual and societal levels. For young people, dropping out of school limits access to employment opportunities, reduces disposable income and ultimately affects their quality of life. On a broader scale, school dropout has a negative impact on the social cohesion and economic growth of countries, and is a priority issue on the public agenda of several nations and international organizations, such as the OECD (González García et al., 2024).

Faced with this critical challenge, "educational re-engagement" emerges as a fundamental response. Re-engagement programmers are specifically designed for young people in vulnerable situations, with the dual purpose of intensifying their participation in learning processes and facilitating their reintegration into both the educational and socio-labour spheres (González et al., 2023). The notion of early school leaving is intrinsically linked to a disengagement from the educational system, which can be the result of academic failure processes or of a progressive disaffection that occurs before the attainment of a post-compulsory diploma (Gutiérrez-de-Rozas et al., 2022).

The relationship between educational outcomes and socio-economic well-being is reciprocal. On the one hand, the interruption of the educational trajectory directly hinders access to better jobs and higher incomes, which has an impact on the quality of life of individuals (Gutiérrez-de-Rozas et al., 2022).

On the other hand, the possibility of getting a job and achieving economic independence is presented as a considerable incentive for young people to resume their studies (Verdeja Muñoz, 2022). However, economic constraints, such as the inability to afford education or childcare, also act as substantial barriers to re-engagement (Morgan et al., 2023). This interconnectedness underlines that the problem is not merely educational, but is deeply

intertwined with socio-economic realities, forming a cycle in which disadvantage can perpetuate disengagement, and educational re-engagement can break this pattern. Effective re-engagement strategies must therefore go beyond purely academic interventions, adopting a holistic approach that addresses the socio-economic context of vulnerable young people, which could include financial support, vocational training and direct links to employment opportunities to create a tangible pathway to stability.

### **Definition and Key Components of Educational Reengagement**

Educational re-engagement" is precisely defined as the set of structured programmes that aim to reintegrate vulnerable youth into the education system (González et al., 2023). It is essential to distinguish this concept from "school drop-out", which represents the end result of a disengagement process (Gutiérrez-de-Rozas et al., 2022).

The theoretical and practical framework of these programmes rests on two main pillars: 1) the promotion of school improvement processes and the establishment of the necessary organisational conditions to enable them, and 2) the understanding of how the educational and organisational functioning of a school influences the dynamics of student disengagement (González et al., 2023). A key organisational aspect highlighted in the research is the critical role of coordination among teachers (González et al., 2023). However, a significant limitation identified is the lack of "coherence and curricular relevance" in this coordination, a situation often exacerbated by the departmentalisation characteristic of Secondary Schools (González et al., 2023). This complexity calls for the development of more functional areas of coordination (González et al., 2023).

Beyond the structural elements, the essence of successful re-engagement programmes lies in their flexibility and adaptability, often allowing students to "design their own programme" (Verdeja Muñiz, 2022). Ultimately, these programmes seek to be a "positive and stable reference" for young people, providing a welcoming environment and personalised support to empower them to continue their studies (Verdeja Muñiz, 2022).

A crucial understanding that emerges is that re-engagement transcends mere academic remediation; it is geared towards the holistic development and autonomy of the student. While the primary goal of re-engagement is educational reintegration (González et al., 2023), the studies consulted consistently point to broader goals such as "socio-occupational reintegration" (González et al., 2023), "personal/professional development" 6, and the cultivation of "self-esteem" and "expectations of success" (Verdeja Muñiz,

2022). The insistence that programmes be flexible enough for students to "design their own" (Verdeja Muñiz, 2022) and the need for a "positive and stable referent" (Verdeja Muñiz, 2022) suggest that re-engagement is not limited to filling academic gaps, but seeks to foster a sense of autonomy, belonging and general well-being. This implies a transition from a deficit-centred model to one that rebuilds confidence and future orientation.

Another key point is that the organisational structure of educational institutions can be a critical barrier or a critical enabler. The explicit identification of "curricular coherence and relevance" as weaknesses in coordination, "exacerbated by the departmentalisation of Secondary Schools" (González et al., 2023), reveals a systemic problem. It is not just about individual teachers or isolated programmes, but about the organisational rigidities inherent in traditional education. The demand for "more functional coordination areas" (González et al., 2023) is a direct critique of the inadequacy of the current structure to support re-engagement. Therefore, sustainable re-engagement requires more than one-off interventions; it demands systemic organisational reform within educational institutions. This includes fostering interdepartmental collaboration, promoting integrated curriculum design and creating flexible administrative structures that can adapt to the diverse needs of students seeking re-engagement.

## **Rationale and Objectives of the Systematic Review**

A systematic review of educational re-engagement is justified by the complex and multifaceted nature of this phenomenon. A comprehensive, evidence-based synthesis is indispensable to effectively inform policy and practice. This review strictly adheres to the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) framework, which establishes a minimum set of elements for the transparent and comprehensive presentation of systematic reviews (Zhou, n. d.). The PRISMA 2020 statement, with its 27-item checklist and model flowcharts (Zhou, n. d.), will guide the methodology, ensuring rigour and reproducibility.

The main objectives of this systematic review are:

- To identify and synthesise the key factors that influence the educational re-engagement of vulnerable youth.
- To map and describe the various types of programmes and intervention models implemented to promote educational re-engagement.



- To analyse and report on the most effective pedagogical, organisational and support strategies to promote educational re-engagement and socio-labour reintegration.

According to the PRISMA guidelines, research questions should be specific, clear and directly address the problem and topic of interest. While PICO (Population, Intervention, Comparison, Outcome, Outcome) is a widely recognised framework, especially in the health sciences, adaptations such as SPIDER (Sample, Phenomenon of Interest, Design, Evaluation, Research Type) or PICOC (Patient, Intervention, Comparison, Outcome, Context) are often more suitable for the social sciences and education. (Zhou, n. d.) These frameworks are invaluable for focusing research, improving search efficiency and ensuring the relevance of findings. Avoiding overly broad questions and ensuring practical relevance are crucial to prevent ineffective information searches.

The user query broadly addresses "Factors, Programmes and Strategies", and the "Outcome" (OR) component of frameworks such as PICO (Zhou, n. d.) is central to defining success. The very definition of "re-engagement" includes "increased engagement with learning and educational or socio-occupational reintegration" (Gonzalez *et al.*, 2023). Furthermore, meta-analyses on dropout prevention measure success not only by reducing dropout rates, but also by increasing graduation rates (Chappell *et al.*, 2015). This indicates that "success" is not a monolithic concept. It encompasses academic return, sustained engagement, improved academic performance, socio-emotional development and eventual successful integration into the labour market. Different studies may prioritise different outcomes, which may influence their findings. Therefore, the systematic review should explicitly recognise and define the various dimensions of 'success' in educational re-engagement. This will be crucial during data extraction and synthesis, allowing for a nuanced interpretation of findings and preventing misinterpretations that might arise when comparing studies with different outcome measures. It also highlights the need for future research to adopt comprehensive outcome frameworks.

The research questions guiding this systematic review are:

1. What are the personal, family, socio-economic and institutional factors that influence the educational re-engagement of vulnerable youth and adolescents?
2. What types of programmes and intervention models have been implemented to foster educational re-engagement in this population, and what are their key characteristics?

3. What are the most effective pedagogical, organisational, support and community strategies to promote the educational re-engagement and socio-labour reintegration of young people and adolescents in vulnerable situations?

## Factors Influencing Educational Reengagement

The review details the multifaceted factors that influence educational re-engagement, categorising them for clarity:

- **Personal Factors:** Motivation emerges as a primary factor, highlighting its critical role in re-engagement (Verdeja Muñiz, 2022). The ability to project expectations of success and experience small triumphs significantly improves self-esteem and confidence, fostering re-engagement. (Verdeja Muñiz, 2022). Emotional well-being is crucial; resolving emotional conflicts and achieving stability creates a highly favourable environment for re-engagement (Verdeja Muñiz, 2022). The presence of a "key reference person", such as a family member, school counsellor or programme instructor, who provides constant support and encouragement, is consistently identified as vital (Verdeja Muñiz, 2022).

**Employment/Economic Factors:** The prospect of employment and achieving economic independence serves as a powerful incentive for young people to re-engage (Verdeja Muñiz, 2022). Programmes that successfully integrate vocational training with employment opportunities are particularly motivating (Verdeja Muñiz, 2022). However, economic constraints, including inability to afford education or childcare costs, can also act as significant barriers to re-engagement (Morgan et al., 2023).

- **Family and Social Factors:** The family and wider social environment play a very important role in a young person's educational trajectory (Verdeja Muñiz, 2022). Strong parental support is identified as a significant factor influencing school re-engagement (Morgan et al., 2023), and family engagement consistently shows a direct and positive effect on student achievement.
- **Institutional and Contextual Factors:** The design and flexibility of educational programmes themselves are crucial. Programmes characterised by "great flexibility and adaptation", where students can "design their own programme", are more effective (Verdeja Muñiz, 2022). The tendency of the traditional educational model to prioritise academic content over emotional aspects is noted as a limitation (Verdeja Muñiz, 2022). The creation of welcoming

learning contexts and environments that foster joy and comfort is also highlighted as essential (Bolarín Martínez, 2020).

- **Typologies of Vulnerability and Risk Factors:** Studies indicate that young people who drop out of school are often male, foreign-born and come from families with low parental education levels (Sureda-Garcia et al., 2025). School dropout is understood as a complex, dynamic and gradual process influenced by individual, institutional and contextual factors (Sureda-Garcia et al., 2025). Key risk factors include demotivation (Verdeja Muñiz, 2022, sensitive personal situations (e.g. unaccompanied minors, victims of bullying) (Verdeja Muñiz, 2022) and negative school environments (Morgan et al., 2023).
- The importance of emotional factors and relational support in re-engagement is a central finding. Although academic challenges are often perceived as direct causes of dropout, the documents consulted strongly emphasise emotional factors (Verdeja Muñiz, 2022), the need for a "key reference person" (Verdeja Muñiz, 2022), and the observation that young people re-engage when they are "calmer emotionally" (Verdeja Muñiz, 2022). The criticism that the "current educational model" neglects the emotional aspect (Verdeja Muñiz, 2022), is telling. This suggests that re-engagement is less about forced academic remediation and more about creating a supportive, emotionally safe environment where students can rebuild confidence, self-esteem and motivation, often facilitated by a caring adult. Therefore, re-engagement programmes should prioritise comprehensive social- emotional support, including counselling, mentoring and the development of positive relationships within the school environment. Educator training should include skills in social-emotional learning and building rapport with vulnerable students.

In addition, economic factors are dual in nature, acting as both a 'pull' and a 'push'. The data show a nuanced view of economic influence: the "possibilities of accessing a job and having economic independence" are a "very important incentive" (Verdeja Muñiz, 2022), acting as a pull factor. In contrast, "economic constraints" such as inability to afford education or childcare are "barriers" (Morgan et al., 2023), acting as push factors. This highlights that for vulnerable youth, economic reality is a constant and powerful force, simultaneously offering hope and posing significant obstacles. Re-engagement policies must integrate financial support mechanisms (e.g. scholarships, stipends, transport

assistance) to alleviate immediate economic pressures, along with vocational training and clear pathways to employment. Addressing the economic dimension is not an add-on, but an integral part of sustained educational re-engagement.

## Conclusions

Educational re-engagement is defined as a set of structured programs designed to reintegrate vulnerable young people into the education system and into social and work environments.

These programs are based on two main pillars: promoting academic improvement and establishing the necessary organizational conditions, and understanding how the educational and organizational functioning of a school influences student disengagement.

A key feature of successful re-engagement programs is their flexibility and adaptability, often allowing students to “design their own program” and seeking to be a “positive and stable reference” that provides a welcoming environment and personalized support. Although the main objective is educational reintegration, these studies point to broader goals such as socio-occupational reintegration and personal and professional development.

Factors influencing the success of re-engagement include motivation, emotional well-being, the presence of a key reference person, and the integration of vocational training with employment opportunities. However, limitations are identified, such as a lack of “curricular coherence and relevance” in coordination, often exacerbated by departmentalization in secondary schools.

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# Didactic strategies in the bachelor's degree in Administration at FCCA-UMSNH

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This work reflects an effort to continue improving educational quality and the teaching-learning process at the Faculty of Accounting and Administrative Sciences of the Michoacan University of San Nicolás de Hidalgo, through didactic strategies.

## Introduction

This study is a summary of our predoctoral research. The problem statement is as follows: In what way do weaknesses in learning and low educational quality affect the deficiencies in the application of the PBL (Problem-Based Learning) and PjBL (Project-Based Learning) methodologies?.

At UMSNH, the lack of didactic strategies for collaborative work affects student learning and overall educational quality. To address this issue, a mixed-method study was conducted using Action Research and the Historical-Cultural approach (Giardini *et al.*, 2017). Building on this research, the current postdoctoral project at UCLA aims to improve undergraduate education by applying and evaluating PBL and PjBL (Vygotsky, 1996). PBL emphasizes student-centered learning through real-life problem-solving in small groups with tutor guidance, fostering autonomy and critical thinking (Carbajal, 2024). PjBL enhances motivation, life skills, and deep understanding beyond memorization (Botella & Ramos, 2019; Cortijo, 2014). The hypothesis is that applying these strategies will foster more effective learning processes and enhance academic outcomes at FCCA-UMSNH.

Despite collaborative work being part of undergraduate programs at UMSNH, high dropout and failure rates persist, partly due to student learning weaknesses and instructors lacking effective didactic tools. The study seeks to understand how these factors affect the application of strategies like PBL and PjBL.

For the above reasons, the present research is titled Didactic strategies in the bachelor's degree in Administration to strengthen educational quality at the

FCCA of the UMSNH, whose main objective is to strengthen learning and educational quality through the identification, application, and evaluation of the didactic strategies of Problem-Based Learning (PBL) and Project-Based Learning (PjBL) in collaborative work at the undergraduate level. It also seeks to improve teaching practices through Action Research (Vygotsky, 1996).

Espinoza Freire (2021) state that Problem-Based Learning (PBL) is a student-centered methodology that begins with the formulation of a real or contextualized problem to guide the learning process. Instead of traditional classes, students work in small groups, investigate, discuss, and collaboratively build solutions with the guidance of a tutor who acts as a facilitator. The main characteristics of PBL refer to a starting point based on an open problem that does not have an immediate answer. It is developed in small groups, promoting autonomy, self-regulation, and especially collaborative learning. In this sense, the teacher acts as a guide in the process and encourages critical thinking without providing direct answers. Evaluation is usually formative and focuses on the process, the participation in the construction of products, and the improvement of assessment skills and critical thinking (Fallas, 2021).

According to García & Pérez (2018), Project-Based Learning (PjBL) is a student-centered methodology in which learning is developed through the creation of projects that respond to real-world problems. This strategy fosters critical thinking, collaborative work, and the practical application of knowledge. It is characterized as active teaching that requires designing activities that promote the direct participation of students in the learning process. Among the advantages offered by PjBL are increased student motivation and engagement with their learning, as well as the development of life and work skills, including communication, problem-solving, and creativity (Botella & Ramos, 2019). PjBL teaches us to promote complex and deep thinking, going beyond mere memorization and encouraging critical understanding of content (Cortijo, 2014).

In our predoctoral research, the didactic strategy of project-based learning to strengthen learning and educational quality in collaborative work at the undergraduate level of the FCCA at UMSNH was developed using the Action Research methodology, grounded in the historical-cultural approach and following a mixed-methods design. The FCCA was selected as the sample, under the following hypothesis: At UMSNH, deficiencies in learning and educational quality—caused by the lack of didactic strategies in collaborative work—can be addressed by systematically applying and evaluating the project-based learning didactic strategy.

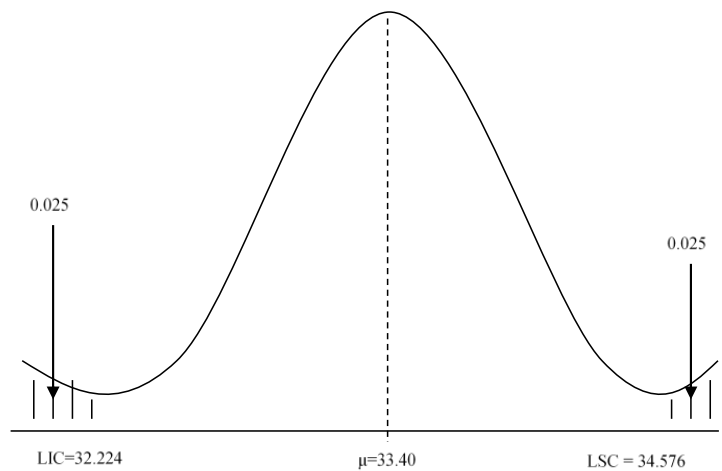
The hypothesis was confirmed after diagnosing the problem over one academic cycle. A questionnaire administered to 70 students revealed that, although collaborative work was present, there was a lack of didactic strategies, which negatively impacted learning and educational quality. An intervention using PBL (Problem-Based Learning) and PjBL (Project-Based Learning) strategies was implemented in two phases and evaluated through a second questionnaire. The didactic strategies served as the independent variable, while learning and educational quality were the dependent variables (Table 1).

The development of this article was guided by the use of a mixed-methods approach, with independent and dependent variables grounded in Action Research as proposed by Latorre (2005) and framed within a historical-cultural perspective. As this author states (Latorre, 2005), once a problem is identified, it is necessary to conduct a recognition or diagnosis of it. During July 2021, to obtain a diagnosis of the problem, 70 instruments (surveys/questionnaires) were administered to an equal number of students, across three groups, averaging 23 students each (i.e., one section of 24 students), at the educational unit selected as the sample from UMSNH. At the time of data collection, the total population at the FCCA was 1,983. It should be noted that these instruments were applied to 460 fourth-semester students from the undergraduate Accounting program at FCCA. The objective was for the sample (70 instruments) to represent the behavior of the entire undergraduate program at UMSNH, which had a total population of 35,600 students (enrollment 2017/2018) (Serna González, 2017).

According to Baca (2010), to obtain data from the instruments, a demand analysis is necessary. For this, primary sources were used by applying questionnaires to the aforementioned educational program. A confidence level of 95% was established, with a significance level or error margin of 0.05 in the results. As mentioned earlier, being a mixed-methods study, we proceeded to determine the optimal sample size using statistical methods. These values are shown in Figure 2.

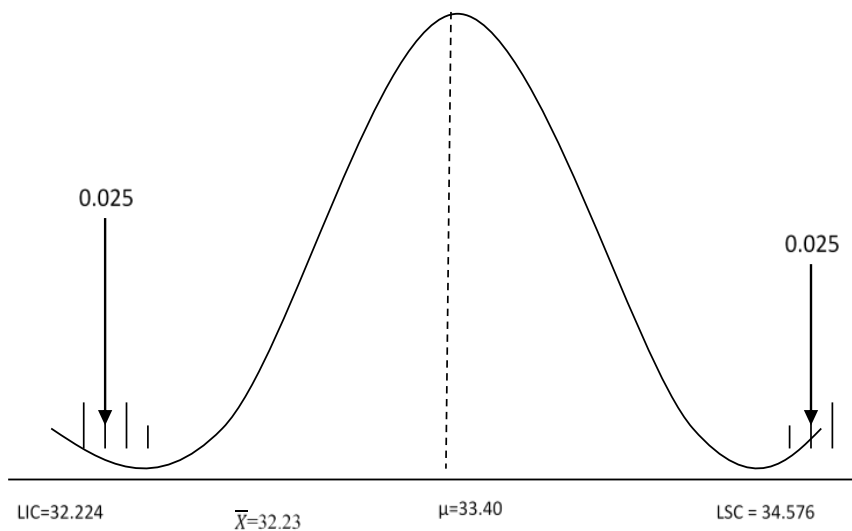


**Figure 1.** Normal distribution for sample size determination.



In the previous figure, we can observe a normal distribution curve. Our null hypothesis is considered as the mean. It represents the proportion of the curve indicated by the significance level ( $\alpha$ ), which we define as the part of the curve where we cannot accept the null hypothesis as valid. Figure 2 shows that the sample value lies within the area between the upper and lower limits; therefore, we do not reject the null hypothesis in the diagnosis of the problem. Since the sample value falls within the range between the upper and lower limits, the null hypothesis is not rejected in the diagnosis of the problem.

**Figure 2.** Acceptance region of the null hypothesis.



Based on the data previously obtained, the optimal sample size was determined to be 69.45. For practical purposes, 70 questionnaires were administered, each containing 10 items, with the goal of obtaining general information on whether didactic strategies are applied to strengthen teaching

practice and collaborative work at the undergraduate Accounting program of the FCCA at UMSNH. General interpretation: As observed, the problem was diagnosed through the application of the questionnaire on July 2, 2022, revealing that while collaborative work exists, there are deficiencies in learning and a lack of didactic strategies, which negatively affect educational quality.

Objective: To strengthen learning and educational quality in collaborative work by evaluating didactic strategies and applying PBL (Problem-Based Learning) and PjBL (Project-Based Learning) at the undergraduate level in the FCCA of UMSNH.

Hypothesis: At UMSNH, deficiencies in learning and educational quality caused by the lack of didactic strategies in collaborative work can be reversed by systematically applying and evaluating the didactic strategies of PBL and PjBL.

Variables: The variables under study are presented below (Table 1).

**Table 1.** *Independent and dependent variables.*

| Independent                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>Didactic Strategies:</b> Problem-Based Learning (PBL) and Project-Based Learning Methods (PBM).</p> <p>Problematic methods: induction and deduction of didactic laws, inferring methodologies, methods, and procedures in problem solving.</p> <p>1. Did you know about the didactic strategies PBL and PBM?</p> <p>2. Can you use the steps of the didactic strategies PBL and PBM?</p> <p>3. Do you consider that PBL and PBM can help solve a problem?</p> |

| Dependent                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>Conceptual learning of the Learning Guiding Base (BOA);</b> procedural and attitudinal with its 4 levels of assimilation: a) familiarization, b) reproduction, c) production, and d) creation. In the case of attitudinal learning, we derive habits, skills, abilities, dexterities, and convictions, both technical as well as cognitive and volitional.</p> <p>4. At this moment, could you use PBL and PBM to give a presentation on the topic?</p> <p>5. At this moment, did PBL and PBM help you to appropriate the concepts of the topic?</p> <p>6. Did PBL and PBM motivate you to read, search for information, and use new technologies to generate knowledge?</p> <p>7. Did PBL and PBM help you solve the problem?</p> |
| <p><b>Educational quality;</b> a system of generalized basic skills that form the core of the profession. Systems of specific basic skills that make up the core of the field of action and the sphere of practice. Essential characteristics of competencies.</p> <p>8. Would you like your teachers or advisors/tutors to apply PBL and PBM during your training?</p> <p>9. Do you consider it feasible for your teachers or advisors/tutors to</p>                                                                                                                                                                                                                                                                                    |

|                                                                                            |
|--------------------------------------------------------------------------------------------|
| master and apply PBL and PBM?                                                              |
| 10. Do you believe that with PBL and PBM you can solve problems in your professional life? |

Teachers are professionals who enter the field of teaching but have not been "taught to teach", and in many cases tend to face the challenge of teaching by reproducing what they themselves experienced as students (Díaz-Barriga & Hernández, 2010). This assertion aligns with Gallardo's findings in his doctoral thesis "Evaluation of the Curriculum of the Faculty of Veterinary Medicine and Animal Science at the Michoacan University of San Nicolás de Hidalgo", which emphasize the need to provide teachers with the necessary pedagogical tools to improve their teaching and learning practices (Gallardo Valencia, 2015).

According to Álvarez de Zayas (1992), learning in his conceptual view is based on the Learning Guiding Base (BOA), which is procedural and attitudinal, with four levels of assimilation: a) familiarization, b) reproduction, c) production, and d) creation. In terms of attitudinal learning, this translates into habits, skills, capacities, abilities, and convictions—both technical, cognitive, and volitional (Alvarez de Zayas, 1992). After deciding to use PBL and PjBL as solutions, the intervention was planned for the week of March 2, 2022. It began by exploring the question "What is an Accountant?" and more broadly examining the accounting labor market as the problem. The didactic strategies of PBL (Problem-Based Learning) and PjBL (Project-Based Learning) consisted of applying the following activities:

- a) Work in pre-formed collaborative teams.
- b) Argue the problem.
- c) Retrieve prior knowledge about the problem through a brainstorming session.

Using a KWL chart to: (a) recognize what is known, (b) what needs to be learned, and (c) what has been learned about the topic. To address the defined problem, students engaged in documentary research, proposed solutions, and presented their results over one week. On March 9, 2022, the intervention was repeated with the same instruments, focusing on a new topic from the undergraduate Accounting syllabus: "Market Structures". This aimed to demonstrate that PBL and PjBL are effective across different themes.

The didactic strategies of PBL and PjBL were applied following Frida Díaz's guidelines (Díaz-Barriga & Hernández, 2010), involving two stages with initial and final interventions using a ten-item instrument. The items measured the independent variable (didactic strategies), and dependent variables (learning and educational quality).

The research on didactic strategies such as Problem-Based Learning (PBL) and Project-Based Learning (PjBL) in the Bachelor's Degree in Administration at the FCCA-UMSNH focuses on the discussion of these strategies to strengthen learning and educational quality through collaborative work at the undergraduate level. The study began with the hypothesis that at UMSNH there are deficiencies in learning and educational quality due to the lack of didactic strategies for collaborative work, and this problem can be reversed by systematically applying and evaluating the didactic strategies of PBL and PjBL.

Following the Action Research methodology, we worked according to Latorre A. (2005) to test our hypothesis, conducting a diagnosis through a closed-ended instrument with 10 items, which was applied to 70 students in the undergraduate educational program in Administration at the FCCA of UMSNH. We confirmed the problem from the very first application of the questionnaire, whose data provided an interesting diagnosis. Although collaborative work does exist, there are learning deficiencies due to the absence of didactic strategies, which affect the quality of education.

The results obtained following the implementation of these didactic strategies indicate that both PBL and PjBL within the Bachelor's Degree in Administration at FCCA-UMSNH have proven to be effective methodologies for improving motivation, skill development, and real-world connection in the university setting. The results indicate that PBL and PjBL foster creativity, autonomy, and critical thinking, as well as problem-solving and teamwork skills.

The application of these strategies (PBL and PjBL) enabled students to progress from qualitative to quantitative understanding, from objective to subjective perspectives, and from empirical to scientific knowledge, thus improving educational quality.

Throughout the interventions, students moved from unfamiliarity with the strategies to applying them, which encouraged information seeking, concept acquisition, reading, and problem-solving. They emphasized the importance of professors and tutors mastering these strategies.

Based on the concept of strategies grounded in the joint construction of the Zone of Proximal Development (ZPD) among teachers, advisors or tutors, and

students (Huerta, 2017), several criteria are proposed to promote meaningful learning. These encompass eight key actions: (1) Embedding student activities within a broader context and objectives where these activities make sense; (2) Promoting student participation and engagement; (3) Continuously adjusting and modifying the planning based on observations of students' performance levels; (4) Using language clearly and explicitly to promote the necessary intersubjectivity (between teacher and students), as well as the sharing and negotiation of meanings; (5) Constantly establishing explicit relationships between what students already know and new content; (6) Encouraging the autonomous and self-regulated use of content by students. This is a key aspect of any teaching based on the construction of the ZPD: ensuring that students can eventually do on their own what they initially could only do with the teacher's help; (7) Using language to recontextualize the pedagogical experience; (8) Emphasizing the importance of student-to-student interaction as another valuable resource to create the ZPD.

## Conclusions

The use of PBL and PjBL strategies improved collaborative work, educational quality, and teaching practice. Students enhanced skills like comprehension, critical thinking, technology use, and problem-solving. Their actual and potential development levels (ZPD) were identified, strengthening learning with teacher and peer support. These strategies are recommended for broader use across undergraduate programs at UMSNH to prepare more competent graduates.

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# A Community of Dialogue: An Epistemological Stake in Inclusion Training

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## Introduction

Within the frame of understanding inclusive education as a right, the effective commitments of various key actors are pertinent to achieve education for all. This requires taking into consideration the specific characteristics and conditions of the student body and their contexts, from a perspective that integrates various aspects of educational policy, culture, and practices (Booth & Ainscow, 2011; United Nations Educational, Scientific and Cultural Organization [UNESCO], 2020). Here, states have a fundamental role to play, to the extent that they have committed to allocating resources and the means necessary to achieve inclusive, equitable, and quality education, which is recognized as a global challenge to be reached by 2030 (UNESCO, 2022). This is reflected by the various laws, guidelines, and regulations in force, as well as the approaches, principles, and dimensions that inform national educational policies, in line with existing global and regional guidelines (Ministerio de Educación [MINEDUC], 2023; UNESCO, 2017).

However, these institutional efforts require systemic coordination with other relevant actors to ensure inclusive education guarantees the presence, participation, and achievement of the entire student body across different levels of the education system. This ongoing, complex, and challenging



process also facilitates progress in the broader framework of social inclusion. To achieve this, it is necessary to identify and address barriers within educational policies, cultures, and practices in order to implement facilitators or best practices in each area and thus foster and sustain initiatives, actions, and innovations that support students' educational processes (Ainscow, 2012; González de Rivera *et al.*, 2022; Laspina-Olmedo & Montero, 2023). Addressing challenges of inclusion in a meaningful and context-specific way within the school environment requires dialogue, collaboration, and the exchange of perspectives and practices among teachers, education professionals, management and administrative teams, parents, and students. This entails understanding the school as a space that is in relationship with the sociocultural context in which it operates and with the educational institution networks that are essential to the educational tasks that take place there (Ainscow, 2012; Blanco, 2009; Echeita & Ainscow, 2011; Juyumaya & Demicheli, 2022; Rojas, 2016; Valdés, 2025).

This research aims to highlight the interaction between initial teacher training during university education degree programs and continuing professional teacher development to progress in inclusive education. To do this, we analyze the training experience with mentor teachers who are currently practicing in the school system. Their role is key in systematically and contextually guiding pre-service teacher students throughout their professional internship, fostering outlook and reflection regarding situations and experiences of inclusion, exclusion, and working with diversity (Herrera *et al.*, 2025).

### **A project of continuity**

This research project is based in two previous studies that sequentially explored the experiences and representations of a group of pre-service teachers at the beginning of their training with regard to diversity and inclusion. The first study revealed that teacher training programs often fail to integrate students' previous experiences into the training models, thereby highlighting a disconnect between theory and lived experience (Leiva *et al.*, 2022). Subsequently, working with mentors or internship supervisors in the second research project, they perceived that the tools acquired during their university education were insufficient to meet the challenges of inclusion (Leiva *et al.*, 2025). These projects aimed to collaboratively construct narratives of experience with various stakeholders from which knowledge and university policy could be developed as a response to the challenges the educational and social system imposes on initial teacher training.

This research seeks to extend beyond the segregated space of university campuses into the authentic contexts of teaching practice, thus continuing the

line of inquiry established in previous projects. In this way, it aims to delve deeper into specific aspects emerging from previous findings. By situating the research in the school environment, it orients toward initial and continuing teacher training where inclusion and diversity are not perceived as challenges to be overcome, but rather as fundamental conditions of the educational experience.

### **Opening spaces for dialogue between research and training**

The current project, implemented within the heart of a teaching community, initially convened five teachers interested in participating in a reflective and formative space. These teachers were awaiting the arrival of education students in their final-year, who would be placed by the internship departments of two participating universities. This group of five teachers, from different levels and subject areas, agreed to prepare for a semester to take on the role of internship mentors at their school.

The core team consisted of four teachers: two primary school teachers and two secondary school teachers. The former were general education teachers, while the latter specialized in chemistry and language. A fifth participant, specializing in music, joined the team. This individual taught classes to both the primary and secondary student body and, as such, served as a liaison between the educational realities, communicating experiences of both primary and secondary education. The larger team included faculty from three public universities, all serving as internship supervisors. Together, they represented two of the three actors that formed the 'training triad' (Ávalos, 2002; Bravo, 2023), with the ensuing incorporation of the pending third component – pre-service teachers. In this paper, we will focus on the construction of a learning community comprised of mentor teachers and internship supervisors.

Early on, John Dewey (1904) emphasized the necessary balance between theory and practice in teacher training. He highlighted the importance of fostering observation, critical analysis, and reflection to prevent teachers from becoming mere implementers of established methods and policies. The idea of implementing a learning community as a hybrid space where academia and school converge (Zeichner, 2010) stems from the need for self-training and preparation to support initial teacher training practices. This is particularly relevant given the absence of institutional policies, at least in Chile, that prepare mentor teachers or supervising teachers for professional internships (cf. Zeichner, 2010, pp. 125-127).

Within this framework, a collaborative research-training project was designed, adopting a phenomenological approach. To this end, the project takes on a

dual focus: investigative and formative (Desgagné *et al.*, 2001, 2007). To conduct the collaborative research, we propose forming a community that establishes a new relationship between research and training. This involves incorporating a common mechanism designed to fulfill both purposes: obtaining information relevant to the theorization of practice and offering a training experience to participants. The relationship fostered in this proposal exhibits a strong horizontal component, informed by the professional trajectories of both researchers and practicing teachers. Initial teacher training serves as the unifying focus, where both branches of the triad (mentors and supervisors) share the training responsibility. All participants engage in research and we prepare ourselves for the common challenge of training new teachers in diversity and inclusive education. The collaborative approach entails experiential and conceptual co-construction among the subjects involved in a common process, which in this case centers on initial teacher training with an inclusive approach. Here, we are committed to an exercise in collective hermeneutics (Molitor, 2017) that restores the authorship of knowledge and professional teacher development to the professional community itself.

Furthermore, the project's phenomenological dimension brings us face-to-face with life events, which are elements of professional experience. This approach, however, stems from an awareness of the significance of these events within our own career and life trajectories. In this sense, Freire (2010, p. 30) invites us to 'think of practice as the best way to perfect one's own practice'. Regarding experience, Huxley (1933) posits that it is not merely what happens to us, but rather what we do with what happens to us. Conversely, Larrosa (2006) defines experience as 'what happens to me,' conceived as a principle of otherness or exteriority that befalls the individual. To cultivate this awareness of what happens to us and how to engage with it, the project's mechanism takes the form of a conversation workshop centered on biographical narratives, selected readings, and constructing stories of experience. Six monthly sessions were held over the course of a semester at the school. The workshop extended beyond the sessions, generating reflective work that enriched the conversations developed during the monthly meetings. While initially set for 90 minutes, the sessions often extended beyond this duration as a result of their intrinsic characteristics and the participants' sustained interest. For instance, Session 1 introduced a theoretical framework for working with narratives and included reading an autobiographical story to introduce the writing modality. This also facilitated an initial approach to the themes of diversity and inclusion, which were embedded in the story. At the end of each session, there was a reading assigned to then discuss at the beginning of the subsequent session. This aimed to establish a shared conceptual framework among all community

members. Thus, the series of sessions unfolded through the writing of stories based on experience, engagement with assigned readings and observation exercises regarding their relationship to pedagogy. To address the phenomenological dimension, we adopted a biographical-narrative approach (Goodson & Walker, 1991; Suárez & Dávila, 2018; Landin & Sánchez, 2019; Delory-Momberger & Jiménez, 2020). In this approach, we employed oral expression and writing to explore experiences and cultivate the reflective dimension of the work carried out by the learning community. This space explored both the biographical experiences, as well as the training experiences developed during the workshop. We conceptualize this space as an *epistemological site*—a place for knowledge construction—where participants consistently reflected on their life experiences in relation to diversity. The ultimate aim was to propose a meaningful, inclusive education training program to the student pre-service teachers who would join the following semester.

With the community's consent, all workshop sessions were recorded and transcribed. We then explored the material to identify units of meaning based on the conversational unfolding.

### **Moving from political duty toward the ethical desire to include**

Based on the work conducted, the initial results show that the learning community recognizes the presence of various factors acting as barriers within the school context. These factors reveal some of the tensions teachers face when addressing inclusion and diversity in the classroom. They include tensions stemming from class structures, the number of students in the classroom, the need to maintain order and discipline, and the demands of academic and/or institutional achievement. Such factors create difficulties that preclude sufficient time or space for an inclusive perspective.

...hopefully now with the new regulations, the level of complexity will decrease a little and the amount of content we are required to cover will decrease, which is a lot of pressure for us, because deep down we don't give ourselves the space, we take attendance, I don't know, we look, but we don't give ourselves the space to know how they are, how they arrived.

Conversely, despite acknowledging a certain inability to directly resolve or act upon the challenges of inclusion, the community observed, through one of the assigned readings, an opportunity to 'educate the eye and the ear'. This brings us closer to understanding and recognizing the singularities manifesting in the

classroom, encouraging us to look, listen, be moved, and allow ourselves to be touched.

...that's why I love it when the author says that this exercise of openness toward others ultimately implies openness toward yourself. Because when you study others and observe others, you first need to look deeper, look at yourself and get to know yourself, give yourself a chance.

Participants positively appreciated spaces to reflect on the challenges of diversity and inclusion in the classroom. They eagerly anticipated the monthly meetings and enthusiastically welcomed the opportunity to convene. These sessions provided a time to rest, relax, discuss important everyday issues, and even left participants feeling challenged. We observed the satisfaction of participating in a space of collective reflection, where they shared common incidents and experiences that are not typically considered as opportunities for receiving feedback.

...I enjoyed this moment, I love to talk, it's super nice, it's like you renew your energy, it's great to share and get to know each other. I find it super valuable, we meet for a reason, destiny brings us together for a reason.

...I leave challenged to let go of my emotions, which is also very difficult for me...I always talk about emotions, but I never connect with them.

The mentor teachers positively assessed various aspects of these spaces, including the importance of sharing within diverse groups, which was perceived as a valuable learning opportunity...

...when we were doing our homework, we were motivated to learn, [...] which can nourish you and much more each time. So, I think that's really important, how we share experiences.

This shared reflection led to a new conceptualization of inclusion. Inclusion, in this context, challenges existing ideals and structures. Working with the reality of the classroom, rather than an idealized vision, expands the understanding of inclusion as an opportunity to take risks, to commit fully, and to create space for it to emerge.

...because inclusion is not just about those who are deaf or blind, I feel that it is about all of us, not just those who have difficulties, but all of us, we all have something. I think we have to think about that, that in this inclusion we are all included, we are all part of it.

Another positive aspect of the reflection space was the participants' perception of the workshop as a respite place from daily demands, serving as an emotional compensatory space for the workload teaching entails. Here, participants could free themselves from worries; thereby, the workshop takes on an emotional component. Reflecting on how we arrived at and left each session opened space for participants to express moods ranging from exhaustion to relief.

...I arrived feeling so overwhelmed... I'm leaving feeling a little lighter, more at peace with my life and my decisions.

...with this space, one tries to stop and also one changes, that is, they are instances of sharing in another way, of learning in another way, of talking about topics that are of interest to us, so... just be grateful for the space we have today to share, make the most of it because time flies.

The construction of narratives based on personal and collective experiences, reflections, and projections is significantly enriched when incorporated into discussion within the community and complemented by texts specifically chosen for group reflection.

...we spent a long time discussing the text, because I think it's really important to take a deeper look at this (...) when we were writing yesterday, we were struck by how we focused on the writing.

...the text enhances the conversation, there is also literature and bibliography on the subject that supports the teachers' stories... some of us lose the habit of writing and turn to reading and what others say.

As the workshops progressed, we observed how the sessions facilitated community members to establish stronger bonds with students. Thus, the rigidity previously identified within the classroom or a specific subject is transformed, becoming a space for meeting and conversation. Ultimately, a transformation began to emerge: relationships with students shifted, subjective barriers in the teacher-student dynamic broke down and evolved into closer interactions, structural barriers in classrooms diminished, and spaces acquired new meaning. Students even took ownership of these transformed spaces, thereby accessing an encounter with the 'other' as a basis for forming bonds and recognizing individual singularities.

...the laboratory has been transformed into a therapeutic center...my students come during recess...they arrive and come in, and there we have a small table, we talk...it has been transformed into a listening center, and

that makes me very happy, because they know where to find me, and not necessarily for pedagogical reasons, which is why I say therapeutic. These are small steps, and I feel good about that.

## Conclusions

This project, which is still underway as the workshop and professional dialogue with all triad participants are ongoing, has gradually emerged as a privileged space for professional development. A learning community was established, fostering a genuine partnership between the worlds of academia and schools and among the actors involved in initial teacher training. As Kenneth Zeichner (2010, p. 141) states, we are committed to 'a new epistemology of teacher training' stemming from a 'third space' of training that 'implies a more egalitarian and dialectical relationship between academic and practical knowledge to support the learning of teachers in training' (p. 132). The self-training process demonstrates progress from an initial discourse characterized by a lack of authority and genuine power to implement inclusive practices, and compounded by the tension of responsibilities imposed by institutional and public policy, toward the development of a true desire and an ethic that addresses inclusion as a commitment to uniqueness. This, in turn, opens up the imperative to engage with the 'other' as a legitimate subject. Grounded in this self-training process, guidelines are beginning to emerge for the situated training of new teachers, who will subsequently become the next generation of teachers. This project concludes a cycle that has explored the experiences and representations of teacher trainers and pre-service student teachers concerning the challenges of diversity and inclusion. However, it has also opened new avenues and horizons for questioning and transforming our practices, based on the reinterpretation of shared foundational experiences.

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# Irrigation and Hydraulics with STEM and PBL methodology for Civil Engineering

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## Introduction

Nowadays, the purpose and importance of STEM education is to prepare students to address current and future technical demands, thereby solving societal problems. Specifically, hydraulic civil engineering addresses the design, construction, and management of infrastructure to conduct, store, and distribute water resources. Among the problems are climate change, water scarcity, and ENSO events, which can lead to deficiencies in sustainability and public health. Hence, the STEM syllabus in both courses aims to foster students with skills that enhance the development of innovative and sustainable solutions to these challenges, integrating current scientific knowledge with creativity and critical thinking (Herrera Barzallo *et al.*, 2024).

This study examines the application of Science, Technology, Engineering, and Mathematics (STEM) education in a civil engineering program at the Bachelor's Degree Level. The goal of this initiative, which has been ongoing since 2019, is to enhance students' learning outcomes and skills through active engagement in real-world projects, contrasting with traditional lecture-based methods. Solving real problems based on scientific principles and incorporating digital tools enables us to experiment with traditional analog labor demand problems, which evolve and require modern equipment and tools.

Recent research highlights the effectiveness of using active methodologies in the teaching-learning process, particularly those based on authentic problem-solving, which are directly related to students' professional and social contexts (Alonso-Nuez *et al.*, 2024; Gaitán Hernández & De la Cruz Hernández, 2024). Yata *et al.* (2020) defined STEM as an active methodology that integrates the disciplines of science, technology, engineering, and mathematics, promoting the practical application of knowledge to address real-world challenges. This approach facilitates the prioritization of key concepts in learning, enabling the selection of relevant, meaningful, and enduring educational content for

students, thereby enhancing the quality of the teaching and learning process (Etukakpan *et al.*, 2025).

Lavado-Anguera *et al.* (2024) reviewed approximately 54 research articles related to Project-Based Learning (PBL), which has been widely adopted in engineering education since the latter half of the 20th century as an active learning methodology where students take a leading role in their learning. This methodology fosters the development of innovative and sustainable solutions by:

**Developing Key Skills:** In addition to academic performance, this methodology enhances both technical and non-technical skills, progressing from a basic understanding and application to higher-order thinking skills, such as analysis, evaluation, and the creation of innovative solutions to complex engineering problems.

**Promoting a Holistic Pedagogical Model:** his approach fosters a comprehensive and applied understanding of concepts, integrating more profound theoretical knowledge into practical problems. Solving real problems based on scientific principles, and adding digital tools enables experimentation with traditional analog labor demand problems, which evolve and require modern equipment and tools. The sources define seven pillars for such a model.

**Technology:** current projects involve the use of emerging advanced technologies, such as Artificial Intelligence (AI), to solve problems. The use of new technology fosters the development of digital skills and data-driven decision-making among students, which is crucial for modern research and in-depth data analysis.

**Integrating curriculum:** PBL experiences combine different subjects or courses that are part of the learning goals of the degree, requiring students to apply and integrate knowledge from various subjects to solve real-world challenges, mimicking the work of engineers. This approach favors teamwork, allowing them to role-play their future engineering performance.

**Multidisciplinary Focus:** These projects foster a multidisciplinary approach.

International, multicultural, or Interdisciplinary, the integration of various disciplines enables the application of problem-solving, particularly in hydraulic civil engineering, topography, and the creation of plans and sketches for water conveyance systems, as well as programming, data analysis, and mapping. The

aforementioned activities aim to address the complex hydraulic resource issues under diverse and uncertain conditions.

**Sustainability:** Water projects are closely connected to sustainable development, aligning with the United Nations' Sustainable Development Goals (SDGs). This approach enables students to analyze socio-environmental causes and propose sustainable solutions, often leading to real-world implementation, integrating their work and ethical values.

**Simulation:** Projects incorporate significant experimental work in the laboratory using prototypes of hydraulic systems. Additionally, free simulation platforms are valuable tools for solving real-world problems.

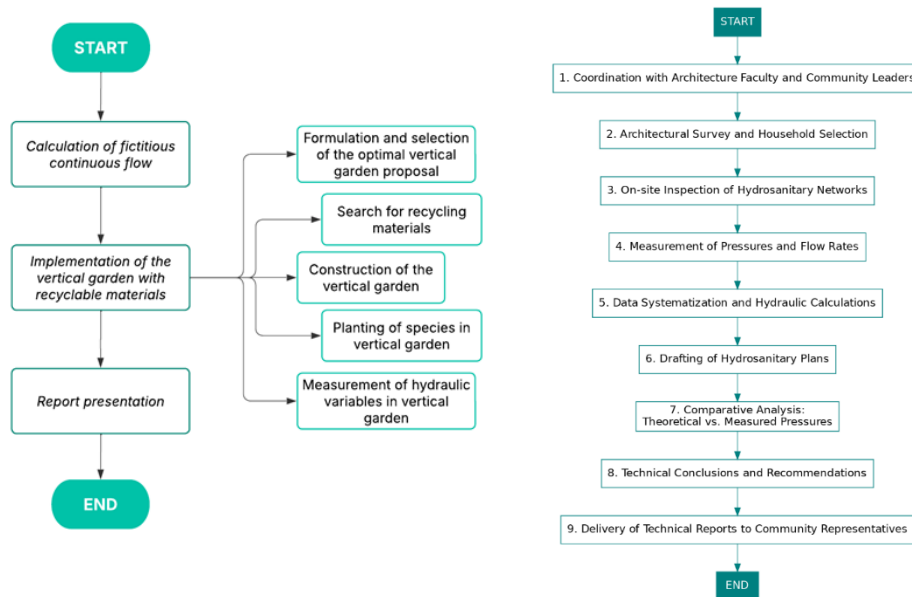
**Professional Environments:** Students interact with the community, which is their potential client base, and often gather feedback from faculty. Such interactions offer valuable insights into real-world business operations and can foster entrepreneurial ambition.

The incorporation of a STEM approach in the field of Civil Engineering has been especially beneficial, as its application has integrated the physical principles such as Newton's Second Law of motion that is the basis for conservation of momentum, which is fundamental in the Bernoulli, and Darcy-Weisbach equations, computational water system simulation, and experimental practice in hydraulic pressure pipe systems. In particular, within the Irrigation component, STEM learning has promoted the development of essential competencies for analyzing, designing, and evaluating hydraulic systems, thereby strengthening the comprehensive training of future civil engineers (Hong *et al.*, 2020).

Reinforcing the basic and professional knowledge related to hydraulic resources in the Civil Engineering Program is one of the main steps towards the Integral Water Resources Management, as well as continuous capacity development and learning, for effective and sustainable water management (Haie, 2021). The key aspects portray the multidisciplinary specialized knowledge foundation from multiple fields. Therefore, the objective of this research is to understand the impact on the academic performance and motivation of students in the Irrigation and Hydraulics courses of the Civil Engineering program at the Universidad Técnica Particular de Loja (UTPL) and the Universidad Central del Ecuador (UCE). To this end, the implementation of this pedagogical approach integrates two active STEM methodologies (Science, Technology, Engineering, and Mathematics) in the Irrigation course and Project-Based Learning (PBL) in the Hydraulics course.

This study is a disciplinary -based education research where the steps of implementation of the methodology of this research in the course of Irrigation at the UTPL and Hydraulics at the UCE are based on the application context, group participation, collection of data, and processing, these activities are developed in the course as similar as real solving problems. Figure 1 illustrates the implementation of the STEM methodology in teaching the Irrigation and Hydraulic course.

**Figure 1.** STEM methodology applied in the Irrigation subject (UTPL) (Left), Hydraulics in the UCE (Right)



## Irrigation course

The Irrigation course is part of the Basic Environmental Sanitation program within the Civil Engineering program at the Universidad Técnica Particular de Loja, Ecuador, and its classes are in person. Fifteen students (three women and twelve men) participated in this course. The grading scale consists of three components: in-person dialogue with the instructor, which scores 3,5 points; experimental and practical learning, valued at 3,5 points; and autonomous learning, valued at 3 points, for a total of 10 points. The course was part of the sixth semester, spanning over 16 weeks, during the academic period from April to August 2024.

The problem solution consisted of two phases after forming five groups, each consisting of three students. In the first phase, the groups defined the continuous fictitious flow of a case study irrigation network using application software. The fictitious flow enabled the definition of the network's circulating

flow rates, depending on demand-based and irrigation-schedule-based operations. In the second phase, the groups built a pilot Vertical Garden (VG). For this purpose, the working groups used AutoCAD software to formulate their proposals, calculate a detailed construction budget, implement the VG on-site, and measure the transfer flow rate in the network. Finally, each group presented a technical report and a micro-video to showcase their work.

It is essential to note that the groups utilized the digital tool Genially to incorporate the theoretical foundation of the topics covered in the course. The researcher conducted a survey to register the students' perceptions of the implemented methodology through a Likert-based.

## Hydraulic Course

The projects developed by Civil Engineering students from the Central University of Ecuador in the Atucucho neighborhood represent a significant educational experience in the training of future hydraulic engineers. The collaboration with architecture students who developed the architectural plans allowed for a key interdisciplinary approach to addressing real-life problems in vulnerable communities in Quito, Ecuador. Each group conducted real-life surveys of the water system in specific homes in Atucucho, including:

- Field pressure and flow measurements.
- Head loss calculations.
- Hydraulic simulation using EPANET.
- Modeling in AutoCAD and SketchUp (2D, isometric, and 3D drawings).
- Design of plumbing plans for real homes with identified users.

This experience enabled students to apply key theoretical concepts in a real-world context, including Bernoulli's principle, Reynolds number, flow regime classification, and the calculation of friction and fitting losses using the Darcy-Weisbach and Colebrook-White equations. They also conducted hydraulic energy balance analyses and modeled the water distribution network. The project was carried out through the collaborative efforts of two schools—most notably the Schools of Architecture and Civil Engineering—working in close coordination with the Atucucho community.

## Irrigation Course

Once the groups have defined their final plans with their respective budgets, the students constructed Vertical Gardens and measured the transfer flow

rates. To evaluate students' perceptions of the implemented STEM methodology, self-assessment questionnaires were administered, focusing on their acquisition of competencies in specific subject areas. The students also expressed their acceptance and engagement with the activities carried out during the academic period. Performance data, including grades from both the first and second halves of the semester, were collected and analyzed based on the weighted contributions of all activities during the semester.

## Hydraulics Course

Students collected data through technical visits to selected homes and the Atucucho Community Center. During fieldwork, they measured pressures using a manometer and determined flow rates by using containers of known volume. They recorded the physical characteristics of the water networks, including pipe diameters, lengths, and the type of pipe material.

They organized the data into tables and used it to calculate hydraulic characteristics such as flow velocities, head losses, and Reynolds number by applying Bernoulli's equation and standard friction loss formulas. By comparing these theoretical values with field measurements, they validated the hydraulic performance of the system.

Finally, the students developed detailed plumbing plans based on the architectural layouts provided by the UCE School of Architecture, working in coordination with community leaders to collect data on the houses.

## Irrigation Course

The calculated fictitious continuous flow ( $Q_{fc}$ ) was 0,34 L/s/ha in the case study irrigation network in the first phase. Figures 2 and 3 illustrate the configuration proposed by Group 4 for the construction of the Vertical Garden, which represents the lowest investment cost for its implementation and construction process.



**Figure 2.** Planning of Vertical Garden configuration, group 4

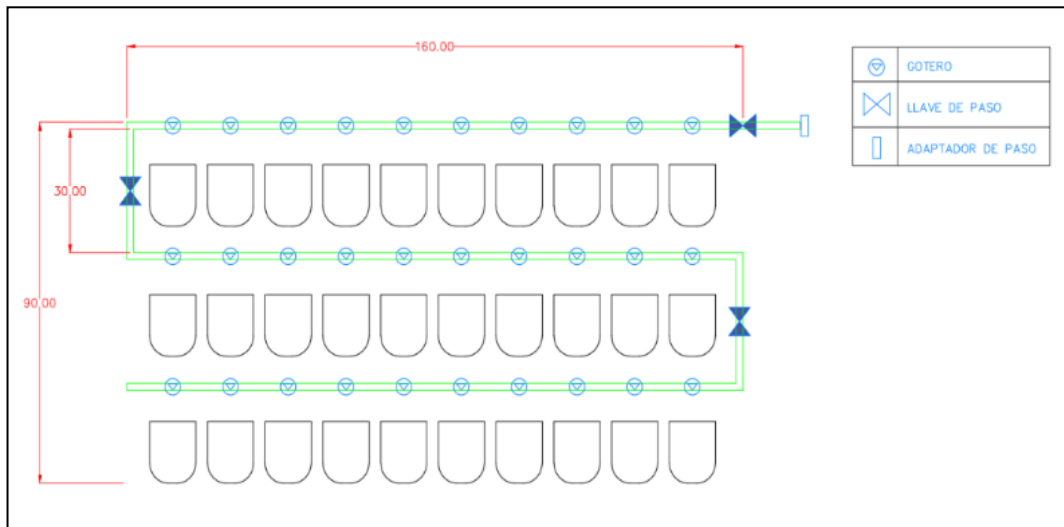


**Figure 3.** Construction of the proposed Vertical Garden, group 4.



After the evaluation of the students on all the activities developed in the first and second two-month periods of the subject in the academic period April-August 2024, a favorable score was obtained with an average grade of 7,98/10, considerably improving by 5,82% concerning the resulting grades in the academic period April-August 2023 and 2,86% concerning the grades of the academic period April-August 2022. Figure 4 illustrates the variation in the final bimonthly average grades achieved by students in the Irrigation subject during the academic years 2022-2024, represented through a box plot. Figure 5 displays the results of students' perceptions of the practical or experimental activities carried out in the subject during the academic cycle.

**Figure 4.** Box plot of bimonthly grades for each academic period studied.

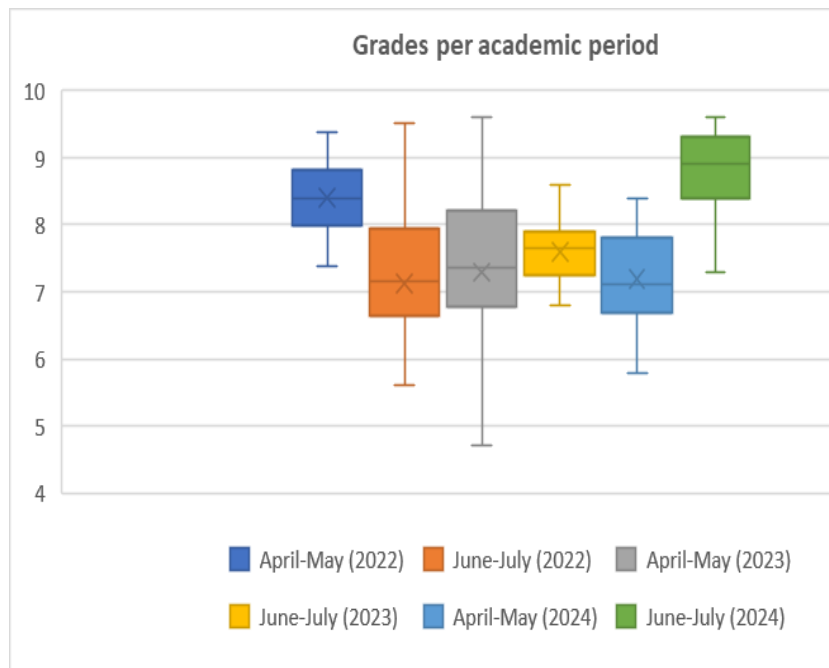
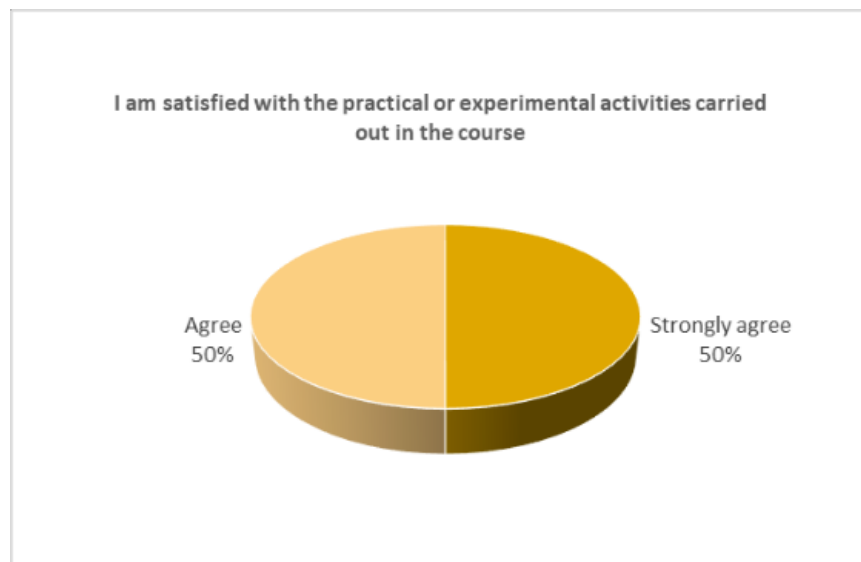


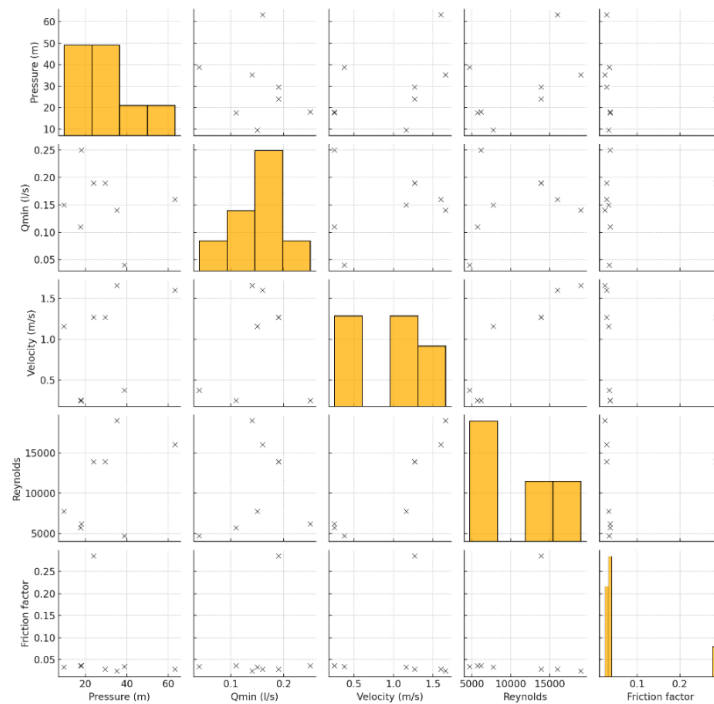
**Figure 5.** Students' perceptions of experimental practices during the April-August 2024 period.



## Hydraulic Engineering Course

The teams simulated and calibrated the hydraulic characteristics using field data collected from each house, as shown in Figure 6. The grouped data reveal the interdependence between pressure, velocity, flow rate, Reynolds number, and friction coefficient within each hydraulic system. The students developed and delivered the final hydro-sanitary engineering plans and operational reports for every household.

**Figure 6.** Scatterplot matrix of hydraulic characteristics



As evidenced by the box plot in Figure 4, during the April-August 2022 academic period, the first two months show a solid performance with a median of 8,49/10 and relatively low dispersion, indicating homogeneity within the group. However, for the second two-month period of this year, a decrease in the median (7,15) and an increase in dispersion are observed, with values ranging from 5,60 to 9,50, suggesting a possible loss of consistency in learning or an increase in the variability of individual performance. During the April-August 2023 academic period, the median was 7,35 in the first two months; however, a notable increase in variability is observed, with grades ranging from 4,70 to 9,60. This behavior suggests considerable heterogeneity within the group, possibly attributable to differences in content understanding, teaching strategies applied, or contextual factors that affected the students. For the second two-month period, the dispersion narrows, although the median (7,56) rises to a moderate level. Finally, for the April-August 2024 academic period,

the first two months present a median of 7,10, with less dispersion than in the previous year. In contrast, the second two-month period shows notable progress, with a median of 8,90, indicating not only higher performance but also more homogeneous performance. This last figure is especially relevant, as it reflects a possible consolidation of pedagogical strategies or materials that promote learning. Figure 5, which represents student perceptions of satisfaction with practical or experimental activities in the course, somewhat supports the previous findings. Fifty percent of students expressed satisfaction, stating that they "strongly agree," while the remaining 50% stated that they "agreed." This positive assessment of practical perceptions may be linked to the improvement in performance observed in 2024.

The students successfully met the learning objectives established in the Hydraulic Engineering I syllabus at the Universidad Central del Ecuador (UCE). They applied theoretical concepts to practical challenges, developed and calibrated hydraulic simulations, and validated their results through fieldwork and data collection. Additionally, they made meaningful contributions to the community by addressing real-world water supply issues, working collaboratively with residents and professionals from the School of Architecture of the UCE. Through this multidisciplinary, problem-based approach, the students deepened their understanding of pressurized pipe systems and open-channel hydraulics, while strengthening their technical, analytical, and teamwork competencies. It is essential to note that the Atucucho community, situated in the high Andean mountains, is a vulnerable neighborhood where water scarcity poses a significant threat to its residents. The students recognized that many additional needs remain to be addressed, including the structural evaluation of infrastructure in the face of seismic and landslide risks.

## Conclusions

The implementation of STEM and Project-Based Learning (PBL) methodologies in the courses enhanced student engagement and motivation, as academic performance is a tool for solving real-world problems. These methodologies facilitate deeper understanding by integrating theoretical science into real-world challenges. In addition, students developed not only technical skills but also non-technical competencies, such as critical thinking, communication, and ethical decision-making. The collaboration between civil engineering and architecture students, along with direct engagement with the community, fostered interdisciplinary teamwork and professional responsibility. Students gained first-hand experience in addressing water systems problems in vulnerable areas while applying design, simulation, and field verification skills. Additionally, they recognized broader infrastructural challenges in addressing

landslide and seismic risk management. During the April-August 2024 academic period, there was a significant improvement in the academic average of students in the Irrigation course. In addition, students expressed a favourable perception of the STEM methodology, suggesting that the application of active methodologies geared toward solving real-world problems has enabled them to approach challenges with a critical and sustainable perspective on civil engineering.

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# Conceptions of the human being and their influence on the application of the student-centered educational model in a private chilean university

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## Introduction

In recent decades, education has faced a series of emerging challenges in a highly globalized society, a scenario characterized by profound social transformation driven primarily by the rapid advancement of technology and communication. These innovations have not only radically redefined our conception of the world and the phenomena that shape it, but have also challenged our traditional ways of understanding educational processes (Durán Chinchilla, *et al.*; Noguera & Giraldo, 2023).

In this scenario, the emergence of different educational models is reflected, where theories, values, and principles that sustain educational practices converge and support the understanding of teaching-learning processes as a task intrinsically linked to philosophical conceptions about the essence and nature of individuals, understanding, in the words of Acosa (2023), that:

Education is a task that exclusively affects human beings, because it is a constitutively human reality. Only through education can man become man; 'he is but what education makes him to be' (p.13).

In particular, the Student-Centered Educational Model emerges as a response to these challenges, questioning the traditional training models that focused on teaching rather than learning, where the main actor in the process was the

teacher (Galván Cardoso & Siado Ramos, 2021). This new approach proposes a paradigmatic shift that recognizes the learner as an active subject, responsible and a protagonist of their formative process, promoting their autonomous, critical, creative, and integral development, redefining the classical roles predominant in the classroom (Ontoria *et al.*, 2023).

In this context, this research aims to examine how philosophical conceptions of the human being influence the implementation of the Student-Centered Educational Model. For this purpose, an exploratory and descriptive qualitative methodology was chosen, based on a case study developed at the Universidad Bernardo O'Higgins (UBO).

### **Educational Paradigms and their transformation of the educational approach in Chile**

Educational paradigms constitute a referential framework that guides and models the way we interpret and relate to our environment, as evident in the educational interactions constructed according to the value we place on the individual as the subject of education (Delgado *et al.*, 2021). These approaches, as social constructs, are born, transformed, and evolve according to the beliefs, ideas, and economic, historical, and cultural conditions of each context and social dynamics (Fernández *et al.*, 2025; González, 2023).

The transformation of the educational approach in Chile is a response to a series of multidimensional factors that condition educational practices, including the significant socioeconomic gaps that affect the performance and achievement of students from the most vulnerable sectors (Bellei, 2013; Flórez Petour, 2023). An example of this is the figures that indicate that, in the year 2024, 63% of the educational establishments that achieved the highest scores in the Higher Education Access Test (PAES) are from the Metropolitan Region, predominantly private schools located in the communes with the highest economic income in the country (CEPPE UC, 2025).

In higher education, these inequalities are manifested in various areas, one of which is the financing system among universities, which is derived from three sources: state contributions, resources from families who pay fees and tuition, and other sources, such as the provision of services by the institutions. In this context, it is noteworthy that 23% of the income of higher education institutions comes from student co-payments. In addition to this contribution, 9% corresponds to the financing obtained through the loan called Crédito Aval del Estado (CAE), which shows the considerable dependence on private resources to support professional education in Chile (Acción Educar, 2025).

In addition to the above, the results of the Report on the Gender Gap in Tertiary Education (2025) show that although the coverage rate in higher education shows that women have a higher participation rate (50.7%) versus 43.4% of men, this is significantly lower in STEM careers, Science, Technology, Engineering and Mathematics (20.8%), compared to 79.2% of men (Subsecretaría de Educación Superior, 2025).

In response to these problems, different public policies and educational reforms have been implemented in Chile, aimed at responding to the current challenges to guarantee the right to quality education, which not only considers the transmission of content and information, but rather, is capable of promoting the development of individuals across social gaps, contributing to the integral development of people, valuing their differences and promoting their participation in the construction of a more just society. Some examples of these initiatives are:

- Educational Reactivation Plan 2025, which is an Initiative of the Chilean Ministry of Education, which seeks to mitigate the negative effects of the COVID-19 pandemic and considers the integral well-being of students and the socioemotional support of students over standardized and decontextualized results.
- Curricular Update 2025, based on a flexible, student-centered curriculum, with a focus on interdisciplinary work, developing the competencies demanded by today's society, promoting contextualized and meaningful learning, supported by pedagogical innovation and the development of digital competencies (Mineduc, 2025).
- Public Financing for Higher Education (FES) is a project being evaluated, aiming to replace the CAE by promoting public financing without socioeconomic requirements (MINEDUC, 2024).
- National Permanence and Retention Policy, which seeks to overcome access barriers and support students with a comprehensive follow-up in favor of their insertion and permanence in the academic world through personalized tutoring, psychosocial support, and retention strategies (MINEDUC, 2024).

It follows from the above that the evolution of the educational paradigm in Chile towards a Student-Centered Model originates as a consequence of the need to address structural inequalities. This change requires recognizing students in their contexts, with their diverse needs and capacities, an essential factor in building a meaningful education that enables social strengthening and



development. This becomes especially relevant in the field of higher education, since it is the one that is socially challenged in its strategic role of training professionals capable of promoting the country's development.

## **Pedagogical Foundations and Institutional Identity of the UBO Educational Model**

Universidad Bernardo O Higgins, founded in 1990, is a private university located in Santiago, Chile. It is inspired by the thinking of Higginiano, based on values such as freedom, meritocracy, spirit of service, and ethical sense.

It is made up of four faculties: Human Sciences, Engineering, Science and Technology, Health Sciences, and Medical Sciences, highlighting, within its wide range of educational offerings, careers such as Law, Journalism, Industrial Civil Engineering, Pedagogy, Occupational Therapy, Medicine, Obstetrics, among others. In addition to its graduate programs, which together reach a total universe of more than 8,000 students and approximately 700 academics with experience in research and teaching.

As an institution of higher education, UBO seeks to consolidate itself as an institution of high educational level, training professionals who represent the values of its tradition and contribute to scientific advancement, social progress and cultural and spiritual growth, both nationally and internationally. It is committed to a training model aligned to its Vision, Mission and institutional values, with a socio-constructivist approach, centered on the student, establishing action axes such as: Comprehensive student training, training based on learning outcomes, internationalization and disciplinary and professional training linked to the social and productive environment of the country and sustainable development (UBO, 2024).

From a philosophical perspective, it aligns with the humanistic vision that emphasizes the holistic development of the individual. Its teaching-learning processes are oriented towards the development of critical thinking, ethics, and social responsibility as citizens. This is evidenced from its general guidelines, in its Educational Model UBO (2024), which states that comprehensive and holistic education is the central axis that articulates three cardinal knowledge for the formation of professional skills, noting that:

The University conceives learning as the harmonious integration of the dimensions of knowing, knowing how to do, and knowing how to be or live together, which is expressed in the acquisition of content, cognitive, and attitudinal skills that, systematically incorporated in the teaching-learning process, contribute to the progressive development of an integral professional

(p.20).

This conception implies three fundamental aspects of the vision of people and education, such as the understanding of the formative process as a continuous instance throughout life (Schmelkes, 2024). It considers not only theoretical and conceptual knowledge (know-how), but also the development of practical skills (know-how). This process is not limited to these two dimensions, but promotes the integral development of the human being, which is manifested in the consolidation of its principles and values, as well as its emotional competencies (knowing how to be) (Colomer Ramos, 2024).

These three types of competencies, cognitive, procedural, and attitudinal, aim to train professionals who know, who know how to execute, but who are also responsible and act with a high sense of ethics and social responsibility, expressing in its Educational Model, that:

*Facing training from this perspective, implies placing the students at the center of the process, who will gradually appropriate disciplinary knowledge, through the use of their skills and values, which will be mobilized in the service of solving practical problems and generating new knowledge (p.20).*

### **UBO Educational Model: Integration of Meaningful Learning, Autonomy, Inclusion and Formation for Lifelong Development**

The UBO integrated educational Model is based on situated and meaningful learning, a concept developed by Ausubel (1983) that postulates the importance of substantially and not arbitrarily relating new knowledge with that which the student already has. This implies a deep appreciation of what the student already is, knows, and of their own experiences and worldviews. It goes beyond reproducing information and mere memorization of data, but requires integrating new knowledge into the existing cognitive structure, where it is incorporated into potentially significant content, modifying it. Learning is then relational, deep, and lasting, because it is comprehensible by relating it to pre-existing concepts. In addition, it is necessary that the student is willing to relate significantly, so motivation plays a crucial role in the process (Matienzo, 2020).

In addition to motivation, the need arises to develop a basal competence from the student-centered approach, such as self-regulation of learning, i.e., the ability of students to set their own goals, develop cognitive strategies, and establish their own rhythms and phases of progression. This favors their

academic performance and personal autonomy. Studies by Fuentes et al. (2023) suggest that this active process promotes metacognition, as students plan their objectives, supervise and manage their activities, and evaluate and self-evaluate their methods, adjusting them to optimize their achievements. In this scenario, the teacher plays an active role in accompaniment, monitoring, and providing feedback on the academic process (Delgado et al., 2024).

The qualitative analysis of the results extracted from the interviews enabled the identification of emerging categories that account for the perceptions of the teachers and students interviewed regarding the application of the student-centered Model at the University. The data grouped thematically revealed that:

**Concept 1: The conception of the human being and the pedagogical perspective;** the interviews with teachers reveal that it is a complex phenomenon. The 6 participants explicitly recognize the student as a singular, active subject, validate their own experiences, and promote active-participative methodologies.

*"I conceive the human being as a social being, reflective and in constant construction of knowledge [...] education, from this point of view, is not a homogeneous process, but a collective experience that seeks to form people capable of transforming their environment consciously and ethically."* On the other hand, five students expressly recognize that their teachers express values of respect, empathy, and inclusion in their daily academic tasks. Three students detect tensions, pointing out that routines, a lack of flexibility, and the real possibility of expressing their differences are established, suggesting that educational practices require greater consolidation in terms of autonomy in knowledge construction.

*"The values reflected in the way my teachers teach are empathy and respect, as they promote a good classroom climate and meaningful learning. However, sometimes I feel that teachers do not always recognize other ways of learning."*

**Concept 2: Methodological strategies for active participation and meaningful learning.** In praxis, the use of active-participatory methodologies predominates, such as inverted classroom, project-based learning, and collaborative work. This is based on the need to generate meaningful and contextualized learning. "Any methodology that allows me to learn by doing and develop critical thinking, solve real problems, and debates are the ones I use the most. Example: PBL, cases, virtual inverted classroom." This is valued by students, as well as group reflection, dialogued classes, collaborative work, and the choice of evaluation forms, which they point out as necessary practices

in all subjects. *"When I participate in collaborative work, debates, or projects where I must research and make decisions, I feel that I am the protagonist of my learning."*

**Concept 3, Autonomous learning.** Regarding these categories, four teachers frequently grant autonomy to their students in the choice of topics, methodologies, and presentation styles for projects. They emphasize the need to support students, especially first-year students systematically. *"I try to encourage autonomy with classroom projects where students decide what topic to investigate, how to approach it, and how to present the results."* Meanwhile, five students report concrete autonomy experiences. *The student-centered Model has helped me to be more autonomous, responsible, and reflective. I have learned actively, developing social skills, working in a team, and valuing the process more than the final result".*

**Concept 4: Inclusive environment and diversity.** Both students and teachers recognize the importance of creating a good classroom climate, one that is collaborative and inclusive, where respect and emotional support are promoted, and the value of reinforcing inclusive practices in teamwork is acknowledged. *"I establish clear rules of respect and valuing diversity from the beginning, promoting a climate where students feel safe to express their ideas."* *"The atmosphere in my classroom is collaborative and respectful, everyone's participation is valued, and teamwork is encouraged. However, sometimes I feel competition or tensions when there is group work."*

Opportunities to decide what, how, or when to learn are restricted and depend directly on each teacher's approach. *"In some classes, I can choose the subject matter of my assignments or the presentation format, which allows me to learn in a more meaningful way. I receive support from my teachers through clear orientations, feedback, and spaces to resolve doubts."*

**Concept 5: Attention to Diversity and Adaptation of Strategies.** Teachers state that they implement a diversity of resources, evaluate through varied instruments, and generate instances of adaptation to the pace and specific needs, although they recognize the challenge of real equity in diverse classrooms. *"I design activities with different levels of complexity and formats for different learning styles and paces."* Students manifest the effective use of digital tools, noticing differences according to the teaching accompaniment. *"The use of technology has been a fundamental tool for my learning, since it facilitates it, but sometimes it depends a lot on the teacher and the subject."*

**Concept 6, Critical and ethical reflection.** Both concepts of the Educational

Model are integrated, in the opinion of the teachers, through the analysis of real cases, open questions, and debates. Students recognize these instances as opportunities to make their values explicit, resulting in significant experiences. *"My teachers invite us to reflect through open questions, debates, and analysis of real situations. This way we can question ideas, think critically, and connect learning to ethics and community life."*

**Concept 7, challenges and opportunities of the Model:** All teachers state that one of the main challenges of implementing the Student-Centered Model is maintaining the motivation of students, attending to the diversity of rhythms, and accompanying autonomy, which represents a significant challenge. In turn, most of them, in addition to generating strategies that favor autonomous work, value the Model as an opportunity for ethical formation, the development of critical thinking, and the contextualization of learning. On the part of the students, six highlight autonomy, direct communication, and active learning as strengths; however, three experience difficulties in organizing themselves in the face of the variety of methodologies, and feel that personalized attention is limited in large classes.

The results show, on the one hand, correspondence between the perception of teachers and the Student-Centered Educational Model, favoring active participation and autonomous work, as proposed by Galván Cardoso & Siado Ramos (2021). In addition, students' perceptions show some inconsistency as standardized methodologies of the traditional Model persist in classroom practices (Ontoria, et al., 2023).

It also highlights the importance of project-based work, since it is valued as fundamental to achieve meaningful and situated learning, as stated by Ausubel (1983) and Matienzo (2020). Although the effectiveness of personalized learning, which ensures inclusive education, is an aspect to be strengthened, as analyzed by Fernández et. al. (2025) and Colomer Ramos (2024).

On the other hand, the importance of developing critical thinking and ethical aspects of training (Schmelkes, 2024; Delgado et al., 2021), these competencies and values are reflected as a concrete manifestation of autonomy, which requires in the effective exercise of teacher accompaniment, especially in the early stages of training (Fuentes, et al. 2023). This presents challenges, primarily associated with the intrinsic motivation of students, which necessitates rethinking pedagogical practices (González, 2023).

## Conclusion

This research provides evidence of the existing coherence between the educational proposal of Universidad Bernardo O'Higgins and the theoretical and pedagogical support of the Student-Centered Model, grounded in a humanistic philosophical conception that recognizes the value of the student as an autonomous, active subject and protagonist of their own education.

The study concludes that both academics and students recognize the progress in consolidating the UBO Model, but there are still elements that indicate the need to ensure mechanisms to reduce the gaps between what is explicit in the Model and classroom experiences. This, in concrete terms refers to the personalization of learning and the differentiated accompaniment that guarantees the inclusion and flexibility of a Model where the student is the center and protagonist of the formative process.

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# Applying Self-Determination Theory to University Students

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## Introduction

Motivation is a concept that has long been employed to explain human behaviours and decision-making processes (Homont & Alcoceba Hernando, 2025). In the context of higher education, part of the recent academic literature suggests that we may be witnessing a gradual demotivation among university students (González Castro et al., 2021), a phenomenon that could be linked to class dynamics, content relevance, or the quality of student–teacher relationships. Given this scenario, it becomes increasingly important to explore how students engage with their studies and what drives their academic behaviour.

This chapter applies Self-Determination Theory as a theoretical lens to examine student motivation in a university setting, distinguishing between intrinsic motivation—related to interest, enjoyment, and satisfaction—and extrinsic motivation, which refers to achieving outcomes such as grades or professional skills. Specifically, the chapter seeks to understand how these types of motivation evolve over the course of an academic term. The central research question guiding this study is: How does university students' motivation change throughout the semester, and what type of motivation—intrinsic or extrinsic—do they identify with most strongly?

To address this question, the study analyses responses from 164 students to two questionnaires administered at the beginning and end of the semester. The objective is to capture the evolution of motivational factors over time and identify which forms of motivation prevail in each phase. By doing so, the chapter contributes to the understanding of how teaching strategies can be

better aligned with students' motivational profiles, ultimately supporting academic engagement and reducing the risk of demotivation. The findings discussed in this chapter offer useful insights for both theory and practice, highlighting the importance of maintaining high levels of intrinsic motivation to foster long-term academic commitment.

## Theoretical framework

In the university setting, we may be witnessing a demotivation among students (González Castro *et al.*, 2021), the origin of which may lie in class dynamics, content, or in the university teacher–student relationship (González Castro *et al.*, 2021; Méndez Santos, 2020).

Understood as an intrinsic phenomenon of human beings (Perry & Wise, 1990), motivation energises behaviours aimed at achieving goals (Luria *et al.*, 2021) that are sustained over time (Yang & Lai, 2011) according to external factors (Barrick *et al.*, 2013; Vallerand, 1997). In the student context, it has been defined as “a positive attitude towards achieving learning” (Ramírez & Olmos, 2020; cited in González Castro *et al.*, 2021, p. 2) and as “students' perceptions regarding their interest and willingness to learn, their academic expectations [...] and their responses to difficulties and frustration in their studies” (Rivas Alvarado & Avilés Marxelly, 2020, p. 2), and is considered responsible for greater academic success and for reducing the risk of dropout (González Castro *et al.*, 2021; Kikuchi, 2015; Mares *et al.*, 2012).

Its low or declining levels (González Castro *et al.*, 2021) are said, in the literature, to stem from maladapted class dynamics and content, as well as from the teacher–student relationship (González Castro *et al.*, 2021; Méndez Santos, 2020). Thus, addressing student demotivation requires an understanding of the factors that influence it, but also an examination of its characteristics. In this context, Self-Determination Theory offers potentially useful insights.

Self-Determination Theory posits that all human beings engage in activities to fulfil their psychological needs for autonomy, competence, and social affiliation (Ryan, 1995, p. 398), understood respectively as “the desire to regulate and control one's own behaviour; [...] the desire to engage in challenging tasks; and [...] the desire to seek attachments and to experience feelings of belonging and connection” (Adler *et al.*, 2018, p. 823). In order to meet these needs, individuals have two alternatives: to focus on the process of the activity or on its outcomes (Homont, 2025); it is from this distinction that Deci (1975) differentiates between intrinsic and extrinsic motivation.

Intrinsic motivation is the type of motivation that centres on learning, exploration, and the search for novelty and challenges (Ryan & Deci, 2002, p. 70), originating from the voluntary engagement in a task to experience interest, enjoyment (Ryan & Deci, 2002), and satisfaction during its performance (Gagné & Deci, 2005). Capturing it therefore consists of assessing whether an individual undertakes an activity with the aim of experiencing these three emotions. In contrast, extrinsic motivation focuses on fulfilling obligations, avoiding punishments (Touré-Tillery & Fishbach, 2018), and achieving external outcomes—whether social or economic (Di Domenico & Ryan, 2017)—to satisfy the needs for autonomy, competence, and social affiliation.

Self-Determination Theory is not frequently employed in the university context, even though the distinction between intrinsic and extrinsic motivation offers an opportunity to understand why students enrol and perform to varying degrees academically. Based on the contributions of Homont and Alcoceba Hernando (2025), this study interprets intrinsic motivation as being concretised in an interest in the chosen degree, in enjoyment derived from studying its subjects, and in a sense of satisfaction experienced while undertaking the studies. Likewise, the same authors suggest that extrinsic motivation can be captured using three criteria: the desire to acquire new skills and competencies required for future employment; the pursuit of good grades; and the opportunity to apply existing skills and competencies.

This study employed a quantitative, longitudinal approach based on the administration of two questionnaires to university students: one at the beginning and one at the end of the semester. The aim was to identify and compare levels of intrinsic and extrinsic motivation at different points during the academic cycle. A non-probability convenience sampling method was used, as the sample consisted of accessible students from the Complutense University of Madrid. A total of 381 students from various courses and degree programmes in Communication and Documentation initially participated, although final analysis was limited to the 164 students who completed both questionnaires.

The questionnaires, adapted from Homont and Alcoceba Hernando (2025), included closed-ended Likert-scale items (rated from 1 to 10) and ranking exercises (from 1 to 6). Data were analysed using descriptive statistics (means and mean differences), which allowed for the observation of changes in intrinsic and extrinsic motivation over time. Although inferential statistical tests were not applied, the descriptive analysis was sufficient to meet the study's objectives. The instrument's reliability was ensured by its prior validation in previous studies. Questionnaires were administered under standardised

conditions, ensuring consistency in data collection. The research was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Participation was voluntary, anonymous, and involved no risk to the students. Informed consent was obtained from all participants, and the data were treated confidentially and used exclusively for academic purposes.

## Key findings

The data obtained through the methodology are organised as follows. Firstly, the motivational state of students at the beginning of the 2024–2025 academic year is presented. Secondly, reference is made to this state at the end of the academic year and, thirdly, to the difference between the two. In all cases, only the 164 students who responded to both questionnaires were considered.

### Students' motivational state at the beginning of the academic year

At the beginning of the year, as summarised in Table 1, students identified more strongly with intrinsic motivation (IIM Mean) than with extrinsic motivation (IEM Mean), particularly with having enrolled due to interest (IIM1) and potential enjoyment (IIM2) of the degree. Furthermore, obtaining good grades (IEM3) was the item with which respondents identified the least. The fact that students identified less with this type of motivation, which responds to the pursuit of outcomes (Di Domenico & Ryan, 2017), suggests that they are driven to complete academic tasks by a personal commitment to and valuation of them.

Nonetheless, despite a stronger identification with intrinsic motivation, students at UCM reported similar rankings for both intrinsic and extrinsic motivation: a mean of 3,73 and 3,7 out of 6, respectively. This balance can be interpreted as a form of integrated motivation, in which extrinsic goals are autonomously internalised by students (Ryan & Deci, 2002).

It is noteworthy that, in general, students exhibit relatively high levels of both intrinsic and extrinsic motivation: considering all items of both types, a mean of 14,62 out of 20 is achieved. Thus, at the start of the academic year, students typically show a positive disposition towards learning, motivated by the desire to learn, explore and enjoy; and in the early weeks, the academic environment is perceived as an opportunity, which also boosts extrinsic motivation.

**Table 1.** *Motivational state of students at the beginning of the 2024-2025 academic year*

| IIM1<br>(1-10) | IIM2<br>(1-10) | IIM3<br>(1-10) | Mean<br>IIM<br>(1-10) | IEM1<br>(1-10) | IEM2<br>(1-10) | IEM3<br>(1-10) | Mean<br>IEM<br>(1-10) |
|----------------|----------------|----------------|-----------------------|----------------|----------------|----------------|-----------------------|
| 8,62           | 8,1            | 6,8            | 7,84                  | 7,42           | 6,79           | 6,12           | 6,78                  |
| PIM1<br>(1-6)  | PIM2<br>(1-6)  | PIM3<br>(1-6)  | Mean<br>PIM<br>(1-6)  | PEM1<br>(1-6)  | PEM2<br>(1-6)  | PEM3<br>(1-6)  | Mean<br>PEM<br>(1-6)  |
| 3,7            | 3,8            | 3,7            | 3,73                  | 3,8            | 3,5            | 3,8            | 3,7                   |

Note. Authors' own elaboration.

IIM1: identification with the interest sparked by the degree; IIM2: identification with the enjoyment derived from the degree; IIM3: identification with the satisfaction experienced while pursuing the degree; IEM1: identification with the desire to acquire new skills and competences; IEM2: identification with the possibility of utilising previously acquired skills and competences; IEM3: identification with the ability to achieve good grades.

PIM1: preference for the interest sparked by the degree; PIM2: preference for the enjoyment experienced in undertaking the degree; PIM3: preference for the satisfaction experienced while pursuing the degree; PEM1: preference for the desire to acquire new skills and competences; PEM2: preference for the possibility of utilising previously acquired skills and competences; PEM3: preference for the ability to achieve good grades.

### **Students' motivational state at the end of the academic year**

At the end of the 2024-2025 academic year, the students' motivational state decreased both in terms of identification and preference, though it remained above average overall: 7,16 out of 10 for intrinsic motivation, 6,68 out of 10 for extrinsic motivation, and a combined score of 13,84 out of 20.

More specifically, as shown in Table 2, interest (IIM1) and enjoyment (IIM2) continued to be the main reasons students reported for enrolling at the end of the semester, while satisfaction (IIM3) was the least cited. However, satisfaction became the most preferred reason among students, possibly reflecting that

personally significant emotional factors gain greater importance when compared with others.

**Table 2.** *Motivational state of students at the end of the 2024-2025 academic year*

| IIM1<br>(1-10) | IIM2<br>(1-10) | IIM3<br>(1-10) | Mean<br>IIM<br>(1-10) | IEM1<br>(1-10) | IEM2<br>(1-10) | IEM3<br>(1-10) | Mean<br>IEM<br>(1-10) |
|----------------|----------------|----------------|-----------------------|----------------|----------------|----------------|-----------------------|
| 7,92           | 7,45           | 6,1            | 7,16                  | 6,75           | 6,4            | 6,88           | 6,68                  |
| PIM1<br>(1-6)  | PIM2<br>(1-6)  | PIM3<br>(1-6)  | Mean<br>PIM<br>(1-6)  | PEM1<br>(1-6)  | PEM2<br>(1-6)  | PEM3<br>(1-6)  | Mean<br>PEM<br>(1-6)  |
| 3,1            | 3,4            | 3,5            | 3,33                  | 3,4            | 3,2            | 3,3            | 3,3                   |

Note. Authors' own elaboration.

### Evolution of the students' motivational state throughout the academic year

Comparing the evolution of the motivational state between the beginning and end of the academic year (see Table 3), a decline in identification with intrinsic motivation is observed, of nearly one point, while extrinsic motivation remains stable. This may indicate that students increasingly perceive the practical and tangible benefits of academic training, such as employability and academic recognition. These findings align with Di Domenico and Ryan's (2017) view that extrinsic motivation may be oriented toward external achievements that satisfy basic psychological needs.

Moreover, the only item that improves is the possibility of achieving good grades (IEM3), while those that decline most are interest and satisfaction related to the chosen degree. This evolution and regression may stem from a mismatch between students' initial expectations and the academic reality encountered. At the end of the semester, grades become a clear and attainable goal, reinforcing the extrinsic dimension of motivation and partially displacing the more personal and intrinsic reasons that initially guided degree selection.

**Table 3.** *Change in students' motivational state from beginning to end of the 2024-2025 academic year.*

| IIM1<br>(1-10) | IIM2<br>(1-10) | IIM3<br>(1-10) | Mean<br>IIM<br>(1-10) | IEM1<br>(1-10) | IEM2<br>(1-10) | IEM3<br>(1-10) | Mean<br>IEM<br>(1-10) |
|----------------|----------------|----------------|-----------------------|----------------|----------------|----------------|-----------------------|
| -0,7           | -0,65          | -0,7           | -0,68                 | -0,67          | -0,39          | +0,76          | -0,10                 |
| PIM1<br>(1-6)  | PIM2<br>(1-6)  | PIM3<br>(1-6)  | Mean<br>PIM<br>(1-6)  | PEM1<br>(1-6)  | PEM2<br>(1-6)  | PEM3<br>(1-6)  | Mean<br>PEM<br>(1-6)  |
| -0,6           | -0,4           | -0,2           | -0,4                  | -0,4           | -0,3           | -0,5           | -0,4                  |

Note. Authors' own elaboration.

## Conclusions

The results of this study have practical implications for the design of teaching strategies. Considering the types of motivation students identify with and their evolution, it appears that students express no strong preference between intrinsic and extrinsic reasons when choosing their degree. However, it is intrinsic motivation with which they identify most strongly at the start of the academic year. Therefore, to maintain high motivation levels, it would be pertinent to foster interest by emphasising the relevance of class topics, whether personally or professionally; enjoyment by tailoring course content to students' interests—for instance, allowing them to choose their own topics for assignments (Homont & Alcoceba Hernando, 2025); and satisfaction by providing regular feedback and support regarding academic progress.

Likewise, extrinsic motivation remains steady throughout the academic year, indicating that students recognise the relevance of academic training for their future professional paths, even if changes occur in related items (e.g., increased identification with the goal of achieving good grades).

Finally, this study highlights that students at the Complutense University of Madrid are not in a state of demotivation, with motivation levels remaining above average despite a slight downward trend over time. This paints a less concerning picture than that presented in previous studies: motivated students, as shown here, tend to be more engaged with their studies and achieve greater academic success (González Castro *et al.*, 2021; Kikuchi, 2015;

Mares *et al.*, 2012). However, these results contradict previous findings by González Castro *et al.* (2021) and Homont & Alcoceba Hernando (2025), where declining motivation was observed. This discrepancy may be due to external factors that future studies should consider, such as the influence of the covid-19 pandemic, which compelled students to complete part of their secondary and higher education virtually. This virtuality may have affected their interest, enjoyment, and satisfaction (intrinsic motivation), as well as their perception of outcomes (extrinsic motivation).

Despite successfully tracing the evolution of intrinsic and extrinsic motivation across the academic year (GO1), this study has several limitations. First, the sample lacks representativeness: the questionnaires were administered solely to students at the Complutense University of Madrid in communication and documentation degrees, so motivational realities in other degrees or universities may differ. Second, questionnaires do not allow for in-depth understanding of why students identify with or prefer certain motivational items over others.

For this reason, future research should employ other methods such as interviews to uncover factors explaining students' motivational identification and preferences. It is also relevant to consider factors that may foster or hinder motivation: sociodemographic, cultural, political factors, as well as aspects of university life itself. In this regard, phenomena such as university student engagement—which leads students to become more involved in their academic, professional, and civic development (López-Navas *et al.*, forthcoming)—may prove useful for understanding student expectations regarding university life, which in turn affect their motivational state.

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# Innovative education and circular entrepreneurship in the construction sector of Arequipa

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## Introduction

Growing concerns about climate change, the depletion of natural resources, and environmental pollution have forced the construction sector to rethink its traditional models. This sector is responsible for approximately 39% of global CO<sub>2</sub> emissions and is one of the main generators of solid waste (UNEP, 2022). In regions like Arequipa, the problem is exacerbated by limited recycling infrastructure and a lack of environmental awareness. In this context, the application of innovative educational approaches and the promotion of circular entrepreneurship emerge as comprehensive solutions for transforming the sector.

Working with university students on this topic is especially relevant because it strengthens their capacity to be agents of change in their communities. Universities, acting as "living laboratories", not only produce knowledge but also develop replicable solutions to local environmental challenges through student engagement and experimentation.

This article addresses the experience of an educational initiative developed at a public university in Arequipa, where active methodologies—such as Design Thinking—were integrated with the development of construction prototypes based on recyclable waste (tires, PET, and plastics). This study explores the technical, environmental, and social impact of these prototypes and reflects on the role of universities as key agents of sustainable development, based on the promotion of research, innovation, and entrepreneurship.

## Innovative Education and sustainable development

Education for sustainable development promotes competencies such as creativity, critical thinking, and informed decision-making (UNESCO, 2020). Methodologies such as Design Thinking enable the development of hard and soft skills through participatory processes focused on solving real-world problems (O'Connor *et al.*, 2022). UNESCO (2021) proposes that universities should act as "living laboratories" of sustainability, generating replicable

solutions in their territories.

In the context of construction, these educational approaches directly align with circular economy principles, since they encourage students to innovate with materials that extend the life cycle of resources. The EU's Green Comp (2022) and UNESCO's ESD Competence Frameworks (2017) both highlight the importance of systemic thinking and collaboration—skills that are essential in designing circular solutions in sectors such as construction.

## **Circular economy in the construction sector**

The circular economy proposes replacing the linear model with a regenerative one, based on the reduction, reuse, and recycling of materials. In construction, it has been applied through the use of waste such as recycled aggregates, shredded tires, or post-consumer plastics (Puttaraj & Agostinho, 2023). The use of eco-friendly bricks, asphalt with recycled rubber, or PET panels has demonstrated positive impacts in countries such as Chile, Colombia, and Spain (Haq et al., 2024; Hall, 2025).

## **Local context: Arequipa**

Arequipa is a region with high construction activity and a growing production of demolition waste and used tires (INEI, 2024). Although national policies such as the "Circular Economy Roadmap" (MINAM, 2021) exist, their implementation in the regions still faces structural barriers (Velásquez & Salinas, 2024). Coordination between academia, industry, and government is essential for scaling up sustainable circular models.

## **Recycled tire asphalt panels**

Inspired by experiences such as the CV-35 highway in Spain, panels were manufactured with 10% tire powder. The results indicated improvements in noise absorption (a 5 dB reduction) and increased durability (up to 30%). According to Sacyr (2024), this type of solution reduces the environmental impact of pavements by up to 25%. In Arequipa, it was identified as a viable solution for neighborhood pavements and recreational spaces.

## **Ecological PET and rubber bricks**

The prototype brick, made with a 12% PET and rubber blend, achieved a strength of 174 kg/cm<sup>2</sup>, meeting the Type V requirements of NTP 399.604. Studies such as those by Lizaraburu Aguinaga et al., Duche-Perez et al., (2024), (2023) and Arguedas & Eyzaguirre (2024) validate that this combination allows for a reduction in cement use of up to 35%, lowering costs and

emissions.

### **Prefabricated recycled plastic solutions**

Prefabricated slabs of crushed PET and epoxy resins were tested, achieving moderate strength (0.75 N/mm<sup>2</sup>) and good thermal insulation. Haq *et al.* (2024) suggest that geopolymers with plastics can reduce the carbon footprint by up to 60%. These solutions could be used in non-structural walls and lightweight roofs in social housing.

### **Social impact and formative**

Students reported improvements in critical thinking, teamwork, and understanding of environmental impact. Surveys showed 82% acceptance of the practical usefulness of the process, and 76% expressed interest in continuing with circular projects. This demonstrates the value of experiential education as a catalyst for sustainable innovation (UNESCO, 2021; López & Guevara, 2023).

The results obtained reflect that the application of active methodologies such as Design Thinking not only allowed students to identify real problems in the construction sector but also to generate viable solutions based on waste recycling. This confirms the findings of O'Connor *et al.* (2022), who highlight the value of these methodologies in developing critical thinking and collaborative skills geared toward sustainability.

In terms of technical and environmental feasibility, the prototypes presented acceptable performances aligned with national and international standards. For example, the PET-rubber bricks met strength standards, while the asphalt panels demonstrated acoustic and durability advantages. These experiences are consistent with the circular practices reported by Haq *et al.* (2024) and Hall (2025) in similar contexts.

Furthermore, the high student acceptance rate and willingness to continue similar projects demonstrates that innovative education has a positive impact on the development of entrepreneurial skills. This finding validates UNESCO's (2021) approach to universities as "living laboratories," capable of training citizens committed to sustainable development based on their local context.

However, structural challenges were identified, such as the lack of local infrastructure for recycling PET and tires, which limit the scalability of the prototypes. This reinforces the need to strengthen the links between universities, businesses, and governments, as proposed by Velásquez & Salinas (2024), to build more robust circular ecosystems in regions like Arequipa.

## Conclusions

The results obtained from this experience demonstrate the potential of innovative, sustainability-oriented education to transform the way challenges in the construction sector are addressed. The application of active methodologies made it possible to identify and resolve local problems through the design and testing of sustainable construction materials made from recyclable waste.

The prototypes demonstrated economic feasibility as well. Estimated cost savings ranged from 15% to 30% compared to conventional materials, primarily due to reduced cement use and the low cost of raw recycled inputs. These figures suggest a potential for cost-effective replication in low-income housing projects and public infrastructure.

The prototypes developed demonstrated technical viability, environmental efficiency, and economic feasibility in scenarios applicable to the region, while also fostering the development of key skills in students, such as teamwork, environmental awareness, and entrepreneurial initiative. This educational approach reinforces the university's active role in generating concrete, contextualized solutions with potential for replication.

The experience also revealed structural limitations, such as insufficient recycling infrastructure and a lack of inter-institutional coordination, factors that limit the possibility of scaling up these proposals. Therefore, there is a need to strengthen alliances between academia, the productive sector, and the state, as well as consolidate the circular economy as a cross-cutting axis in university education.

Finally, it is suggested that these types of experiences be replicated in other regions of the country, adapting them to their specific contexts, to contribute to a sustainable transition from higher education to more resilient, inclusive, and circular territories.

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# Population in Statistics as an object of phenomenology

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## Introduction

A crucial concept to be defined by any researcher using data in general is the definition of the study population. For this purpose, the definition of population provided by statistical science will be used. The researcher's correct understanding of the concept of population will determine the precision and delimitation of his study population and his possible sample, if required. But, if we refer to statistics, what is a population?

The concept of population has been repeatedly defined by various authors of statistical texts. For Triola (2009, p. 4) "population is the complete set of all the elements (scores, persons, measurements, etc.) to be studied". Córdova (2003, p. 2) states that "population is a set of elements (consisting of people, objects, etc.) that contains one or more observable characteristics". López (2004, p. 69) points out: "It is the set of persons or objects about which one wishes to know something in an investigation". And for Ventura-León (2017, p. 648) "The population is a set of elements that contain certain characteristics that are intended to be studied".

From the above definitions it is possible to observe that the traditional concept of population in Statistics refers to real objects or individuals, which constitute a whole and which contain the information of interest for the statistical study to be carried out. This type of populations are characterized as "finite". However, not all populations found in the literature have this character, as Gutiérrez & De la Vara (2012, p. 14) say, "populations can be finite or infinite". But are these conceptions of population sufficient for a person or researcher who has a considerable level of study and experience in his or her disciplinary area to understand and successfully use the concept of population? If so, then there would be no difficulty at all in specifying this concept of population in applied studies.

In this regard, Robles (2019) highlights errors in the understanding and

applicability of the concepts of population and sample in research studies. She specifies that the units of interest, both in the population and in the sample, should coincide in nature, pointing out that in many research works this does not occur. She recommends not confusing population with study sample, as happens in some cases when the researcher expresses "... because it is a small population, the sample is the population". Similarly, García-García & López-Alvarenga (2013) express that, the population to be investigated, is the population of interest and the sample to be drawn from it, must be representative, therefore, the sample must be probabilistic. On the other hand, Castro (2019) states that, with an insufficient sample size, the estimated results may be imprecise and lead to erroneous conclusions.

The examples of populations found in the literature are defined through their elements in an intuitive manner without further precision. In the case of a finite population, it is clear that the units that compose it are real, observable in their totality. Populations are described on the basis of their constituents, which are entities with real existence and attainable in space-time. However, occasionally populations also appear that could be interpreted in a similar way to Deming's conceptual populations (as cited in Hahn & Meeker, 1993, p. 1); for example, the population of road accidents, exemplified by López (2004, p. 69).

### **Bruner's categories of thought**

With the aim of deepening the study of the concept of population in the field of statistical science, it is essential to take into account Bruner *et al.* (2017) appreciations on the categories of objects; in particular, the so-called "formal categories". These categories are constituted by specifying the intrinsic (defining) properties and attributes required by the members of the class. An example of a category is constituted by people with an annual income higher than the national minimum income residing in some city of the Lambayeque region, Peru, during the year 2024. Undoubtedly, this category could constitute the target population of more than one statistical study.

Bruner *et al.* (2017, p. 26), state that "An attribute ... is any discriminable feature of an event that is susceptible of some discriminable variation from event to event". Formal categories are constituted through attributes that define them and, under certain considerations, they fully meet the characteristics required for them to be feasible of being considered as target populations for statistical studies. For example, in the category of people who reside in a city in the Lambayeque region and who in the year 2024 had an annual income equal to or greater than the national minimum income, there are two defining attributes that take on specific values: "resident" (in a city in

the Lambayeque region) and “income in 2024” (greater than or equal to the minimum income). Note, in this example, the perceptible variation that these defining attributes possess, whether this variation be discrete or continuous.

Bruner *et al.* (2017) distinguish three kinds of categories: affective, functional and formal. In this paper, only the formal categories are considered. It should be noted that affective and functional categories cannot be understood as a target population for a statistical study, since the defining response they involve is not related to an intrinsic common factor of the constituent elements.

The following distinction that Bruner *et al.* (2017) establish is relevant:

... the act of categorizing ... may occur in a perceptual situation or one not involving the presence of stimulus object. ... One of the principal differences between the two forms of categorization– “the perceptual” on the one hand and “the conceptual” on the other–is the immediacy to experience of the attributes by which their fitness to a category is determined. In the perceptual case, the relevant attributes are more immediately given by which we judge the categorial identity of an object, at least in simple perceptual situation. At the other end, the attainment of knowledge about the attributes that are relevant may require a difficult strategy of search ... There are, of course, steps in between the two extremes where the relevant cues to categorization are only “moderately immediate” and in which some strategy of search behavior is required of the subject ... (p. 9)

## Types of population in Statistics

Hahn & Meeker (1993) have highlighted the importance of understanding the differences between certain types of populations addressed in research studies and their corresponding assumptions.

It has been our observation, however, that many analysts (both with and without statistical training) often fail to appreciate these assumptions; this can result in misleading or incorrect conclusions. The distinction between enumerative studies and analytic studies that has been emphasized by Deming (1950) is especially important. An understanding of this difference, and the potential consequences of making incorrect assumptions, is essential for correctly planning a statistical study, analyzing the resulting data, and acting based on the results (p. 1).

Considering that Statistics is a developing science, it makes sense to seek a clarification of the concept of population from a perspective that provides it

with the appropriate unity that is desirable. To this end, the objective of this research was to study the concept of population as a phenomenon within Statistics and its role in statistical thinking. Here “phenomenon” is understood as “Any manifestation that becomes present to the consciousness of a subject and appears as an object of his perception” (Real Academia Española [RAE], n.d.)

The population instances considered were organized in tables with the textual contents of this concept, distinguishing three essential aspects, which are presented in Table 1. Table 2 presents some examples of these classes.

For Bruner et al. (2017, p. 1), “to categorize is to render discriminably different things equivalent, to group the objects and events and people around us into classes”. That is, a category is a grouping of objects that share certain characteristics, which coincides with the essential aspect C1, of the three that we have distinguished in Table 1. In this sense, every population is a category.

Considering Bruner's statement, we can affirm that a statistical population is essentially a formal category, whether this category is perceptual or conceptual, which, as we have already pointed out, differ mainly by the experientially immediate character of the attributes that determine membership in the category.

**Table 1.** *Description of the essential aspects associated with the concept of population.*

| Essential aspect                | Designation              | Description                                                                                      |
|---------------------------------|--------------------------|--------------------------------------------------------------------------------------------------|
| C1: Essential aspect of Class 1 | Comprehensive collection | Expressions that establish a grouping of elements that share a common property and form a whole. |
| C2: Essential aspect of Class 2 | Finite population        | Expressions that refer to a finite set of elements.                                              |
| C3: Essential aspect of Class 3 | Infinite population      | Expressions that specify an infinite set of elements.                                            |

Next, let us consider the other two essential aspects revealed in the investigation of the population instances selected for this study, whose respective classes were denoted by C2 and C3 and which are related to the

finite or infinite nature, respectively, of the population, see Table 2. If the population is finite, then, understood as a category, it must contain a defining attribute that directly or indirectly determines its finiteness. Consider, for example, the population of individuals who had the quality of residents in the city of Chiclayo throughout the year 2024. In this example the corresponding population is finite since its elements can be counted. Infinite populations, i.e. not finite, complete a first "finite-infinite" dimension that allows to classify populations.

In what follows, let us review the special case of the empty category. For Bruner *et al.* (2017, p. 14) an example of an empty category "is the class of creatures known as centaurs, half man and half horse ...". For this example, note that there is no objective perception of the existence of a centaur, nor of the existence of attributes that allow for variation; this category is empty. Empty populations are not of interest in Statistics; therefore, we must take care to specifically exclude the empty category from being a population. In relation to the existence of the instances or elements of the population, it is sufficient to require that for these instances there exist attributes attainable with a certain degree of immediacy in the world of objective perceptions; what could be called "empirical or observable existence". This condition on the defining attributes is necessary and sufficient to guarantee the existence of the elements of the population; that is, to guarantee that the population is not empty, unless there are two incongruent defining attributes.

**Table 2.** *Instances of the concept of population and its phenomenological reductions.*

| Ctg. | Selected instances of the population concept                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| C1   | <p>"Set of people inhabiting the Earth or any geographic division thereof" (Rodríguez <i>et al.</i>, 2011, p. 2)</p> <p>"Are sets of all individuals or individual elements of a specific type" (Walpole <i>et al.</i>, 2003, p. 2).</p> <p>"It is the set of measurements of interest to the researcher" (Mendenhall <i>et al.</i>, 2006, p. 8).</p> <p>"It is the set of all items of interest in a given study" (Anderson <i>et al.</i>, 2008, p. 15).</p> <p>"It is the collection of all possible information that characterizes a phenomenon" (Canavos, 1988, p. 1).</p> <p>"A well-defined collection of objects that constitute a research population" (Devore, 2008, p. 2).</p> <p>"Set of individuals or objects of interest or measures that are obtained from all individuals or objects of interest" (Lind <i>et al.</i>, 2012, p. 7).</p> |

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- C2 "It is any collection of either a finite number of measurements or ..." (Canavos, 1998, p. 1).  
"Finite, identifiable, unchanging set of individuals or objects that make up a population" (Deming as cited in Devore, 2008, p. 6).  
"If it is finite and small all individuals can be measured to have an "accurate" knowledge of the characteristics (parameters) of that population" (Gutierrez & De la Vara, 2012, p. 14).  
"When it is an analytical or experimental study, this presents a finite number of a population of interest" (Zambrana *et al.*, 2020, p. 74).
- 
- C3 "In most cases, we are primarily interested in the population, but the population may be difficult or impossible to enumerate" (Mendenhall *et al.*, 2006, p. 3).  
"... a large, virtually infinite, collection of data about something of interest" (Canavos, 1988, p.1).  
"There is therefore no sampling frame that lists the individuals or objects of interest" (Deming as cited in Devore, 2008, p. 6).  
"The word infinite implies that, logically speaking, there is no limit to the number of values that could be observed" (Freund, 2000, p. 266).  
"It is impossible to verify in a physical way all the elements of the population. Some populations are infinite" (Lind *et al.*, 2012, p. 267).  
"If the population is infinite or large it is impossible and unaffordable to measure all individuals" (Gutierrez & De la Vara, 2012, p. 14).  
"The size of the population,  $N$ , can be very large or even infinite" (Walpole, 2003, p. 3).  
"When it is a descriptive epidemiological study, the general population is infinite" (Zambrana *et al.*, 2020, p. 74).  
"If the sample size is very small relative to that of the population, the population is usually considered infinite" (López-Roldán & Fachelli, 2017, p. 7).
- 

A new dimension of interest for population classification arises with experiments. Devore (2008, p. 10), notes "Engineers and scientists often gather data by conducting some sort of experiments. This may involve how to assign several different treatments (such as fertilizers or anti-corrosion coatings) to the various experimental units (plots or pipe runs)."

Other examples related to experiments can be found in Hevia (2023). In this case, randomized experiments are considered that yield numbers as results and in which, the population is the category of observations of the experiment results. As Hevia points out, one soon realizes that, having a number of such

observations, it is always possible to add one more. Consequently, a population as such is infinite, at least conceptually, to the extent that there is an unlimited supply of the resources involved in its corresponding experiment.

Experimental designs and randomized experiments lead to another relevant distinction between populations, which is related to the need to make the objects of the population tangible through a procedure for generating these entities. Deming has been fully correct in calling the populations associated with the experiments "conceptual" (which coincides with the language introduced by Bruner *et al.* (2017) if these populations are considered as Bruner's categories) and the corresponding studies "analytical".

In the other cases Deming considers, the population is present and available in its entirety at least theoretically; generation of the category instances is not required. Deming (1950) calls the studies corresponding to these populations as "enumerative studies"; but, in addition, he adds the condition of finiteness; however, the latter condition does not necessarily follow from the requirement that the population be present and available in its entirety. For example, the population of the points of a coordinate plane or the population of the positive integers. So, populations that are present independently of the investigator can be infinite.

According to the above, we have finite or infinite populations that are present independently of the researcher and we also have populations that come from experiments, which are always infinite, under the assumption of unlimited resources. In the former, the researcher has a passive role of observer; in the latter, the role of the researcher is active and a direct participant in the generation of observations.

In Figure 1, we can recognize the four classes of populations that are revealed from the two phenomenal dimensions found: finiteness-infiniteness and participation-non-participation of the researcher in the generation of the population instances. With thick borders, the classes of population observed by Deming (1950) stand out. The nominations "perceptual" and "conceptual" introduced by Bruner *et al.* (2017) for the categories are extended to the two classes of populations formed under consideration of the second phenomenal dimension.

**Figure 1.** The four classes of populations and their relationship to the populations of Deming's enumerative and analytical studies

|                                                                                                                                            | Finite populations                                                                                              | Infinite populations |
|--------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|----------------------|
| <b>PERCEPTUAL POPULATIONS</b><br>Instances are attainable in the world of objective perceptions, without mediating any production.         | <div>Deming's enumerative studies populations</div>                                                             |                      |
| <b>CONCEPTUAL POPULATIONS</b><br>The production of instances is necessary for them to be attainable in the world of objective perceptions. | <div>Finite resources</div> <div>Populations of Deming's analytical studies</div> <div>Infinite resources</div> |                      |

## Conclusions

A first conclusion to be drawn from this study is that a statistical population is a non-empty formal category of objects with empirical or observable existence with a certain degree of immediacy.

The salient aspects of a statistical population are its finite or infinite aspect and whether or not its elements are intentionally produced by the researcher. Any statistical population must fall into one of the classifications established by these two aspects.

The existence of researcher participation in the generation of the population instances defines exactly the same class of populations defined by Deming as conceptual; however, the non-existence of researcher participation in the generation of data does not define the same class of populations corresponding to Deming's enumerative studies, due to the existence of infinite populations whose data are available independently of the researcher.

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# The right to education in rural areas. An approach from K. Tomaševski

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## Introduction

In this study, we propose indicators contextualized to rural territories that enable the analysis of the State's fulfilment of the right to education. The indicators are based on a literature review of recent educational articles and the original Tomaševsky proposal with its four components. The proposed set of indicators serve as an open, flexible, transparent, and situated approach to assessing the right to education in rural territories in Mexico and other countries that share rural characteristics. This proposal is necessary to advance this constitutional and international right in rural areas, where literature has shown progress in access, mostly to basic education (Hernandez & Esparza, 2022), but there is no information regarding the fulfilment of contextual needs.

The literature review included academic works focused on the right to education and on rural areas. The analysis comprises the four components defined by Tomaševski and considers other proposals. The results highlight the importance of defining specific criteria according to specific contexts, especially those historically marginalized, as rural areas, while also noting that they are not exclusively applicable to rural territories in Mexico but in other geographical areas. The proposed indicators can support the monitoring of educational services and the conditions under which they are provided, reflecting both, access to schooling and the quality of teaching. This proposal aims to inform decision-making and help ensure the fulfilment of the right to education in rural contexts to provide valuable learning experiences.

To achieve this objective, this article firstly presents a literature review on the right to education focusing on diverse topics and approaches. In the second part, it introduces the proposed indicators derived mainly from Tomaševski (2001), Ruiz Muñoz (2012), and Refaat and Hadi (2018) works. Finally, the paper concludes with a reflection on practical considerations for assessing the right to education in rural settings.

The right to education is defined as the right to access and participate in formal education, considering the conditions for learning development of specific nations and the aspirations of their people. This discussion is not new, it is based on the contrast between international declarations and national laws that define its compulsory nature (Nogueira, 2008). In Mexico, for example, the debate has focused on constitutional reforms and legal frameworks (Castrejón, 1978; Labastida, 1978; Valadés, 1981, cited by Ruiz Muñoz, 2012; Hernández y Esparza, 2022). Viewing the right to education from a legal perspective is considered a first step, as it establishes the foundations for political and educational actions. However, this is not sufficient, since the gap between the educational laws and the actual exercise of educational rights is not addressed.

From a legal perspective, the right to education has been studied as a social right. There have been academic efforts to develop instruments for measuring the compliance with social rights (Refaat and Hadi, 2018; Ruiz Muñoz, 2012; Tomaševski, 2001), and, in education, to assess the impact of the constitutional recognition of the right to education, focusing on state spending (Chilton & Versteeg, 2017). In Mexico, the wording of the right to education in the constitution has been analysed, for example, Robles *et al.* (2018) studied the implications of “quality” as the aim of the educational system, highlighting the debt with respect to significant learning, despite the progress in other educational indicators, such as attendance. The meaning of the right to education has also been examined in international and national speeches, for example, Ruiz (2012), through documentary analysis identified emerging terms such as quality, equity, and equality of opportunity (Ruíz, 2012). And Aboites (2012), taking a historical stance, distinguished significant constitutional changes in Mexico and how the right to education was “conceived and translated into practice” (Aboites, 2012, p. 361).

Overall, these studies evidence a gap between the legal recognition of the right to education and its enactment (Robles *et al.*, 2018, Chilton and Versteeg, 2017; Hernández & Esparza, 2022); Latapí, 2009a, cited by Ruíz, 2012; Aboites, 2012; Heymann *et al.*, 2014). These results led to studies that specifically focused on understanding the gap in compliance with the right to education recognizing the socio-historical background of inequality among populations that permeates access to education (Ancheta & Lázaro, 2013). In India rural contexts, the meaning that families give to university education for women has shown that it is considered as an income booster and as a factor could improve their marriage opportunities (Arends-Kuenning & Amin, 2001, p.140); in Brazil, inequalities among rural and urban right to education compliance have been revealed, and the importance to overcome these inequalities has been highlighted since “the right to education strengthens the defence of other

social rights also unequally distributed among the urban and rural populations” (Santos *et al*, 2018, p.317 - 318). For minority groups (i.e. rurality, disability) various studies have examined the compliance with international recommendations, such as Article 24 of the United Nations Convention on the Rights of Persons with Disabilities, especially in signatory countries such as some African countries, India, and Spain (Kalyanpur, 2008; Chataika, 2012; Calderón-Almendros & Rascón-Gómez, 2022), and others, considering only the right to education for indigenous population (Aikman, 2011; Ames 2012), stating a call to address this right from a cultural and social justice perspective.

Recent studies still refer to international frameworks to assess the right to education (Lázaro Lorente, 2022) in specific educational levels, such as higher education (Lázaro Lorente, 2022), or early education (Ancheta & Lázaro, 2013), when the international conventions and laws focused attention on them. And since 2020, because of the COVID-19 pandemics, several studies have been carried out analysing the role of digital literacy and teaching in fulfilling the right to education for all (Martínez *et al.*, 2024), (Cotino, 2020; Ramón, 2020; Ávila & Woolcott, 2025).

The literature review on the right to education includes works that address both the national and international legality of this right, as well as studies focusing on specific areas, geographically (Sub-Saharan Africa, India, rurality) or by educational levels (early or higher education). The work of K. Tomaševski's (2001) has been a fundamental contribution for analysing the right to education in diverse cultural contexts and geographical region, however there is still a need to compare the exercise of this right among urban and rural areas, to identify and face disparities.

With respect to developing indicators for monitoring the right to education compliance, it is important to recognize the complexity of the phenomena, that might include several dimensions, and this complexity increases when different groups are being compared (Refaat & Hadi, 2017, p. 60). For this reason, this chapter proposes a set of indicators focused on rural areas.

The right to education framework developed by Tomaševski (2001) unfolds in four dimensions (4-A scheme): availability, accessibility, acceptability and adaptability. *Availability* entails that education is reachable for the targeted population and that their conditions are suitable to promote students' learning; when assessing availability, the following elements are taken into account: fiscal allocations, school infrastructure, teachers' working conditions (de Beco, 2009, p. 20). *Accessibility* is focused on removing the barriers to accessing education, for example: legal, administrative and financial, but also physical,

socio-cultural, and gender obstacles, among others (de Beco, 2009; Tomaševski, 2001); efforts are placed for reaching marginalized population and avoiding students' discrimination (ActionAid, 2021, p. 6). *Acceptability* relates to the content of education, aiming to ensuring its relevance for the targeted population, according to their sociocultural contexts and the expected learning outcomes; this includes the language used in schools, linking the teaching and learning processes to local realities, school discipline that guarantees children wellbeing, and recognising children's rights and their capacity to act. And, *adaptability*, deals with the ability to suit different students' needs and their contexts, this requires flexibility in education provision (Marín Posada et al., 2022; Open Knowledge, 2021; Ruiz Muñoz, 2012, 2014).

The 4-A framework has been widely used to classify state obligations to guarantee the right to education, since they are closely aligned with international legislation on human rights, and they entail both quantitative and qualitative aspects of the right to education (de Beco, 2009; Ruiz Muñoz, 2014, p. 4). Various proposals have been developed based on the 4-A framework, reframing the right to education dimensions, for example: UNICEF-UNESCO (2008) regrouped them in right to access to education, right to quality of education and right to a respectful learning environment; Action Aid and Right to Education Project proposed a 10 fundamental rights framework to be fostered in schools, comprising free and compulsory education, non-discrimination, adequate infrastructure, quality trained teachers, safe environment, relevant education, knowing rights, participating in education, transparent and accountable schools, and quality learning (ActionAid, 2021).

Collectively, in all these frameworks the following constructs play a critical role in understanding the right to education: *gratuity*, *enforceability*, *justiciability*, and *compulsory education* (Ruiz Muñoz, 2012). *Gratuity* is essential for the accessibility dimension of this right, and it entails direct (v.gr. school fees, parent association fees, examination payments) and indirect costs for attending school (v.gr. meals, transportation expenses, sanitary pads); this demonstrates that realizing the right to education requires the participation of multiple public policy areas, such as transportation, health, economy, among others. *Compulsory* education has to do with the state responsibility to guarantee access to education, the implementation of educational programs in different modalities that correspond to the needs of the population, and the achievement of desired outcomes; we pose that this construct is linked to the four dimensions of the right to education framework developed by Tomaševski. *Enforceability* comprises social mechanisms to demand compliance with the right to education; the civil society, activists, legal tools, and social movements play an important role in enforceability (Ruiz Muñoz, 2012, p. 57). *Justiciability*

is represented by the legal mechanisms established by the state to demand the right to education; these mechanisms are particularly relevant for vulnerable populations, to visualize when the right of education is not fulfilled (Ruiz Muñoz, 2012, pp. 58–59).

Rural communities are considered a vulnerable population due to their geographic isolation, low population density, the limited access to services, and the economic activities in which they are engaged, among other characteristics (Marín Posada *et al.*, 2022); additionally, the daily experiences in rural contexts might represent different ways of learning, that should be taken into account in the acceptability and adaptability dimensions of the right to education. In general, this vulnerability is revealed in school limited resources, low teaching salaries and high teaching attrition, lack of professional development opportunities for teaching staff, teaching isolation, among other conditions (Ihrig *et al.*, 2022). It is also worth noting that some studies have documented affordances in these contexts, such as, teachers' agency and control over curriculum and pedagogy and continuous communication with parents and pupils that translates into a deeper understanding of their students' needs (Ihrig *et al.*, 2022, p. 384). Below we will analyse the implications of each of the dimensions of the right to education for rural communities. In this analysis we will pose guiding questions and suggest indicators derived from them.

Within the *availability* dimension, it is necessary to monitor how reachable are schools for rural students, not only in terms of physical location but also regarding the costs that imply students' attendance. The adequacy of school infrastructure and resources must also be examined: are rural state schools properly equipped and staffed to deliver the curriculum effectively and support students in achieving the desired learning outcomes? Continuity of educational provision is another relevant aspect in rural communities: are measures in place to prevent temporary closures, early school departures, or the cancellation of lessons? Finally, teacher-related factors need also to be checked: are rural teachers qualified to teach, proficient in the language of instruction, and protected in their labour rights? The following indicators are associated with these questions: rural schools meeting infrastructure standards, qualified teachers in rural areas, incidence of school closures, length of school day, availability of textbooks and other materials in schools, computer equipment and technological services.

The dimension of *accessibility* entails an examination of whether basic education is effectively reaching all rural students, removing the barriers for their participation in schools. It is necessary to measure the costs associated

with school attendance to determine to what extent rural state education is free, identifying voluntary and compulsory costs that might undermine students' enrolment, attendance and completion. Parental freedom of choice in these contexts should be assessed, looking for the recognition and support of this right; it is likely that in these contexts parents are faced with no school choices. Accessibility is also related to school organisation, for example with respect to the alignment of school schedules with the needs of rural families, particularly those engaged in seasonal or agricultural work. Monitoring attendance is another relevant aspect in this context, through mechanisms to track attendance and actions to foster it. Indicators in this dimension should include enrolment, attendance and completion rates; direct and indirect school costs; policies supporting flexible school schedules.

The *acceptability* requires examining if educational standards are established, encouraged, and monitored in rural communities. Responding to students' needs is a central component of this dimension, through providing instruction in a language that corresponds to students' mother tongues, linking curricular contents to the local context, implementing school discipline practices that protect children's well-being and dignity, using teaching methods and materials that mirror rural contexts and scaffold learning. Additionally, the recognition of learners' rights within schools and the professional development and supervision provided to rural teachers to ensure responsiveness to students' diverse needs. These aspects suggest indicators such as language of instruction in schools and correspondence with students' mother tongue, disciplinary school practices, rural teacher participation in contextualized professional development programs, local content included in curricula and materials, literacy rates, learning outcomes compared to the desired curriculum outcomes.

The *adaptability* dimension addresses how schools respond to students' diverse needs, such as divergent abilities, educational requirements, and particular needs of minorities. In adjusting to these needs, schools might implement accommodations for ensuring that children have access to flexible learning opportunities, for example when they are engaged in family economic activities. Indicators in this dimension might include schools implementing inclusive education policies, availability of flexible learning schedules for children supporting family work, integration of human rights education in curricula, and tailored support provided to students from minority groups.



## Conclusions

The analysis undertaken in this chapter reveals the complexity of ensuring the right to education in rural settings. It is undeniable the role of socioeconomic factors in influencing education provision and outcomes, but expecting rural socioeconomic factors to align with those of urban areas is not a viable option to improve educational outcomes. Instead, the analysis based on the 4A framework developed by Tomaševski and the indicators we derived from it, provide a foundation for monitoring educational and non-educational factors that shape the fulfilment of the right to education. Additionally, this analysis, particularly in the acceptability and adaptability dimensions of the framework, takes into consideration the local sociocultural conditions of rural areas, so that, educational provision responds to them and recognises the values that rural inhabitants have built on them.

The indicators suggested in this chapter could enable decision makers to identify gaps in the fulfilment of the right to education in rural settings, to monitor its progress, assess the effectiveness of current policies and design and implement interventions. With respect to the availability dimension of the right to education, it could help decision-makers to embrace an integral and comprehensive perspective, aiming at meeting infrastructure standards, ensuring that qualified teachers are assigned to rural areas, examining how time is used in these schools, the provision of textbooks and other materials, computer equipment and technological services. To assess accessibility, we pose that it necessary to look at traditional indicators such as enrolment, attendance and completion rates, but other indicators should be added that examine direct and indirect school costs implied in school attendance, and the policies supporting flexible school schedules. The acceptability indicators focused on the correspondence of the language of instruction at schools with students' mother tongue, disciplinary school practices, rural teacher participation in contextualized professional development programs, local content included in curricula and materials, literacy rates, learning outcomes compared to the desired curriculum outcomes. Finally, the adaptability dimension indicators are centred in inclusive education policies, availability of flexible learning schedules for children supporting family work, integration of human rights education in curricula, and tailored support provided to students from minority groups.

Further work needs to be carried out for refining and discussing these indicators with educational actors involved in rural contexts and other public policy areas that play a crucial role in ensuring the right to education. Additionally, methodological implications in indicators development need to

be addressed, to capture this multifaceted and complex reality. We expect that discussing our analysis and the suggested indicators may drive conversations that translate in specific policy actions. We conclude that developing context-sensitive indicators is a fundamental step in ensuring the right to education for populations historically underserved by educational systems, and to reduce their persistent inequalities.

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# Enhancing Learning: Glocal Action and Collaboration through Service-Learning and COIL

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This text arises after a semester-long teaching of Human Rights and Culture of Peace subject at Pontifical Catholic University of Ecuador to Languages Applied to Global Studies major students with application of active methodologies such as Collaborative Online International Learning and Service-Learning.

## Introduction

Higher education institutions nowadays are evolving towards integral education of their students, which fosters not only by encouraging advancement of academic skills, but also their ethical and social aptitudes. This kind of training can be achieved through educational models that focus on research, outreach projects, proficiency in foreign languages, and critical appropriation of knowledge, thus preparing young fellows to become active agents of transformation.

In this regard, Global Citizenship (GCE) is an educational paradigm that supports educational reform by learning at cognitive, socio-emotional and behavioral levels. This aims to prepare future professionals whose global awareness, critical thinking, respect for diversity, civic participation and ethical decision-making foster future professionals' cross-communicational acquaintance, identity formation and active engagement attitude. Nevertheless, to build a solid institutional model, there is a need of employing pedagogical strategies or methodologies and implement a thorough plan. Much has been written about Collaborative Online International Learning (COIL) and Service Learning (SL) methodologies advantages, however, there is limited literature on the combined application of both methodologies within the same classroom setting.

## Collaborative Online International Learning

The beneficial aspects for university students to travel abroad – including the acquisition of valuable professional skills are well-documented (Ballesteros-Sola & Magomedova, 2023; House et al., 2022; Huertas-Abril & Palacios-Hidalgo,

2024; Jones, 2025; Nuñez et al., 2023). Ballesteros-Sola & Magomedova (2023) also consider that students succeed professionally and develop cultural intelligence when exposed to international experience.

Nuñez et al. (2023) pinpoint that during COVID-19 there was a great scarcity of travelling opportunities prompted the use of COIL methodology as a tool for facilitating virtual approximation among higher education institutions all over the world. This approach remains relevant in post-pandemic times, especially for students who may have financial, logistical or personal constraints.

Jones (2025) underscores the importance of equity in international opportunities among other strengths of COIL. Mestre-Segarra & Ruiz-Garrido (2022) view the methodology as a pivotal shift that enhances learners' collaboration and cross-cultural skills. Additionally, Huertas-Abril & Palacios-Hidalgo (2024) point to the positive impact on teachers throughout the process.

COIL is a useful, cost-effective, interactive virtual pedagogical instrument, which assists students' intercultural exchange. While methodology places students in the center of the learning process, faculty members also play significant role within it. In a COIL experience, teachers usually need to co-design a curriculum of at least four sessions, they also select academic material and assign collaborative activities with international students. This collaboration enriches the learning-teaching experience and fosters professional development as well as institutional engagement. An important component in this process is peer assessment, conducted after each session. This element is integrated into the course evaluation and contributes to a reflective, participatory learning environment.

## Service Learning

It is worth mentioning that SL serves as a powerful pedagogical approach that bridges the classroom learning with real life situations (Paredes, 2017; Rolán González et al., 2016; Tucci, 2016; Vázquez Sánchez & Gigirey, 2016; Rovira et al., 2015). Schultes et al. (2025) describes the methodology as one that benefits not only the vulnerable community that participates in the experience, but also students and teachers. Celio et al. (2011) declare that Service Learning can impact positively all the stakeholders within the Service-Learning process, making emphasis on skills that students acquire through the methodology. Also, the authors highlight the importance of training both students and teachers in areas of curriculum development, global citizenship, and social responsibility.

This case study is constructed by analysis of students' insights after experimenting COIL and SL methodologies within the same subject framework and is shown as the following.

### SDG 1 - No Poverty - End poverty in all its forms and everywhere.

This corpus contains 1 document with total of 1,758 words and 568 single word form.

Vocabulary density 0.323

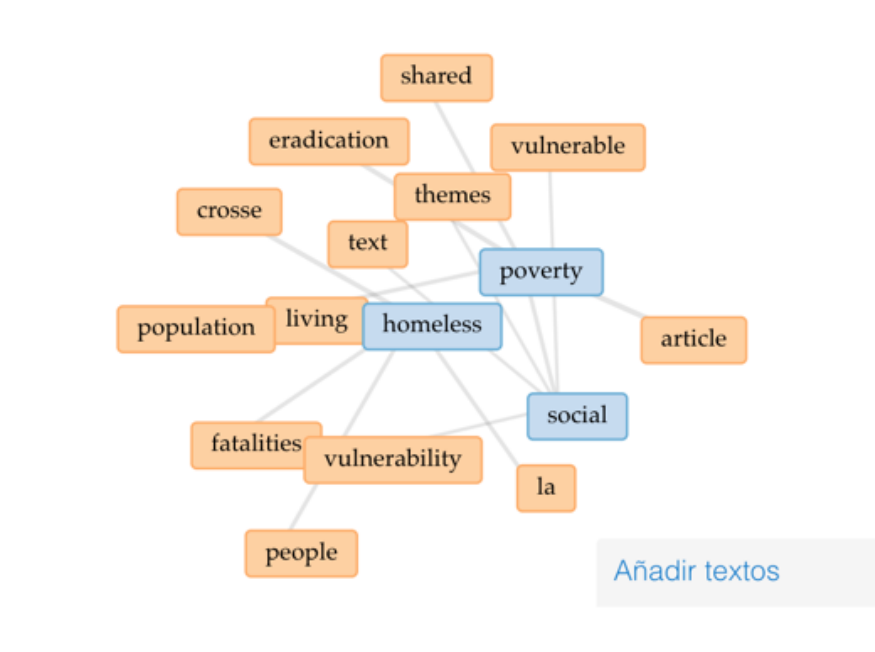
Readability Index: 12.632

Average of words per sentence: 25.9

Most frequently used words in corpus:

- poverty (30); homeless (11); social (8); drug (8)

*Image 1. Students' position while describing SDG 1.*



As can be seen in the Image 1, the most frequently used word is *poverty*, aligns logically to with the focus of the assigned SDG. Interestingly, the second



term mostly used is *homeless*, a related phenomenon that emerged organically during discussions with peers. Two other terms that appeared with notable frequency are: *social* and *drug*. The former was often used to characterise concepts, and latter, reflected students' concerns about substance abuse.

## SDG 2 – Zero Hunger - End hunger, achieve food security and improved nutrition and promote sustainable agriculture.

This corpus contains 1 document with total of 1,936 words and 615 single word form.

Vocabulary density 0.318

Readability Index: 12.397

Average of words per sentence: 26.9

Most frequently words in corpus:

- poverty (31); food (21); hunger (18)

*Image 2. Students' perception on SDG 2.*



Image 2 shows how again *poverty* is the most frequently used concept, followed by apprehension about *food*, and *hunger*.

## SDG 6 – Clean water and sanitation - Ensure availability and sustainable management of water and sanitation for all.

The corpus contains 1 document with total of 1,631 words and 514 single word form.

Vocabulary density 0.315

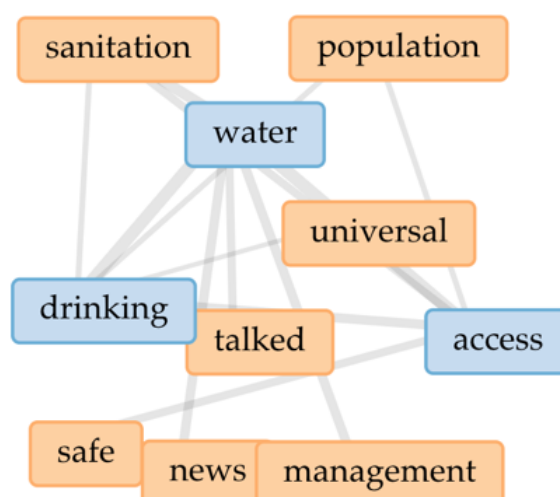
Readability Index: 14.283

Average of words per sentence: 28.1

Most frequently words in corpus:

- water (59); access (18); drinking (14); sustainable (13); sanitation (13)

*Image 3. Students' perception on SDG 6.*



Unsurprisingly, the word *water* appears most frequently when describing SDG 6, what is more notable is that the term was the most repeated overall, for 59 times. The second one is *access*, mostly used in a phrase with *water*. Then, almost with the same frequency *drinking*, *sustainable* and *sanitation* are appearing.

## SDG 7 – Clean water and sanitation - Ensure access to affordable reliable sustainable and modern energy for all.

This corpus contains 1 document with total of 1,751 words and 556 single word form.

Vocabulary density 0.318

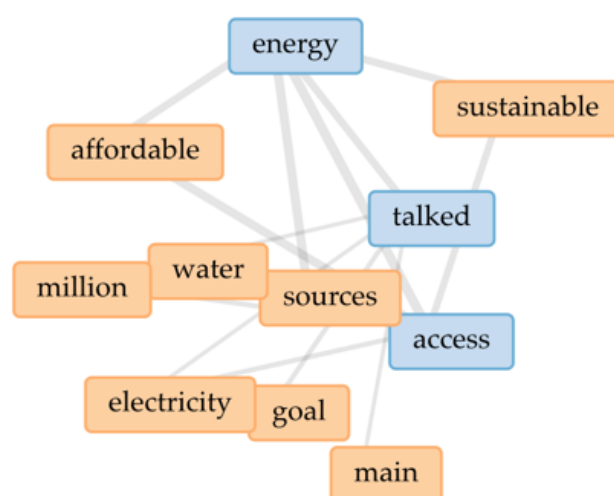
Readability Index: 14.832

Average of words per sentence: 28.7

Most frequently words in corpus:

- energy (45); access (19); water (12); mining (12)

*Image 4. Students' position about SDG 7.*



The term *energy* appeared most frequently across the text, reflecting the central theme of the SDG. It is worth mentioning that *access* is mentioned again in this SDG as well as in SDG 6, *water* and *mining* were mentioned with the same frequency, though *water* remained prominent term across multiple SDGs. This recurring focus suggests that students perceive it as particularly urgent or alarming issue.

**SDG 8 – Decent work and economic growth – Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.**

This corpus contains 1 document with total of 1,953 words and 685 single word form.

Vocabulary density 0.351

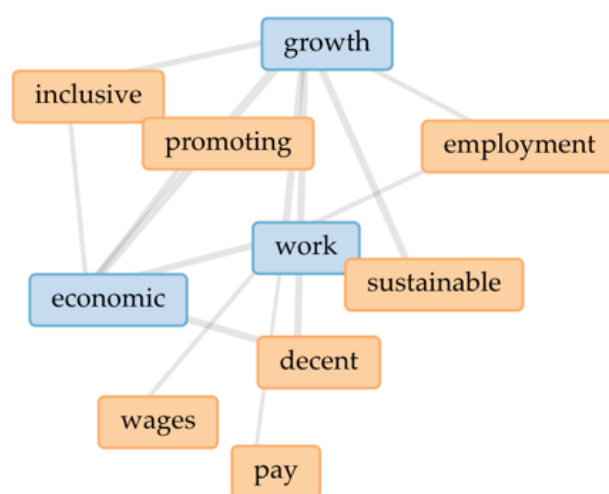
Readability Index: 14.206

Average of words per sentence: 26.8

Most frequently words in corpus:

- economic (21); work (15); growth (15); sustainable (14)

**Image 5.** Students' position about SDG 8.



As seen in image 5, *economic* was the most frequently employed word, followed almost with the same incidence by *work*, *growth* and *sustainable*.

**SDG 9 – Industry, Innovation and Infrastructure – Build resilient infrastructure, promote sustainable industrialization and encourage innovation.**

This corpus contains 1 document with total of 1,266 words and 505 single word form.

Vocabulary density 0.399

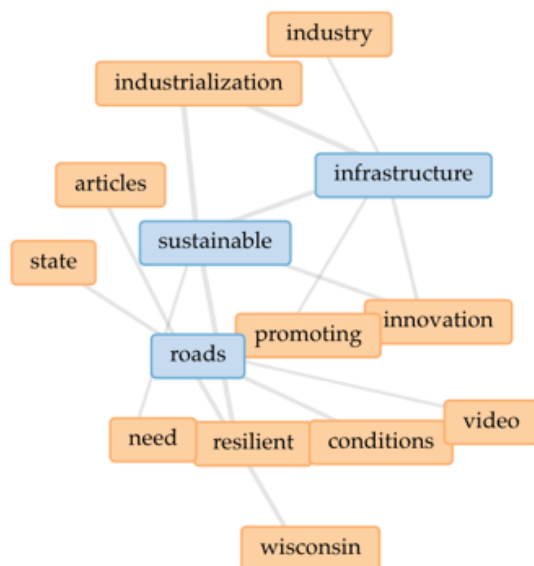
Readability Index: 14.014

Average of words per sentence: 27.5

Most frequently words in corpus:

- roads (24); infrastructure (13); sustainable (10)

**Image 6.** Students' perception of SDG 9.



In the last SDG that is analysed in the present research framework, *roads* was the most made use of, followed by *infrastructure* and *sustainable*.

**Image 7.** Students' insights on SL experience.

|                                                        |
|--------------------------------------------------------|
| En 3 palabras describa su experiencia de ApS.          |
| 13 respuestas                                          |
| Concienciación, educación, cultura                     |
| impresionante, solidario, desarrollo                   |
| Immersivo, informativo, educativo                      |
| empatía social y aprendizaje                           |
| enriquecedora, reflexiva y muy significativa           |
| Significativa - Gratificante - Comunitaria             |
| Agradable , compromiso, cooperación                    |
| Fue enriquecedora, interesante, y de mucho aprendizaje |
| Empatía, conciencia social, local                      |

Withal, in discission about SL, the following can be mentioned.

At the end of the course, students were asked to fill a short anonymous survey in, showing their insight on overall experience, whose results in Spanish can be seen in Image 7.

In image 7 are shown the outcomes of the survey in which students announced about their experience. The list of words mentioned in order of the frequency is the following:

- Related to level of impact: 9 (impresionante; enriquecedora; muy significativa; muy significativa; gratificante; agradable; interesante;) 2-5-5-6-6-7-8-8
- Related to education: 4 (educación, educativo, aprendizaje; de mucho aprendizaje)1-3-4-8
- Related to cooperation: 3 (solidario; comunitaria; cooperación)2-6-7
- Consciousness: 3 (concienciación; reflexivo; conciencia social) 1-5-9
- Empathy: 2 (empatía; empatía social) 4-9
- Culture: 1(cultura) 1
- Development: 1 (desarrollo)
- Engagement: 1 (compromiso) 7
- Informative: 1 (informativo) 3
- Local: 1(local) 9

26 concepts in total

## Conclusions

While it is in a university interest to achieve social transformation in their community as well as to interconnect with the society through cooperation and dialogue, attachment to Global Citizenship Education through understanding of Laudato Sí, Pope Francis' encyclical, published in May 2015, can be of high practicability, as it explains the relevance of the following topics: Response to the Cry of the Earth, Response to the Cry of the Poor, Ecological Economy, Adoption of Sustainable Lifestyles, Ecological Education, Ecological Spirituality, possible only in common participation, resilience and community empowerment.

The outcomes of the present research uncovered that students developed acknowledgement of global affairs and global awareness through their engagement with SDGs. Discourse analysis of COIL evaluation responses indicate that the topics are of students' interest across cultural contexts. Collaborative exchanges with foreign peers deepened students' understanding of the SDGs and encouraged to consider their global implications.

Regarding Service-Learning, textual analysis of students' reflections showed no use of negative term, and only a minimal neutral language was present, which reveals overall positive perception of the methodology and its impact on personal and civic maturation.

After carrying out the study, it is inferred that the research question whether undergoing an experience of COIL with foreign university peers alongside with Service-Learning methodology in a local vulnerable community has impact on university students was answered positively. And the hypothesis, which states that Active Learning Methodologies such as COIL and Service-Learning application in the same group of students within a subject is beneficial for university students' global citizenship values consciousness, was proven.

Global Citizenship Education can be effectively constructed through a comprehensive program, supported by targeted methodologies, strategies and activities. Such a program enhances global awareness, fosters global understanding (global awareness with local responsibility), strengthens ethical social responsibility, boosts global competencies and expands respect to others, preparing students to act as informed and passionate agents of change.

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# Effects of dropout in higher education: a prospective study from a systemic approach in the case of Colombia

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## Introduction

Student dropout in higher education is a multidimensional phenomenon that compromises both the equity of the educational system and the institutional sustainability of Higher Education Institutions (HEIs) in Colombia. Traditionally, this phenomenon has been approached from a student-centered perspective, focusing analyses on individual, social, economic, or academic causes (McCubbin, 2003; Ministerio de Educación Nacional, 2015). However, this view has created an analytical gap regarding the effects that dropout produces on institutions, particularly in their core functions of teaching and research (Barragán & Guzmán, 2022).

The implications of dropout go beyond the personal sphere of the student, directly affecting the structural functioning of HEIs, their financial planning, faculty, and scientific and technological capacities. In Colombia, cohort dropout rates have remained around 9.83% for public universities and 8.38% for private ones between 2016 and 2020 (Asociación Colombiana de Universidades, 2022). The Education Economics Laboratory (LEE) at Pontificia Universidad Javeriana (2024) indicated that the increase in higher education enrollment reflects the result of policies aimed at expanding access; however, this rise contrasts with a decrease in the number of graduates in 2023 compared to the previous year. This situation, alongside enrollment growth, suggests a potential increase in dropout rates or inter-semester absenteeism, which limits the benefits of expanded access to higher education in the country (Pontificia Universidad Javeriana, 2024, p. 12). The above highlights a persistent challenge for the higher education system, which must face this phenomenon amid deep social, economic, and territorial inequalities (Herbaut & Geven, 2020).

From an institutional perspective, dropout jeopardizes the financial

sustainability of HEIs, particularly those whose operations depend primarily on tuition revenues. The loss of students leads to a contraction in income, which impacts faculty hiring and training, research program development, and the academic positioning of the institution (Bisschoff & Asvat, 2019). This deterioration also affects university outreach, understood as the social projection supported by teaching and scientific capacities (Cosenz, 2022).

At the operational level, the effects of dropout are reflected in a reduction of the teaching staff and an increase in workload for those who remain in the institution, creating tensions in time allocation between teaching and research activities (Barragán & Guzmán, 2022; Barragán, 2020). This not only reduces academic productivity, as measured by indicators such as articles accepted in indexed databases (SCOPUS, WoS), but also impacts the perceived institutional quality and the capacity to retain students, affecting institutional sustainability, image, and finances (Aznar-Díaz *et al.*, 2025; Amado *et al.*, 2023; Barragán & Guzmán, 2022).

Despite the severity of this issue, existing studies have rarely analyzed the systemic effects of dropout from the perspective of HEIs as complex organizations. The bulk of the literature has favored descriptive approaches focused on the individual determinants of dropout, relegating the analysis of its organizational impacts to a secondary dimension (Camacho *et al.*, 2016). This omission limits the design of comprehensive and effective public policies that take into account the institutional consequences of student dropout.

This study seeks to fill that gap through a systemic approach. Its objective was to simulate the effects of dropout on the development of teaching and research missions within Colombian HEIs. To this end, System Dynamics was used as a methodology, which is particularly useful for representing nonlinear phenomena with feedback structures and time delays (Bala *et al.*, 2017; Forrester, 1961), as found in educational systems. This methodology has proven effective in modeling complex educational scenarios and formulating more adaptive, evidence-based public policies. The proposed simulation model considers a six-year time horizon (until 2031) and was parameterized with official data from the Colombian Ministry of National Education (SNIES and SPADIES) and the Ministry of Science, Technology, and Innovation. Based on these data, contrasting scenarios were formulated to observe system behavior in the presence and absence of public policies for access, retention, and timely graduation.

This chapter is structured into four sections. First, the conceptual and theoretical framework is presented, where the key concepts of the study are

operationally defined: student dropout, core functions of HEIs, relevant public policies, and System Dynamics. Second, the methodology is described, outlining the structure and phases of the simulation model. Third, the results section presents the simulated scenarios and main findings. Finally, the chapter concludes with reflections and future research directions, emphasizing the usefulness of the systemic approach for institutional management in higher education.

## Conceptual and contextual framework

Student dropout in higher education has historically been conceptualized as a phenomenon centered on the individual's experience. In the Colombian context, the Ministry of National Education (MEN) defined dropout as the voluntary or forced abandonment by the student for two or more consecutive academic periods (MEN, 2015). This definition has served operational and comparative purposes but does not fully capture the complexity of the phenomenon. In this regard, the ALFA GUIA Project proposed a deeper and more systemic understanding, viewing dropout as a complex, multidimensional, relational, and dynamic event that can be interpreted both as a cause and an effect, a personal choice or a forced response (Proyecto ALFA GUIA, 2013). This approach aligns with the proposal by Barragán and González (2024), who addressed dropout as a highly complex phenomenon that must be analyzed on multiple levels: individual, institutional, and social. Likewise, the definition from the ALFA GUIA Project is consistent with the findings of Guzmán and Barragán (2022), who demonstrated how student dropout negatively impacts the core functions of HEIs, leading to a deterioration in their teaching, research, and outreach capacities.

In Colombia, HEIs are legally defined as organizations that carry out functions of teaching, research, and social outreach, with the purpose of contributing to the country's economic, social, cultural, and environmental development (Congress of Colombia, 1992). According to Cosenz (2022), these functions are interdependent and must be managed systemically to ensure institutional sustainability. Specifically, teaching aims to develop students' capacities and competencies; research seeks to generate new knowledge; and social outreach extends the benefits of both to the wider community. From this perspective, student dropout has both direct and indirect effects on all three functions, as it reduces the demand for educational services, limits faculty hiring, affects academic planning, and decreases the financial base needed to support research groups and outreach programs (Guzmán & Barragán, 2022).

Educational public policies in Colombia have aimed to expand access and

improve retention in higher education, especially among vulnerable populations. These policies include funding programs (such as *Ser Pilo Paga* and *Generación E*), systems for monitoring student trajectories (SPADIES), and institutional guidelines like the Management Model for Retention and Timely Graduation (MEN, 2015). However, in the context of rural education revealed that the implementation of these policies shows structural limitations, especially in peripheral areas where social and territorial inequalities restrict the effectiveness of such interventions. In the absence of comprehensive policies, HEIs face challenges in retaining students, which affects their operational sustainability. Therefore, this study proposes to simulate scenarios with and without public policies to understand their impact on institutional development.

From an institutional perspective, HEIs must be understood as complex systems composed of interdependent subsystems that respond to both internal and external changes. In this context, dropout is not merely a loss in enrollment but a trigger that disrupts organizational balance. Recent studies highlight that when the number of students decreases, so do the operating revenues of institutions, particularly where government transfers fail to compensate for the drop in tuition income (Tilley, 2025). This decline in resources forces universities to reduce their teaching staff, which in turn increases the workload for remaining faculty. Therefore, the time available for developing research projects becomes limited, directly affecting the institution's capacity to generate knowledge and maintain academic quality standards (Barragán & Guzmán, 2022).

This research adopted System Dynamics as its primary methodological approach. This decision responded to the need to represent the complex, feedback-driven, and non-linear nature of the student dropout phenomenon, which cannot be adequately explained through traditional statistical methods (Cosenz, 2022; Forrester, 1961). System Dynamics enables the construction of causal models and computational simulations to understand how dropout cumulatively affects institutional capacities, particularly when comparing scenarios with and without public policies on access, retention, and timely graduation. This methodology has been successfully applied in previous studies to model complex educational phenomena such as academic productivity (Barragán & Guzmán, 2022), dropout in rural areas, and institutional sustainability (Barragán & Guzmán, 2022).

## General model design

According to Aracil & Gordillo (1997), Bianchi (2026), and Bala *et al.* (2017), the overall model design included five methodological phases that allowed for the representation and simulation of the system's dynamics:

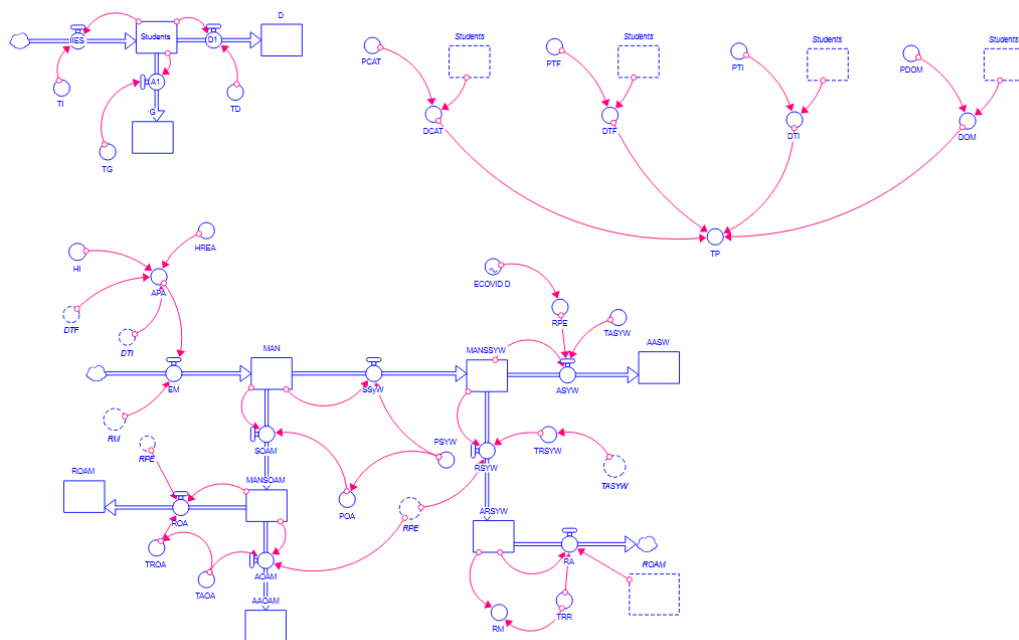
1. Design of causal loop diagrams representing the feedback structure of the system. These diagrams identified key linkages between student dropout, faculty workload, investment in research, and academic productivity. Both reinforcing and balancing loops were mapped.
2. Construction of subsystems: From the generic model, differentiated subsystems and a consolidated system were developed. These subsystems were modeled using Forrester diagrams (stock and flow diagrams), allowing for the dynamic behavior of the system to be represented over time.
3. Model parameterization: Each subsystem and the complete system were parameterized using real data provided by Colombia's Ministry of Science, Technology and Innovation (Minciencias) and the Ministry of National Education. This information included academic production rates, investment levels, retention indicators, and the gender composition of the research workforce.
4. Verification of structure and behavior: Logical and empirical consistency of the model was verified through sensitivity tests, internal coherence analyses, and contrasts with previous studies. The simulated system's evolution was validated by its replication of patterns observed in institutional reality, such as decreased productivity under high dropout and low faculty investment scenarios.
5. Scenario simulation: Finally, different six-year scenarios were simulated to assess the impact of various combinations of public policies and dropout rates. The simulation acted as a computational laboratory for analyzing cumulative and long-term effects on the core functions of teaching and research. The simulations generated evidence on the differential impact of public policies and highlighted the need for strategic interventions in critical contexts.

Two contrasting scenarios were simulated. Scenario 1 represented institutional behavior in a context where there are no structured programs for student support, financing, or monitoring of academic trajectories. In this case, the dropout rate remains constant. Scenario 2 incorporated mechanisms such as scholarships, early warning systems, academic tutoring, digital connectivity, and faculty strengthening. In this scenario, progressive reductions in dropout rates were simulated.

The analysis of results was carried out through a comparative interpretation of the simulations generated for the two contrasting scenarios over a six-year time horizon. First, dynamic changes in stocks and flows were evaluated. This involved examining temporal trajectories within each subsystem of the model (teaching and research), identifying inflection points, decreasing or sustained trends, and predominant causal relationships among the variables.

The constructed model (Figure 1) consisted of a total of 46 variables, encompassing all the necessary elements to represent the dynamic structure of the system. A total of 10 stocks were defined, representing key accumulators such as the number of active students, available faculty, or consolidated scientific production. These stocks were increased or decreased through 11 flows, which regulated inputs and outputs such as admission, dropout, and graduation rates, as well as changes in faculty hiring.

**Figure 1.** Stock and flow diagram.



Additionally, 25 converters were included to transform signals or values

between variables, allowing for the adjustment of causal relationships and the modeling of nonlinear behaviors. The model also included 13 constants, which set fixed parameters during the simulation, such as baseline dropout rates, faculty workload coefficients, or investment levels. In total, 23 equations were formulated to describe the mathematical relationships between variables, integrating empirical data and validated theoretical assumptions. Finally, 5 macro-variables were used as control parameters to activate or deactivate public policies, modify external conditions, or introduce structural changes to the model.

The behavior observed in the model (Figure 2) shows a sustained downward trend in the student population ("Students") and total professors ("TP") from 2019 to 2031. This progressive decrease in students—from about 3 million to fewer than 2 million—reflects a pattern of cumulative dropout that directly undermines the operating income of Higher Education Institutions (HEIs). In parallel, the reduction in the number of faculty suggests budget cuts and an institutional inability to maintain the teaching workforce in the face of declining enrollment, which negatively impacts teaching capacity and academic development.

The consequences of this deterioration are reflected in academic output variables. For example, the number of articles accepted in SCOPUS and WoS ("ASYW") shows initial growth until approximately 2023, resulting from the momentum of earlier research efforts. However, from that point onward, scientific productivity declines and then stabilizes at a lower level. This curve indicates that the reduction of faculty and resources begins to impact high-level research, affecting the international visibility of HEIs and weakening their academic standing. Similarly, articles accepted in other databases ("ROA") exhibit oscillating behavior, peaking around 2022–2023 followed by a series of fluctuations. This suggests that, in the face of diminishing formal capacities (such as access to research groups or institutional support), institutions attempt to maintain output through alternative channels or lower-impact publications, which may lead to a gradual decline in academic quality.

In contrast to the previous scenario, here we observe progressive growth in the student population ("Students"), rising from just over 2 million in 2019 to more than 3.5 million in 2031. This trend reflects the positive effect of public policies and institutional actions aimed at student retention, reducing the annual dropout rate to 5%. Containing dropouts, without increasing the admission rate, enables a stable accumulation of active enrollment, ensuring sustainable revenue for HEIs. Consequently, the total number of professors ("TP") also increases, reaching 800,000 by 2031. This growth not only responds to the



need to serve an expanding student population but also reflects greater institutional capacity to hire, retain, and train faculty, thereby strengthening the core function of teaching. In the research domain, the impact is equally significant. Articles accepted in SCOPUS and WOS ("ASYW") experience accelerated growth until 2023, followed by slight stabilization and then sustained upward momentum. This curve suggests that reducing dropouts fosters favorable conditions for quality research. Likewise, articles accepted in other databases ("ROA") follow a similar trajectory, with peaks indicating periods of higher productivity and stabilization around 2,500 to 3,000 articles, demonstrating the consolidation of research capacity at various levels.

**Figure 2.** System behavior – Scenario 1.

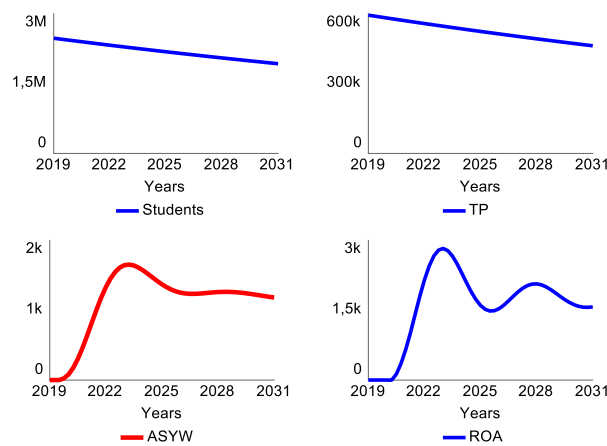
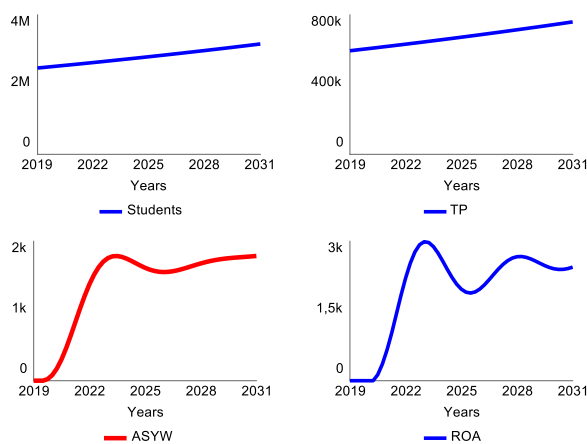


**Figure 3.** System behavior – Scenario 2.



## Conclusions

The results obtained confirm that student dropout in higher education is a structural phenomenon with cumulative effects that go beyond the individual level and deeply compromise the institutional sustainability of HEIs. In the

absence of effective public policies, a trajectory of progressive system deterioration becomes evident: the sustained decline in the number of students leads to a contraction in revenues, which negatively affects faculty staffing and limits research capacity, directly impacting the core functions of teaching and research. This negative feedback dynamic results in a loss of academic productivity, lower perceived quality among students, and increasing difficulty in maintaining institutional standards—particularly in contexts where government transfers fail to offset the decline in tuition revenue.

In contrast, the simulated scenario with strategic interventions demonstrates that it is possible to reverse this trend through coordinated policies on access, retention, and institutional strengthening. The progressive reduction in dropout—without the need to increase admission rates—enables the consolidation of a stable student base, the expansion of the teaching workforce, and significant improvements in scientific output, both in indexed journals and other academic sources. These conditions create a virtuous cycle of academic, financial, and operational sustainability. Consequently, the systemic approach adopted in this study not only makes it possible to visualize the interdependent impact of critical variables but also provides a useful tool for decision-making and the formulation of public policies aimed at achieving long-term institutional balance for Colombian HEIs.

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# Theoretical and Practical Reflections from a University Learning Community: Strategies for Curriculum Internationalization

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## Introduction

The internationalization of the curriculum (IoC) in higher education is understood as the process of systematically integrating an international, intercultural, and/or global dimension into the content, methodologies, learning outcomes, and assessment of academic programs within a university institution, thereby improving the quality and relevance of education. This practice has consolidated itself as a key strategy for training professionals capable of acting effectively and facing the challenges of an increasingly complex, diverse, and interconnected world. Leask (2009, p.209) defines it as "the incorporation of an international and intercultural dimension into the content of the curriculum as well as teaching and learning arrangements and support services of a program of study."

In recent years, this has been driven by factors such as the globalization of knowledge, the advancement of digital technologies, and the need to train citizens committed to sustainable development. Thus, strategies such as the development of intercultural competencies, inclusion of multiple perspectives in disciplinary content, and physical and virtual mobility have been consolidated. Among these, internationalized learning experiences without the need for physical mobility stand out, such as mirror classes, virtual mobility, and collaborative online international learning (COIL), which provide access to global education.

In Latin America, this process acquires particular characteristics, framed by its cultural diversity, structural inequalities, and the need to respond to local challenges. From a critical perspective, it is proposed that IoC should not only be a mechanism for academic competitiveness but also a tool for inclusion, equity, critical thinking, and global citizenship. This perspective demands a reflection on predominant Eurocentric models, integrating territorial knowledge, contextual practices, and intercultural approaches that recognize the richness and complexity of the region.

The health emergency caused by the COVID-19 crisis accelerated the digital transformation of higher education, positioning virtual international

collaboration experiences as an effective way to foster internationalization at home and strengthen institutional capacities (Pozo et al., 2024). These strategies have contributed to the development of communicative, digital, and intercultural competencies in teachers and students, as well as a greater understanding of professional practice in diverse contexts (Ballesteros-Sola & Magomedova, 2023, 12; Mota et al., 2025, 6).

In parallel, approaches advocating for critical internationalization emerge, anchored in transdisciplinary education and research processes, which integrate diverse knowledge and actors into learning communities aimed at solving socio-ecological challenges. From this perspective, mutual learning, the facilitating role of the teacher, and ethical-affective care that supports the co-creation of knowledge and the cultivation of common ground are promoted (Merçon, 2021).

The present study aims to document and analyse the experience of an interdisciplinary university Learning Community at the Universidad Católica de Temuco (UC Temuco), oriented to promote IoC from a glocal perspective. This experience, which articulates strategies such as COIL, mirror classes, and collaborative teacher reflection, is presented as a replicable proposal for other higher education institutions seeking to advance towards a meaningful internationalization.

### **Institutional context of internationalization at UC Temuco**

In Chile, the regulatory framework for higher education recognizes the relevance of international collaboration in knowledge generation (Higher Education Law, N°21091, 2024). Article 2 establishes that the system must ensure regional and international integration through academic exchange networks and scientific collaboration. Aside from this mention, no other reference is made to the internationalization component (Asociación Mexicana Para la Educación Internacional (AMPEI) & Chiappa, 2022).

At UC Temuco, internationalization is understood as a transversal process that integrates an international, inter-epistemic, intercultural, and global dimension into its teaching, research, and community engagement functions. This understanding of internationalization translates into five strategic axes that guide its implementation: (1) institutional internationalization, (2) internationalization of teaching, (3) internationalization of research, (4) academic mobility, and (5) internationalization for society. These axes are aligned with the educational model and the institutional development plan (PDI) 2030, positioning internationalization as a pillar of university work (Universidad Católica de Temuco, 2021a). As such, concrete actions have been

promoted in the curriculum, fostering virtual collaborative experiences, and participation in strategic alliances. However, significant challenges remain, including overcoming language barriers and consolidating an institutional culture open to the internationalization process.

### **Learning Community: theoretical foundation and practical relevance**

Learning Communities, according to Cox (2011), are self-managed collectives that enhance student learning through quality teaching, sustained by situated knowledge and critical reflection. In this sense, the aim is to develop a culture of collaborative work, assuming that knowledge is situated in the day-to-day lived experiences of teachers and that these are better understood through critical reflection (Buysse et al., 2003, 263-277). At UC Temuco, these communities are guided by four objectives: to identify training needs linked to the graduate profile, to implement methodological and evaluative innovations, to generate transferable pedagogical knowledge, and to strengthen teacher development from a participatory and dialogical approach.

In this context, the Internationalization of the Curriculum (IoC) is closely linked to the work of these communities, promoting student-centred teaching and interaction with diverse cultural contexts. The "Internationalization of Curriculum" Learning Community brings together academics from different disciplines who work collaboratively to integrate international, inter-epistemic, and intercultural dimensions into teaching and research. Through strategies such as: COIL, mirror classes, masterclasses and academic mobility; communication and critical thinking are enhanced, enriching the glocal environment of university education.

### **Design and implementation of the IoC Learning Community**

The IoC Learning Community was formed in the year 2023 by 4 faculty members participating in the Internationalization Advisory Council (CAI), with support from CINAP, the Office of Internationalization and a curricular advisor. Its main objective is to foster interculturality in undergraduate students at Universidad Católica de Temuco through methodologies and internationalization strategies that contribute to the formation of global citizens. It seeks to strengthen competencies that contribute to knowledge and interculturality through COIL or mirror classes, support institutional internationalization actions to improve retention, pass, and satisfaction rates in the courses associated with IoC in Design, Geological Civil Engineering, Public Administration, and Kinesiology Careers programs.

For this purpose, five milestones were defined that guide its planning: constitution of the community, identification of generic competencies that contribute to the knowledge and practice of interculturality, implementation of COIL projects, connection with external peers and dissemination of results, with annual monitoring through reports to the General Directorate of Teaching. (Figure 1).

**Table 1.** *Planning of Learning Community milestones, activities and products for three years. (Source: Prepared by the authors, 2023)*

| Milestone                                                                                                                                                                                                            | Activity                                                                                                                                                                                             | Evidence                                                                                                                                                                                                                                         |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| I. Establishment of Learning Community loC                                                                                                                                                                           | 1. Weekly work meeting                                                                                                                                                                               | a) Meeting Minutes<br>b) Conformation Resolution of Learning Community loC                                                                                                                                                                       |
| II. Identify the generic or disciplinary competencies that contribute to the knowledge and practice of interculturality in fields of Design, Civil & Geological Engineering, Public Administration, and Kinesiology. | 1. Review Learning Guides and courses in which internationalization strategies will be implemented.<br>2. Update Learning Guides.                                                                    | a) Course report with learning guides based on an internationalization strategy.<br>b) Updated Learning Guides with COIL strategy.                                                                                                               |
| III. Implementation of COIL projects during the academic year                                                                                                                                                        | 1. Identify courses that could implement COIL strategy in professors members of the Learning Community loC's academic departments.                                                                   | a) Course executed with COIL methodology.<br>b) Student perception surveys.<br>c) ODUCOIL Platform records.                                                                                                                                      |
| IV. Linking with national or foreign collaborating peers who participate in the learning community                                                                                                                   | 1. Integrate a foreign collaborating pair into the community's internationalization actions.                                                                                                         | a) Meeting Minutes<br>b) Collaboration agreement.                                                                                                                                                                                                |
| V. Communicate academic experiences on loC                                                                                                                                                                           | 1. Dissemination of internationalization experiences of the learning community.<br>2. Manage virtual space for disseminating community experience.<br>3. Innovation project in Teaching formulation. | a) Digital materials for dissemination.<br>b) Activities registered on the institutional platform.<br>c) Evaluation of dissemination activities.<br>d) Published academic article.<br>e) Web portal.<br>f) Institutional project form completed. |

The first actions of the Learning Community were aligned with Institutional Internationalization Policy's strategic pillars and with PDI 2030's second strategic pillar in areas of interculturality, sustainability, and internationalization. In coherence with these guidelines, practices such as COIL, mirror classes, and virtual exchange were integrated, responding to the rise of these strategies during the pandemic. The participating faculty members incorporated actively these methodologies into teaching, promoting diverse, collaborative, and culturally contextualized educational experiences. The work within the community encouraged loC in four undergraduate programs, through activities of student and academic mobility, peer collaboration, development of intercultural competencies in connected learning environments, and peer training by sharing experiences, among other activities. Below, the most relevant findings from two case studies are presented: Design and Kinesiology.



## **Case 1: Faculty of Architecture, Arts and Design – Design Program**

The conviction that creative learning must occur through practice and experimentation is one of the central pillars of the identity and educational model of the Faculty of Architecture, Art and Design (FAAD). Since 2018, an annual interdisciplinary workshop open to the university community has been established with national and international experts. This instance, using the project-based teaching methodology, is characterized by fostering creativity through the interaction between a creative dimension and a rational one, understanding the latter as a systematic and sequential operation; and the former as a-systematic and a-sequential, that is, simply opposite (Simian-Fernandez et al., 2025, 426). During the pandemic, the Workshop was carried out virtually, implementing an incipient COIL methodology, which allowed the continuation with international actors in this modality at low cost and with successful results.

Subsequently, the program consolidated strategic links with the Pontifical Catholic University of Ecuador, systematically developing conferences and Masterclasses' within the course "Universal Design." As a result of this relationship, a joint article has recently been submitted to Communication and Applied Technologies: Proceedings of ICOMTA 2025.

In addition, the implementation of an international internship is highlighted, in collaboration with the School of Visual Arts in NYC (SVA); initiated in 2023 and formalized through an institutional framework agreement. This formative experience has benefited students and faculty, strengthening glocal competencies, although it has also revealed economic barriers that limit student participation. In response, the academic unit has begun to seek external funding to democratize access to this form of in-person International Internships.

## **Case 2: Faculty of Health Sciences – Kinesiology Program**

Since the year 2023, the implementation of the COIL model has shown a process of consolidation and diversification in the Kinesiology program. During the first semester of that year, an international collaborative experience was carried out with the Physiotherapy program of Universidad La Salle (Brazil), which posed a significant challenge in terms of language mediation. To facilitate effective communication between the participating students and faculty, various technological tools for simultaneous translation and automatic subtitling were incorporated, which not only favoured intercultural understanding but also strengthened the digital and communicative

competencies of those involved. In the second semester, an interprofessional project was developed that integrated students and faculty from Nursing at the Universidad de Aysén (Chile) and Physiotherapy at the Universidad Autónoma de Manizales (Colombia). This latter experience was supported by the Teaching Innovation Fund (FID, code URY 20992), which allowed not only to enhance its curricular development but also its research and formative projection. In 2024, the COIL collaboration with the Nutrition program of the Universidad Católica de La Plata (Argentina) deepened the training line in the promotion of cardiorespiratory health, also favouring the dissemination of results in international scientific events. In addition to the above, in two years this learning community has accomplished: 1 internal project awarded with an international peer, 1 national collaborative project, 1 framework agreement with SVA, 4 book chapters published, 2 presentations in symposia, 5 presentations in congresses, 2 works presented in UCT teaching conferences, 7 COILs executed, 2 Masterclasses' conducted, and 2 faculty members with annual participation in CAI.

## Identified obstacles and challenges

Although the experiences developed within the framework of the learning community have shown significant advances in IoC, its implementation has not been free of challenges. Based on the analysis of the cases and reflections of the participating faculty, obstacles were identified that can be grouped into three dimensions: pedagogical, institutional, and structural.

**Pedagogical challenges:** One of the challenges observed lies in the resistance to methodological change by some faculty members. The incorporation of strategies such as COIL or mirror classes requires a redesign of the teaching role, curricular planning, and evaluation methods. Additionally, abandoning traditional practices and assuming a collaborative and intercultural stance. Another aspect has been the integration of technological tools. Although digital platforms, simultaneous translation, and audio visual resources were used, sufficient time was required to acquire the necessary digital competencies, demanding processes of self-training, peer collaboration, and institutional technical support, which were not always systematic at the beginning.

**Institutional challenges:** A certain fragmentation was evidenced in the implementation of internationalization experiences. Many initiatives arose from the motivation and commitment of individual faculty members, without necessarily being articulated within a formal curriculum improvement plan or clear incentives from the respective administration or institution, which limits

their sustainability and scaling of actions over time. On the other hand, the evaluation of the impact of the experiences is vital to analyse the development of intercultural, communicative, and professional competencies in students.

**Structural challenges:** Among the aspects to consider, difficulties stand out such as the synchronization of academic calendars between collaborating institutions, time differences that affect the scheduling of synchronous meetings, and the existence of technological asymmetries among participating institutions, such as the type and speed of internet they have, having an adequate platform/space for interaction, and the digital resources to be used.

Finally, in culturally diverse contexts such as those in Latin America, the challenge arises to overcome Eurocentric models and incorporate territorial approaches that engage with the local realities of the territory, which implies not only adapting content and methodologies but also recognizing the habitual practices of the contexts. As a discussion, it is proposed that, the internationalization of the curriculum can take multiple forms and when articulated from a situated, critical, and collaborative perspective, it can become a powerful pedagogical strategy to promote inclusive and relevant higher education aligned with contemporary challenges. Likewise, those strategies that have demonstrated greater effectiveness share principles that promote meaningful learning, encourage intercultural dialogue, adapt to the institutional context, and align with the formative objectives of each program. Below, some of the most successful strategies are described, both in the literature and in the institutional practice of UC Temuco:

Collaborative online international learning has positioned itself as a transformative and effective strategy. It allows for the creation of meaningful intercultural experiences, favouring the development of key competencies such as intercultural communication, critical thinking, and collaborative work. The results of its implementation with health sciences students, as evidenced in an experience between universities in Chile and Argentina, demonstrate advances in cognitive, behavioural, affective, and professional dimensions of intercultural competencies. This approach strengthens the training of professionals prepared to perform in diverse sociocultural contexts, while allowing higher education institutions to integrate inclusion and territorial relevance in their formative processes (Hunter, 2023).

Participation in exchange programs, both in face-to-face and virtual modalities, remains a key strategy. At the virtual level, access to international experiences is

democratized; while face-to-face participation allows for deep immersion in diverse sociocultural contexts. Both modalities strengthen language competencies, autonomy, adaptability, and intercultural communication skills (Universidad Católica de Temuco, 2025). The Internationalization of Curriculum (IoC) at UC Temuco emerges as a key driver to promote and sustain curriculum internationalization processes where a culture of collaborative work and critical reflection is encouraged. The learning community fosters interdisciplinary and inter-epistemic dialogue, generating innovative pedagogical practices where new forms of communication and collaboration had to be integrated, opening up to new technologies and digital tools that articulate global knowledge with local realities. Additionally, by focusing on professional teaching development, communities enhance the critical appropriation of tools such as COIL, mirror classes, or masterclasses, giving these strategies a contextualized and transformative meaning within multiculturalism. In this sense, they act as articulating nodes between institutional policies, disciplinary knowledge, and sociocultural challenges, enabling a more coherent and meaningful implementation of internationalization. Therefore, this community is recognized not only as a continuous training environment but also as a key agent for institutionalizing and transversalizing internationalization, fostering inclusive, ethical, and common-good oriented practices (Gómez and Torres-Hoyer, 2023).

## Conclusions

The analysis of the activities carried out yields preliminary results indicating that these pilot experiences demonstrate the significant impact and reach of the use of the COIL methodology, transforming teaching practices in 4 disciplines at UC Temuco. From observation, intercultural aspects also stand out, as well as the evaluation of generic competencies of collaborative work and respect and appreciation of diversity; such as: accepting, respecting, and identifying cultural differences without judging them, supporting the elimination of racism, prejudice, and discrimination, as well as total disagreement with preconceived ideas about some cultures (Simian-Fernandez et al., 2025, 432). On the other hand, it is evident that the collaborative work of faculty in a Learning Community allows going beyond the exchange of experiences to create collective meaning and sustainable pedagogical transformations. It is concluded that IoC presents an innovative response to the challenges of the university teaching and learning process, installing a culture of collaboration that transcends borders, having as a key the development of the glocal (global-local). At the same time, it is evident that the Academic Learning Community formed in this context is also a promoter of IoC at the institutional level, being a virtuous circle of action-reflection.

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# Identity construction in the first year of an early childhood education degree programme

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## Introduction

The construction of a professional identity is a dynamic and multifactorial process that incorporates individuals' personal and social life experiences for its development (Morales Escobar & Tobarda Caro, 2021; Ruvalcaba-Coyaso *et al.*, 2011). However, studies indicate that formally begins with access to higher education (Alcina Tarrés & Masardo, 2021; Canton Mayo & Tardif, 2018; Cuadra-Martínez *et al.*, 2021; Pérez Gracia *et al.*, 2022; Kelchtermans, 2005).

The personal construction of the 'professional self' progresses through at least three stages during a teacher's professional development (Garrido-González & Flores Meza, 2025; Kaddouri & Vandroz, 2008; Toledo Jofre, 2012; Olivares *et al.*, 2020):

- 1) Before entering university, people's perception of the profession is shaped by social ideology and preconceptions.
- 2) University entrance implies a gradual transition for future teachers, especially those specialising in early childhood education, from their belief system to the reality of university life. At this stage, all education specialists are expected to have the necessary pedagogical and didactic knowledge.
- 3) Professional development in the exercise of profession, establishing the

professional trajectories from this moment forward.

These three stages are based on the concept of an “identity crisis” (Erikson, 1980; Miranda Cervantes & Vargas Dengo, 2019), which is understood as a complex situation that affects professionals’ behaviour and/or responses to certain individual scenarios. Many of these identity crises begin during initial teacher education (ITE) (Casanova-Fernández *et al.*, 2022; Cantón Mayo & Tardif, 2018; Vaillant Alcalde, 2007). This arises from the clash between “the ideological personal self” and “the professional self they expect me to be”, which puts identity processes at stake (Garrido- González & Flores, 2025). In this context, “each subject decides which elements of the group are their own, which ones to adopt and which ones not, what makes them similar to the group and what makes them different” (Vanegas Ortega & Fuentealba Jara, 2019, p. 123).

The main objective of this research was to understand the perceptions of pedagogy among Early Childhood Education students at the end of their first year of academic training at a Chilean university. The specific objectives were to identify preconceptions about being an early childhood educator before starting university and to assess whether these expectations had been met by the end of the course.

### **Initial teacher training for early childhood teachers**

Starting university is an important event for everyone because it enables you to pursue your dreams and life projects (Guzmán Gómez & Serrano Sánchez, 2011; Ramírez Casas & Maturana, 2018). However, career choices are often influenced by social ideologies (Riffo-Pavón, 2022). These ideologies are formed from preconceptions about professions, which are often romanticised by personal experiences and/or the opinions of others (Buenaño de D, 2016).

When it comes to being an early childhood teacher, the profession is often visualised as being feminine. According to the Center of Studies Ministry of Education [CEM] (OECD 2021) the 99.1% of early childhood teachers in the Chilean education system are women. These women are defined by their love for all the children, romanticising a profession that “from its origins is built on maternalist speeches, associated in collective imagination of being an instinctive and natural work of women, which does not require previous professional training” (Falabella *et al.*, 2024). They are also expected to be cheerful, patient and affectionate (De la Torre, 2013).

These gendered stereotypes do not align with the reality of university life. This is because becoming a teacher of early childhood education requires



knowledge of neuro-education, psychology, pedagogy and didactics, among other subjects. These subjects are not usually part of the typical student's expectations prior to university entrance (Barnett & Nores, 2012; Falabella *et al.*, 2024). This situation can lead to one of the first identity crises during initial teacher training (Garrido-González *et al.*, 2024; Kaddouri & Vandroz, 2008; Toledo Jofre, 2012).

The university is key to overcoming this initial crisis. In some cases, this involves doubts and internal conflicts that can impact motivation and interest in one's chosen career path, which is a common cause of dropping out of higher education (Joshi, 2024; Trusty *et al.*, 2025). Additionally, "It involves both the formation of a new identity and the destruction of the old identity" (Olivares *et al.*, 2020, p.13). This process requires gradual transitions between familiar life and university life.

This study was conducted within a qualitative interpretative paradigm (Vaillant Alcalde, 2012), with the aim of "understanding the reality from the narratives, visions and meanings from the people participating in the research" (Marín-Suelves *et al.*, 2021, p. 128). The methodology employed was a single-case study. Stake (1998) describes it as "the study of the particularity and complexity of a singular case, in order to understand its activity in important circumstances" (p.11). The units of study were the narratives of forty-two students who had completed their first year of training, and the sample was selected using purposive sampling (Patton, 1990). This method was chosen because "the researcher is interested in analyzing its particularities" (Stake, 1998, p.44). The analysis was performed using inductive coding without a pre-established structure, allowing categories to emerge as the information was processed (Saldaña, 2016).

The results show a strong initial stereotype of the romanticised role of an early childhood educator, which does not align with the reality of the formative years at university. However, the first year of the career and being an early childhood educator are viewed favourably within university parameters. Nevertheless, they do not feel that curricular activities bring them closer to working with children, nor do they consider them to be very relevant, as they are centred on theory.

The analyses revealed three main categories: preconceptions about being an early childhood educator; significant individuals; and university training.

### **Preconceptions about being an early childhood educator:**

This category refers to the ideas, dreams and/or expectations that the female

students had before entering university. What future professionals have in common is their interest in children's well-being and their satisfaction when spending time with them:

*Once upon a time there was a curious and shy girl who from a very young age, dreamed of teaching. [...] she was full of dreams, seeds of love for teaching that would grow over the years (NN2)*

*I always imagined myself playing with children, in a room full of light, watching them play freely, that's what I want, to create cozy environments where children feel safe in complete comfort (NN15).*

The statement from the future professionals aligns with that of Riffo-Pavón (2022). The decision to pursue a career in early childhood education was based on preconceived notions of a profession centred on children and their care and well-being, with a strong maternalist ethos. However, this view changed over the months:

*I must admit that when I entered the career I wanted to leave in the first week, I always imagined that we would do manual work and that the courses would teach me how to work with children, but it was pure theory, in fact, the only thing we had to do was ludo. (NN4)*

*With time, some of my classmates left the career. They said that they didn't liked it or that it was not what they expected. I think they imagined that we would have other types of courses, I stayed because I entered for vocation (NN8).*

## Significant people

This category brings together personal stories that recognise the significant figures who influenced their decision to become an early childhood teacher. Most of the stories focus on teachers who trusted and valued the storytellers, as well as family members who work in educational environments.

*In middle school, I remember my teacher Judith with love, she said she trusted me, listened to me and explained the subject with great patience, that is what I want to do (NN21)*

*I come from a family of teachers that makes me proud. I will be the first kindergarten teacher [...] teaching is in our veins (NN32).*

Among the stories alluded to in this category, it was decided to include those where the students explicitly stated that the decision to enter the career came

from their family, especially their mother:

*I always liked children very much, I felt comfortable with them, and everyone saw how they followed me, so my mother told me that I could be a kindergarten teacher and here I am. (NN17)*

*My mother told me since I was little that I should study kindergarten education, because when she studied at the university, she saw that they were the prettiest ones, skinny, long hair on a ponytail [...] she believed that those were also my personal characteristics. (NN27)*

According to Figueroa-Céspedes (2023), it is helpful to clarify the narratives of future educators, as they argue that “the teaching identity of Chilean kindergarten teachers in training [...] is trapped in the imaginary perfect woman-mother role and oriented by gender stereotypes”. (p.3)

## University education

The emotions and experiences of the first year of a career establish the category of university education. The narratives demonstrate a significant impact due to the wide range of subjects and/or content covered in curricular programmes, which challenges professional preconceptions:

*I never imagined that in this career you would have to read so much, I expected something else, drawing, songs, theater. I thought that would be my courses this semester, but it was not like that at all, every teacher would give us different articles or books to read every week (NN13)*

*When I entered the career, I realized that being a kindergarten schoolteacher was not easy, a professional must know a lot of psychology, pedagogy, neuroscience, language and many other things. I am proud to be in this career (NN32).*

Olivares et al., (2020) define the first stage of university as a period of self-knowledge. It is a time when future professionals learn to articulate their values and personal preferences, and decide whether to continue with their chosen career. However, sometimes this process “requires others to define oneself and the world” (p.16).

## Conclusions

Professional constructions go through various stages. They are mobilised after the identity crises that people experience, such as starting university. This research aimed to understand how students perceived the pedagogy of early

childhood education at the end of their first year of academic training at a Chilean university. To achieve this, their preconceptions were first identified. They had a maternal attitude towards childhood and a romantic view of the career and its subjects, although this perception varied throughout the semester.

The beginning of university life can be challenging for some students. This is particularly true when their preconceptions about their chosen career are far from their initial expectations. This includes the complexity of pedagogy in early childhood education, particularly given that social stereotypes depict it as a childcare and entertainment profession.

Nevertheless, most students who start the course remain at the end of the first year, despite the challenges this could imply. They speak of a desire to become professionals, complete their studies and enter the job market. They hope to work in children's classrooms, suggesting that their expectations of becoming educators are being realised.

One interesting finding was that one of the reasons participants gave for choosing to study at university was the influence of their mothers. This may indicate a degree of submission and/or immaturity in decision-making, which is a significant factor when considering the influence of personal life on professional identity. This raises questions about the entry profile of students who enrol on the course.

It is important to support and encourage the development of the identities of future professionals through formative activities that give meaning to their learning and, at the same time, demonstrate the responsibilities of being an early childhood teacher. This reveals the implications of their professionalism in the children's full and integral development.

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## Virtual Learning Environment to promote research in education

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### Introduction

Research is presented on the design and use of a Virtual Learning Environment (VLE) as a didactic support resource in face-to-face classes, to promote and strengthen knowledge, skills and positive attitude for the development of research projects in education, in higher education students of a public university in Mexico.

In this regard, in higher education and postgraduate levels, acquiring knowledge, competencies and disposition to do science involves challenges and difficulties faced by the different school actors. The student, during these processes of learning to do research, faces a series of problems, uses different learning strategies, and develops different knowledge and attitudes, according to his interests. On the other hand, the teacher is a key actor, having the responsibility of promoting and assuring this learning; he is the one who can potentially influence the students to develop this knowledge and attitudes to learn to investigate and do science; where much will depend on his quality of training, his knowledge and experience, specifically in this type of subjects.

During the teaching and learning processes, cognition and emotion interact (Brunning *et al.*, 2011; Smith & Kosslyn, 2007). In this regard, when conducting this research, during the course of the educational program, it was observed in the classroom that some students expressed that they did not like “methodology classes”, that they had a hard time learning, that they had many confusions and doubts. On the other hand, to a lesser extent, other students expressed that they liked methodology, that they wanted to learn to do better research and to be able to write papers, and to continue with their graduate studies. However, during the development of this subject and the use of the OVA, little by little the understanding, comprehension, knowledge and attitude of the students for learning research improved.

Therefore, teachers in higher education, when teaching subjects related to methodologies and research, should strengthen their teaching strategies, to bring their students closer to proximal learning, by building scaffolds, which are facilitated by Information and Communication Technologies (ICT). As was the case in this research, where a VPA was designed and applied, which in combination with face-to-face teaching practices, helped students to learn and value their knowledge about methodology, to better understand the theories of their disciplines and to develop research projects in education.

## **Virtual Learning Environments**

Virtual Learning Environments (VLE) are pedagogical scenarios designed for different academic processes, mediated by Information and Communication Technologies, where students participate autonomously and collaboratively, advance flexibly in their tasks and knowledge acquisition, and the needs are adapted to each student, which guarantees their own learning (Santamaría, 2022).

The efficiency of the design and application of VPAs for the training and learning of higher education students has been demonstrated in recent research. In a study on the POE (Prediction-Observation-Explanation) teaching strategy, it was found that teaching through prediction, observation and explanation, as well as effective interaction between teachers and students greatly strengthens the cognitive and attitudinal skills of Physics students (Jiang & Li, 2024).

The study of the importance of Virtual Learning Environments for the cognitive development of students has shown that the interaction of students among their peers when performing collaborative learning tasks is important; however, it has recently been proven through statistical models that the instructional design influences significantly more than the interaction among peers

(Dunmoye *et al.*, 2025).

## Virtual Learning Objet (VLO)

A Virtual Learning Object (VLO) is considered as an object that is digitized or materialized, which is used to support and facilitate the learning of certain school content. Among its classifications are: 1) instructional objects, which support learning and the student is usually more passive; 2) collaborative objects, useful for communication in collaborative learning; 3) practice objects, which promote self-learning and intense student interaction, and which were used in this research; and 4) evaluation objects, which investigate the degree of knowledge of students (Callejas *et al.*, 2019).

The importance of supporting teaching and learning, through the use of an OVA, was proven in research that was conducted in students who had insufficient digital skills and low performance in learning English as a foreign language, in a public educational institution in Colombia. The results showed that the creation and use of OVA develops competencies in information and communication technologies in students, and motivates the learning of English (Parra, 2022).

## Educational Digital Platforms

Research on the usefulness of digital educational platforms suggests that they influence the development of cognitive and emotional competencies of students. This was proven in research, which was conducted in China between a control group and an experimental group of students, the latter used the Rain Classroom platform, which integrates digital technologies, while the control group followed a standard model. The results showed that students in the experimental group showed significant improvements in emotional intelligence, creativity, academic independence and attention concentration (Jiang, 2025).

## Google Drive

Another technological resource used in this work was the creation and use of electronic portfolios in Google Drive. The portfolio is a metatext that serves as a collection of work extracted from an archival repository. The portfolio documents diverse content, which highlights individual, cognitive, and cultural differences of students. Portfolios serve as instruments and forms of teacher assessment and student self-assessment. These tools are also important as cognitive support resources, as they can help students to be more critical about their productions and advances in their knowledge. Portfolios also

promote and awaken students' emotional development and self-regulation, which occurs when they review their work, receive grades and feedback from their teachers, as well as the participation of their peers when they work collaboratively (Bozorgian et al., 2024), as was done and observed in this work.

In order, the results of descriptive statistics on the response of students' perception for each of the evaluated scales, about the digital and technological resources, which integrated the VPA, are presented. It is important to mention that the scale of student responses ranged between scores ranging from 1 which is equal to "Nothing", 2 is equal to "Almost nothing", 3 is equal to "Almost a lot" and up to 4 which is equal to "A lot". According to Table 1, the mean response of the students, for this scale, was between a score of 3.43 to 3.66, which brings them close to affirming that the Virtual Learning Object (VLO) is very useful to develop each part and the total of a research project. These results in Tables 1 and 2, show that the use of the OVA in higher education strengthens learning, the acquisition of school content, promotes self-learning, intense interaction (Callejas et al., 2019), communication between students and teacher (Parra, 2022).

**Table 1.** *Usefulness scale of the OVA to elaborate the research project.*

|                                     | Min | Max | Mean | Std Dev |
|-------------------------------------|-----|-----|------|---------|
| It was useful to develop my project | 1   | 4   | 3.54 | 0.74    |
| Introduction                        | 1   | 4   | 3.60 | 0.69    |
| Abstract                            | 1   | 4   | 3.60 | 0.77    |
| Research problem                    | 1   | 4   | 3.66 | 0.68    |
| Research justification              | 1   | 4   | 3.63 | 0.73    |
| Research objectives                 | 1   | 4   | 3.46 | 0.78    |
| Research questions                  | 1   | 4   | 3.54 | 0.78    |
| Theoretical framework               | 1   | 4   | 3.54 | 0.74    |
| State of knowledge                  | 1   | 4   | 3.60 | 0.73    |
| Methodology                         | 1   | 4   | 3.63 | 0.69    |
| Research design                     | 1   | 4   | 3.57 | 0.73    |
| Scope of the study                  | 1   | 4   | 3.63 | 0.69    |
| Sample                              | 1   | 4   | 3.57 | 0.69    |
| Techniques and instruments          | 1   | 4   | 3.46 | 0.85    |
| Hypotheses                          | 1   | 4   | 3.46 | 0.78    |
| Procedure                           | 1   | 4   | 3.49 | 0.78    |
| Data analysis                       | 1   | 4   | 3.51 | 0.70    |

According to Table 2, the mean response of students for the OVA

Effectiveness scale ranges from 3.46 to 3.71, indicating that it is very effective in developing research projects. The students' statement that the OVA is very helpful in learning how to develop research projects stands out.

**Table 2.** *Effectiveness of the OVA to develop the research project.*

|                                                            | Min | Max | Mean | Std Dev |
|------------------------------------------------------------|-----|-----|------|---------|
| Structure each part of the project                         | 1   | 4   | 3.51 | 0.78    |
| Understand each part of the project                        | 1   | 4   | 3.46 | 0.81    |
| Conceptualize each part of the project                     | 1   | 4   | 3.57 | 0.69    |
| Exemplify each part of the project                         | 1   | 4   | 3.60 | 0.69    |
| Complement my knowledge of the subject when I miss classes | 1   | 4   | 3.54 | 0.74    |
| Learning to develop research projects                      | 1   | 4   | 3.71 | 0.66    |

In the Scale Use of the University Digital Platform (Table 3), students place their mean response, between scores of 3.40 and 3.63, which indicates that the platform is very useful for developing their research projects. The statements that the platform helped them to hand in their homework on time, the material included was useful and strategically guided the development of their research project, among other important statements, stand out. These results prove that the use of digital platforms helps to improve creativity, academic independence, action concentration and emotional intelligence (Jiang, 2025).

**Table 3.** *Use of the University Digital Platform to develop the project*

|                                                                     | Min | Max | Mean | Std Dev |
|---------------------------------------------------------------------|-----|-----|------|---------|
| Consult the activities of the subject                               | 1   | 4   | 3.54 | 0.78    |
| The didactic units guided the development of my project             | 2   | 4   | 3.51 | 0.70    |
| Facilitate the consultations of the development of my project       | 2   | 4   | 3.43 | 0.77    |
| The materials included are useful for the development of my project | 2   | 4   | 3.60 | 0.60    |
| I deliver the tasks on time                                         | 2   | 4   | 3.63 | 0.54    |
| I strategically guide the development of my project                 | 2   | 4   | 3.57 | 0.65    |
| It is fundamental to follow the work plan                           | 2   | 4   | 3.51 | 0.65    |
| It is useful to develop the projects                                | 1   | 4   | 3.51 | 0.74    |
| It is important for the classroom work                              | 1   | 4   | 3.40 | 0.88    |

Table 4, in the scale Use of the Drive, shows that the students' response scores are between 3.60 and 3.83, which suggests that the use of the Drive was very useful to develop their research projects. It highlights the students' statements that the use of the Drive guided the development of their research project, kept them aware of their progress, as well as to conceptualize the parts of it. These results demonstrate that the use of portfolios helps students in their cognitive development, emotional self-regulation, guides their work, serves as a self-evaluation tool for the student and as an evaluation tool for the teacher, and helps the student to be more critical (Bozorgian et al., 2024).

**Table 4.** *Use of Google Drive to develop the research project.*

|                                                                  | Min | Max | Mean | Std Dev |
|------------------------------------------------------------------|-----|-----|------|---------|
| It is useful to develop my project                               | 2   | 4   | 3.83 | 0.51    |
| It guides to develop the parts of my project                     | 2   | 4   | 3.80 | 0.47    |
| It helps to recognize what is missing to develop from my project | 2   | 4   | 3.60 | 0.65    |
| It made me aware of my progress                                  | 2   | 4   | 3.74 | 0.56    |
| It gave me confidence for a good grade                           | 2   | 4   | 3.80 | 0.47    |
| It helps to conceptualize the parts of a research project        | 2   | 4   | 3.69 | 0.58    |
| It helps to decrease my worry about the progress of my project   | 2   | 4   | 3.66 | 0.63    |

Finally, in another important complementary data, which is not added to the table due to lack of space, is that in the Collaborative Work Scale, a mean of responses close to 4 was found, which would indicate that most students perceive that collaborative work contributed a lot to learning and elaboration of research projects, as well as to their integral development, to accept their challenges as a person, promotes their communication skills, to be more responsible and to resolve conflicts respectfully, which are characteristics that are demonstrated in other research (Mujtaba & Qureshi, 2025).

## Conclusions

This article analyses the importance of the design and use of a Virtual Learning Environment (VLE), for the strengthening and development of knowledge, skills and positive attitude in higher education students, to learn methodology and its application for the development of research projects in education. The results of this research prove that the design and use of AVA, and its resources: Educational Digital Platform, Virtual Learning Object and Google Drive,

together are factors that, when used in a careful and well stratified way, strengthened the cognitive and emotional development of this group of students of Education Sciences, since they acquired better knowledge, skills and positive attitude to develop the parts and the total integration of a research project in education. The VPA and the resources used were didactic support tools, which in combination with face-to-face classes and teacher instruction, improved and guided learning, collaboration, self-regulation, and autonomy among students. The face-to-face and virtual interaction between teacher and students promoted synchronous and asynchronous communication, facilitating the development of communication skills and emotional regulation, as well as the development and conclusion of the research project.

Finally, in order to improve this research, it is suggested to carry out pre- and post-evaluations to verify the efficiency of this type of interventions. For future research it is necessary to investigate how the conceptual, procedural and attitudinal acquisition processes of students occur and their relationship with the use of ICT and Artificial Intelligence.

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# Career choice among domestic non-local students: the case of a private university in Mexico

This text emerges within the framework of the project "Academic Trajectories and Holistic Development of Undergraduate Students," in the context of Universidad Panamericana, Aguascalientes campus.

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## Introduction

Access to higher education is a significant issue viewed from multiple perspectives. From a personal standpoint, it enables the development of professional and disciplinary competencies that prepare individuals for their chosen careers, thereby contributing to their human, academic, and occupational growth. From a societal perspective, higher education drives continuous development by producing professionals capable of proactively influencing social transformation.

In Mexico—the context of this study—during the 2023–2024 academic year, 1,247,090 students enrolled in higher education at the University Higher Technical Degree (TSU) and bachelor's degree levels, bringing total enrollment to 4,890,145 individuals. Additionally, a dropout rate of 7.22% was reported. Compared to the previous academic cycle (2022–2023), there was a slight decrease in both new enrollments (which totaled 1,264,124 students, 17,034 more than in 2023–2024) and dropout rate (which stood at 8.08%) (Sistema Integrado de Información de la Educación Superior, 2025). The observed decrease in new enrollments, and the persistently high dropout rate underscores the importance of studying factors associated with career choice. Understanding what motivates upper secondary graduates to select particular academic paths can inform the development of strategies aimed at promoting continuity in professional training and improving terminal efficiency. By identifying and addressing these factors, educational institutions and policymakers can devise more effective interventions to support student retention and successful degree completion.

Given the current context of educational innovation, access to higher

education in Mexico increasingly involves processes of internal mobility. However, the lack of research addressing this phenomenon highlights the need for studies that generate specific knowledge about students who leave their homes and local contexts in pursuit of professional training. These students represent a unique segment of the higher education population whose experiences and decision-making processes remain understudied

### **General analysis of the vocational process**

This category comprises studies examining vocational decision-making from a broad perspective, identifying key influencing factors or tracking shifts in career choice trends. In Latin America, research has approached vocational decision-making through diverse lenses. For instance, Bulgarelli-Bolaños *et al.* (2016) found that scientific interests and intrinsic occupational values are powerful motivators, especially among students with academic delays. In Mexico, Vallado-Flores *et al.* (2020) emphasized family's significant role in vocational decisions, though this influence diminishes among students in technological high schools who tend to reject familial involvement.

Miranda-Morales *et al.* (2018) observed in Colombia a rising demand for higher education among women, alongside the influential roles of peer relationships, institutional prestige, tuition costs, and employment opportunities in shaping decisions. Similarly, Norzagaray-Benítez & López-Dórame (2018) highlighted socio-familial conditions and the impact of significant others as crucial factors in Mexico, with marked gender differences.

In Chile, Gomez-Arizaga *et al.* (2020) underscored family support as vital for both male and female students, noting gender-specific distinctions. Within schools, the guidance role of teachers was particularly valued by female students, illustrating the complex and multifaceted influences in vocational decision-making.

### **Specific analysis of factors influencing career choice**

This thematic group focuses on particular variables shaping career decisions, such as gender, socioeconomic status, and socio-familial dynamics. In Spain, Olmos-Gómez *et al.* (2021) identified parental influence as significant, with medium-to-high socioeconomic status positively correlating with stronger self-concept and self-esteem. In Colombia, Izquierdo-Torres & Buitrago (2020) linked gender to undergraduate program selection and highlighted socioeconomic strata as structural barriers.

Sánchez-Martín (2020) found female students tended toward social sciences,

with peer relationships outweighing family influence in vocational decisions. Ruiz-Gutiérrez & Santana-Vega (2018) reported women's preference for caregiving fields, while men prioritized economic independence and social prestige. Also, they explain that men generally pursue short-term financial autonomy and social recognition, whereas women's choices are more often rooted in abilities, interests, and intrinsic motivation. This divergence reflects patriarchal cultural norms that associate men with rationality and intelligence and women with affective-emotional traits, alongside the lower prestige and leadership opportunities associated with feminized professions.

In Mexico, Maza, Stange, and Ortega (2024) noted that engineering students exhibited stronger academic commitment and trajectories when perceiving robust family support, alignment between training and employability, and prospects of working in their trained field. Emotions also critically influence vocational choices. Maldonado *et al.* (2023) emphasize emotional experiences as pivotal in decision-making, while García-Martínez *et al.* (2024) highlight family and peer networks, location, costs, infrastructure, and institutional prestige. Guerrero *et al.* (2024) underscore the importance of emotional support in navigating uncertainty and fostering effective communication during career choice.

From a psychoeducational perspective, vocational decisions are shaped by a complex interplay of dispositional and contextual factors. Norzagaray-Benítez & López-Dorame (2018) note that personal histories, situational variables (such as marital status and place of residence), inclinations, emotions, access to profession-related information, gender stereotypes, social role expectations, and family aspirations collectively influence career choices.

In accordance with the research objective, a quantitative study was conducted using a non-experimental, cross-sectional design with a descriptive scope (Ato, López, & Benavente, 2013) and a correlational approach (Jiménez & Ramírez, 2011). This approach was selected because the variable was observed, not manipulated; the aim was to measure it in order to characterize the sample and allow for generalizations about the target population.

The study considered the population of out-of-state Mexican students newly enrolled at a private university in the state of Aguascalientes (Mexico) during the 2023–24 academic year. Table 1 presents a description of their characteristics.

**Table 1.** *Sample description*

| Aspect               | Description                      |
|----------------------|----------------------------------|
| Gender               | Female = 40.2% / Male = 59.8%    |
| Age                  | Mean = 18.17 / SD = 1.08         |
| Previous institution | Private = 89.7% / Public = 10.3% |
| Type of locality     | Rural = 5.7% / Urban = 94.7%     |

Data were collected through an electronic questionnaire composed of two sections: the first focused on sociodemographic variables, and the second included an adaptation of the Inventory of Factors Influencing Career Choice (IFIEC) (Norzagaray-Benítez & López-Dórame, 2018). The original version consists of 25 items on a five-point Likert scale, distributed across six dimensions. The adapted version (IFIEC-AD) incorporated one additional dimension, the removal of one item, and the inclusion of five new items, resulting in a 29-item version. Table 2 presents the corresponding operationalization matrix.

**Table 2.** *Operationalization of the IFIEC-AD*

| Dimension                       | Description                                                                                                                                                                         | Items |
|---------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| D1. Other significant persons   | Opinions and comments from teachers, counselors, romantic partners, blogs or websites, and friends.                                                                                 | 25-29 |
| D2. Physical objects and events | Classroom conditions, technological and didactic equipment, academic offerings, university modalities, promotional materials (e.g., fairs), program duration, and academic demands. | 8-14  |
| D3. Social circumstances        | Friendships, romantic relationships, family situation, and employment status.                                                                                                       | 1-4   |
| D4. Significant individuals     | Opinions and comments from parents, siblings, and other relatives.                                                                                                                  | 21-24 |
| D5. Personal inclinations       | High school specialization, courses taken, and professional practice interests.                                                                                                     | 15-17 |
| D6. Macro-contingent elements   | Adequate remuneration, career prestige, and high demand for the program.                                                                                                            | 5-7   |
| D7. Personal motivations        | Potential societal impact, alignment with personal skills and aptitudes, and coherence with life goals.                                                                             | 18-20 |

Note: Based on Norzagaray-Benítez & López-Dórame (2018). Dimension D7 and items 13, 14, 18, 19, and 20 were added in the adaptation.

The scale showed a very good level of reliability ( $\text{Alpha} = 0.918$ ) (Nunnally & Bernstein, 1994). Regarding construct validity, an item-domain correlation analysis was conducted for each instrument. Since the items are ordinal variables and the dimension scores are quantitative variables, Spearman's Rho coefficient was used. In all cases, the correlation coefficients reflected moderate ( $r > .40$ ) or strong ( $r > .70$ ) associations (Dancey & Reidy, in Akoglu, 2018). Based on these results, it can be affirmed that the instrument exhibits robust psychometric properties, thereby constituting a valid and reliable tool suitable for the objectives of this study.

The instrument was administered during the first week of August 2022, coinciding with the induction course for newly enrolled students. This timing was chosen to ensure that responses reflected the participants' current thoughts at that moment, minimizing bias from initial impressions of official courses. Data collection took place in university auditoriums, with student groups organized according to the school or faculty to which their degree programs belong. Upon completion of the data collection period, a database was created and processed using IBM SPSS Statistics 27, where the appropriate statistical analyses were performed for the psychometric evaluation and quantitative data analysis.

The entire research process was carried out in accordance with the ethical principles promoted by the Committee on Publication Ethics (COPE). These included obtaining informed consent, ensuring anonymity and confidentiality, and restricting the use of data exclusively to research purposes. The research objective was to describe the factors influencing career choice among domestic non-local students at a private university in the state of Aguascalientes, Mexico. Accordingly, the collected data were processed through three analyses: score analysis by dimension, comparative analysis based on the variable of sex, and item score analysis, aiming to identify the factors with the greatest and least influence on career choice.

Regarding the dimension-based analysis, Table 3 presents the mean score and standard deviation for each dimension. The results are interpreted considering that the possible score range was from 1 to 5, with values closer to 5 indicating a higher degree of presence of the corresponding aspect.

**Table 3.** *Scores by dimension*

| Dimension                       | Mean | SD   |
|---------------------------------|------|------|
| D1. Other significant persons   | 2.07 | .868 |
| D2. Physical objects and events | 3.33 | .757 |
| D3. Social circumstances        | 2.47 | .994 |
| D4. Significant individuals     | 1.99 | .907 |
| D5. Personal inclinations       | 3.64 | .974 |
| D6. Macro-contingent elements   | 3.46 | .973 |
| D7. Personal motivations        | 4.21 | .734 |

The analysis indicates that personal motivations (D7x = 4.21) were the most influential factor in students' career choice, followed by personal inclinations (D5x = 3.64), macro-contingent elements (D6x = 3.46), and physical objects and events (D2x = 3.33). These results suggest that internal factors and perceived professional opportunities guided most decisions. In contrast, social circumstances (D3x = 2.47) and the influence of significant others, such as friends, teachers, or family (D1x = 2.07; D4x = 1.99), exerted a comparatively lower influence on students' career decisions. Overall, students prioritized individual alignment and future prospects over external opinions.

For the comparative analysis based on the gender, the independent samples t-test was applied. The results revealed two statistically significant differences. In D6. Macro-contingent elements ( $p = .050$ ), women ( $M = 3.70$ ) scored significantly higher than men ( $M = 3.30$ ). A similar pattern was observed in D7. Personal motivations ( $p = .026$ ), with women ( $M = 4.42$ ) showing a greater influence than men ( $M = 4.06$ ).

Finally, an item-level mean analysis was carried out to identify, in greater detail, the factors with the highest and lowest influence on career choice among domestic non-local students. Table 4 presents the results, highlighting the three items with the highest and lowest scores.

**Table 4.** *Factors with the greatest and least influence on career choice*

| Greatest influence                                                                                                                                                 | Least influence                                                                                               |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| R20. <i>Que la carrera se relacione con tu plan de vida</i> [That the degree program aligns with your life plan] ( $x = 4.38$ )                                    | R24. <i>Lo que piensen y digan otros familiares</i> [What other family members think and say] ( $x = 1.67$ ). |
| R18. <i>Que la carrera te permita impactar en la sociedad</i> [That the degree program allows you to make an impact on society] ( $x = 4.18$ )                     | R25. <i>Lo que piensen y digan tus amigos</i> [What your friends think and say] ( $x = 1.66$ ).               |
| R19. <i>Que cuentes con las habilidades y aptitudes para la carrera</i> [That you possess the skills and aptitudes required for the degree program] ( $x = 4.06$ ) | R04. <i>Tu relación de pareja</i> [Your romantic relationship] ( $x = 1.63$ ).                                |

The item-level analysis revealed that the factors with the greatest influence on career choice among domestic non-local students were those related to personal motivation. Specifically, the highest mean scores corresponded to the degree program aligning with the student's life plan ( $M = 4.38$ ), the potential to make an impact on society ( $M = 4.18$ ), and possessing the skills and aptitudes required for the program ( $M = 4.06$ ). In contrast, the items with the least influence were external social factors, such as the opinions of friends ( $M = 1.66$ ) and other family members ( $M = 1.67$ ), as well as romantic relationships ( $M = 1.63$ ). These results suggest that students' career decisions are primarily guided by intrinsic motivations and perceived personal fit, rather than by external social expectations or interpersonal considerations.

## Conclusions

This study examined the factors influencing career choice among domestic non-local students at a private university in Aguascalientes, Mexico. The results highlight that intrinsic motivations, such as alignment with life goals, perceived societal impact, and personal aptitudes, were the most influential. This aligns with previous research emphasizing internal drivers in vocational decisions (Bulgarelli-Bolaños et al., 2016; Ruiz-Gutiérrez & Santana-Vega, 2018). In contrast, external social influences—such as the opinions of friends, extended family, and romantic partners—had the least impact, supporting findings by Sánchez-Martín (2020), who observed a shift toward greater autonomy in career decision-making.

Gender-based differences showed that women were more influenced by macro-contingent elements and personal motivations, consistent with patterns

noted by Ruiz-Gutiérrez & Santana-Vega (2018), suggesting a stronger orientation toward social contribution and internal coherence.

Overall, these findings underscore the importance of designing guidance strategies that emphasize personal values, emotional clarity, and long-term planning, especially for students navigating geographic and cultural transitions. As Norzagaray-Benítez & López-Dorame (2018) argue, vocational decisions emerge from a complex interplay of personal and contextual factors, an understanding that must inform institutional efforts to foster retention and meaningful educational pathways.

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# Student retention in for-profit education: an updated analysis

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## Introduction

Like other postsecondary institutions, proprietary schools encounter significant challenges in retaining students. When students drop out, they miss the comprehensive education required to pursue their desired careers. Student attrition has become a widespread issue, impacting not only the individuals involved but also the institutions themselves, which suffer from lost tuition revenue that is essential for their sustainability. Over the years, numerous studies have examined student persistence, retention, and dropout rates (Schulz, 2000). While many of these studies have focused on broader higher education contexts, research addressing retention and persistence in proprietary school environments remains relatively limited (Capaz et al., 1990). A recent reevaluation of the educational landscape, marked by a decline in the number of students opting for traditional brick-and-mortar universities, underscores the need for an updated analysis of previous research (Dengler, 2014). The research identifies such factors as a main factor in students' retention: The teachers' supportive attitude and the parents' motivation from home.

## Background

Traditional universities have historically been what people envision when pursuing a college degree. There was once a time when the primary discussion among guidance counselors and students centered largely on the four-year Bachelor's degree, with the alternative being a two-year associate's degree. Key determining factors typically include grades, finances, and the students' desire to excel at the next level.

As society evolved toward the millennium, they began to see a new breed of educational institutions emerge: For-Profit Colleges and Universities (FCPUs). These schools arose from a need to cater to non-traditional learners. FCPUs effectively reached their target audience through extensive marketing campaigns (Hentschke et al., 2023). To find the earliest studies on undergraduate retention in the United States, one could look back to the 1930s. At that time, this issue was referred to as "student mortality" (Demetriou & Schmitz-Sciborski, 2011). It was later classified by Berg (2005) as

the failure of students to graduate.

While one can analyze numerical data, such as retention and attrition rates; there is still limited documentation regarding the student experience in college. By 2010, 40% of incoming freshmen were first-generation college students (Davis, 2023). The FCPU sector showcased a marketing model linking college attendance to increased income, employability, and overall quality of life (Tierney & Hentschke, 2007). To cater to non-traditional learners, FCPUs offered varied schedule options, individualized pacing programs (often including online courses), and condensed class lengths (quarters instead of semesters).

The For-Profit model transformed opportunities for degree-seeking individuals and challenged societal perceptions of higher education (Tierney & Hentschke, 2007) noted that while for-profits "do" education, they "behave" like businesses. This model focused on tailoring the student experience to the needs of the students themselves. By increasing the number of students served and improving retention, FCPUs enhanced their image and desirability for more enrollments (Davis, 2023). Traditional colleges and universities rarely advertised on television or utilized billboards, yet FCPUs began appearing everywhere, with examples including the University of Phoenix, The Art Institutes, DeVry, and Strayer University. It is crucial to recognize that FCPUs accounted for 39% of all institutions but only 9% of total enrollments between traditional and non-traditional college and university options (Hentschke et al., 2023).

What contributed to such a boom in the educational sector? Between 2000 and 2010, changes in public sector funding significantly impacted college enrollments. As restrictions on funding from state and local governments increased, public institutions experienced declining enrollment, while FCPUs experienced growth (Goodman et al., 2020). More funding enabled FCPUs to offer a broader range of courses due to access to costly new technologies, allowing them to provide credentialed programs from vocational levels up to doctoral degrees. (Dos Santos, 2020) emphasizes that there is limited research on student satisfaction as well as the impact of educational programs on students. While FCPUs typically see increased student enrollment, they do not raise teacher salaries, reflecting their business-oriented approach.

One significant distinction between traditional colleges and for-profit institutions is that for-profit institutions generally lack strong local networks, which are present in non-profit institutions. FCPUs focus on enhancing student experience rather than educational quality (Dos Santos, 2020). This raises the

question of why so few researchers have explored the reasons behind student attrition. Additionally, what implications does this have for both students and FCPUs that fail to ensure their student body persists to the point of graduation? This updated analysis of previous work (Dengler, 2014) seeks to uncover new insights, patterns, and indicators to address these questions. This situation represents the gap to inspire the author of this paper to theorize regarding the strategy for the retention of students in the FCPUs.

## Findings and Contributions

In review of author's prior research (Dengler, 2014), what is most notable is that when a student gains admission to college, gone are the days of the students merely focusing on his or her studies. Ten of the twelve students interviewed, worked part-time, one student worked two part-time jobs, and the final student worked full-time; along with attending college as a full-time student. What this means for students and their ability to persist is that the outside factors that impact student success are often multi-layered. Persistence is no longer affected by intrinsic factors, in the modern educational world; it stems more from extrinsic factors.

Regarding the literature review, the research conducted on student "drop-out" rates reveals their significant impact not only on institutions but also on students and global society as a whole. In this context, "drop-out" is used alongside the term "attrition," which refers to the inability to retain students. (Fernandes, 2024) highlights that when students abandon their studies, it represents a lost opportunity for them to earn a degree, while simultaneously creating operational inefficiencies for institutions due to underutilized resources. This issue of student abandonment captures the reader's interest, as it underscores the broader consequences that extend beyond the individual student to hinder universities as well.

Preventing students from dropping out of their academic programs poses a considerable challenge for higher education institutions. Therefore, understanding the factors that influence students' decisions to leave is essential for developing strategies to retain them (Nurmalitasari et al., 2023).

Numerous research studies conducted in the past five years (2020-2025) have uncovered various reasons for student attrition, and a common theme has emerged regarding the need for institutions to improve student satisfaction and success. (Crawford et al, 2024) noted that a sense of belonging remains a significant challenge for higher education providers, leading to consistently declining ratings. But what does a sense of belonging entail? Bell (2022) emphasized the importance of teaching quality concerning student satisfaction,

outlining those strong connections outside the classroom and ongoing support for acclimating to college life are critical for a successful student experience.

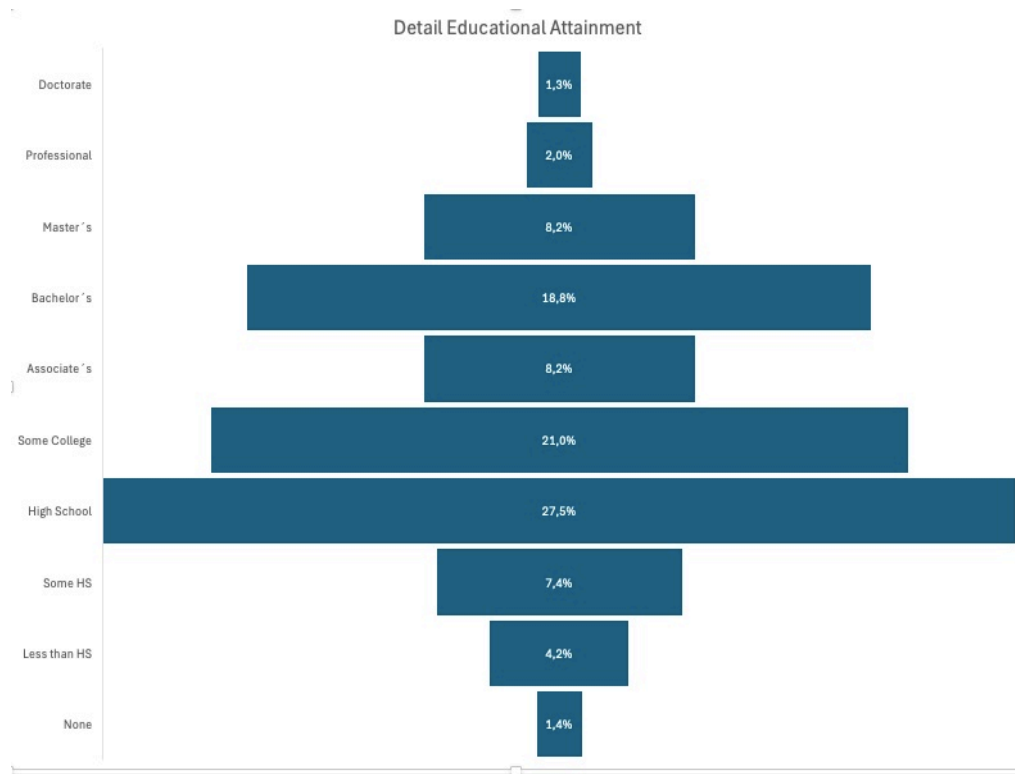
Different research approaches reveal that the reasons for students not completing college are varied. Perchinunno et al. (2021) found that the most significant indicators of attrition occur between a student's first and second years. Factors contributing to this trend include inadequate prospective student orientation, the urgent need to secure employment, and a lack of awareness about the challenges associated with specific courses of study. This underscores the importance of the connection between students and faculty. Bell (2022) noted that the quality of teaching directly affects student satisfaction. Additionally, a study carried out by Hassani and Wilkins (2022) employed a conceptual model involving student surveys in the United Arab Emirates. This approach revealed that institutional reputation, organizational identification, and overall student satisfaction influence a student's commitment to their institution. The findings indicated that student satisfaction has both direct and mediating effects on students' intentions to remain enrolled and seek support. While this data applies broadly to higher education, what happens when we differentiate between for-profit colleges and traditional non-profit institutions?

Higher education leaders are often concerned about low retention rates. Research comparing freshman students who live on campus to those who commute from home demonstrates that every choice made by a student can directly impact their future educational trajectory, ultimately affecting degree attainment. Khosravian (2022) conducted a qualitative exploratory case study to investigate the marketing strategies employed by for-profit online higher education institutions to increase student retention. The themes identified in this analysis could serve as a blueprint for foundational components of student success. The emerging themes were: 1) addressing student needs to create personalized experiences, 2) implementing strategies to engage online students, 3) aligning institutional structure and resources to cater to online learners, and 4) measuring the impact of student retention on business profits and revenue. Regardless of the researcher, study, or methodology, all findings converge on the premise that achieving a degree not only benefits the individual but also contributes to the advancement of their communities.

In continuing the discussion of advancement, we can examine the Administrator's Toolkit, which begins at the secondary level. McFarland et al. (2018) design the Toolkit which focuses on the costs borne by individuals and society when education is not completed. It argues for viewing education as a moral imperative, asserting that all children deserve a quality education.

McFarland et al. (2018) built a table that presented a detailed educational attainment reference (Figure 1).

**Figure 1.** Detailed Educational Attainment.



\*Source: Statistical Atlas: U.S. Census Bureau Current Population Survey (2018).

Ultimately, the data presented in the table indicates that after graduating from high school, the percentage of individuals pursuing further education peaks. Among people aged 25 and older, the second highest educational attainment category is "some college." This observation raises an important question: Why do students start but not finish their college education? Currently, 21% of students begin college, yet many do not complete their degrees. As academic programs become more specialized and challenging, enrollment numbers decrease even further.

Chahar et al. (2021) emphasize that the motivation and happiness of employees, including teachers, directly influence student satisfaction. When teachers are happy and motivated, students are more likely to feel connected to their programs of study, which strengthens their bond with the institution itself. Faculty at higher education institutions have a crucial role not only in teaching but also as leaders in knowledge through research and professional development. If faculty members do not receive the support they need, they

may lack the inspiration to excel and provide quality service to their students.

Everyone has a story about a teacher who significantly impacted their learning journey, regardless of their educational level. To improve student retention, institutions must also prioritize the retention and professional development of their faculty while enhancing their reputation. According to Davis (2023), increasing retention and graduation rates will inherently improve the institution's desirability and public image.

## Conclusions and future research

Conclusions about the relationships between students and teachers, as well as the parent's support from home, ties back to expectations that were framed growing up, seeking to pursue a college degree; it wasn't a choice but an expectation. Retaining a student and seeing them to completion does so much more to garner institutional success. It shows that the institution is doing something right. If any school, no matter if it is for-profit or not, does not see its students to completion, it does not bode well for future enrollments (Dengler, 2014). Regardless of the type of student, it is up to the institution to provide a diverse offering of supportive services from the time the student tours and/or applies to their higher educational institution of choice. For students and their families who invest in attending post-secondary institutions, it is up to the for-profit colleges and universities (FCPU's), especially because they are serving students of varying needs (also known as the non-typical learner), to support student persistence by retaining the students. Making a connection and solidifying it will only serve our future, as a whole, in a positive manner.

Future research needs to shift away from focusing solely on student failure. Perhaps one should adopt a cultural or global perspective to uncover the holistic reasons behind such failures. As the author reviews the research developed since an initial analysis in 2014, respect for those pursuing post-secondary degrees has only grown. The journey is challenging, and the experience often involves teachers who inspire curiosity in their students, while also challenging them to think beyond the perspectives they learned at home. Educators who can continue to motivate students are invaluable to our future society, as they help develop creative, investigative, and confident yet compassionate global thinkers.

Instead, why not focus on those who succeed? One should investigate where these successful students attend school, what differentiates their experiences, and create a comprehensive study that identifies a proactive approach to student success. This approach should aim to develop a formula that is



prescriptive and adaptable to the changing needs of students. The closest research approach to this idea was presented by (Demetriou & Schmitz-Sciborski, 2011); however, they missed the opportunity to explore this further, as they published their findings in the same year that the author of this paper began an educational journey toward obtaining a doctoral degree.

While the research has taken on a more global outlook since then, there doesn't seem to have been a groundbreaking discovery. The future research could use as a closest reference, culture, geography, socioeconomic status, religion, teacher pay, recruiting methods, and stereotypes. A tool to consider, is the *2023 Effective Practices for Student Success, Retention, and Completion Report* (RNL, 2023), which emphasizes the necessity for institutions to have a formalized retention plan, academic support through a learning center, and specialized programs for first-year students, such as orientation and comprehensive first-year experience programs.

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# PhD research: Can We Talk About a Field of Study?

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## Introduction

The doctorate (or PhD) is a training process characterized by high expectations from individuals and society, profoundly influencing subjective, institutional, and societal levels. It serves as a locus where training and research converge, enabling the contribution of research to permeate society.

A critical aspect of research concerns the interplay between the quality of the training process, competencies acquired by graduates, and opportunities to contribute to societal research. Various studies have explored the factors that characterize the quality and success of doctoral training, indicating that the achievements of these programs result from multiple interrelated components, including the curriculum, teaching quality, student characteristics, and the nature of the training institutions (de la Vega, 2024).

From a systemic perspective, a literature review by Sverdlik, Hall, McAlpine, and Hubbard (2018) identified crucial factors influencing doctoral student completion, underscoring the significance of subjective attributes such as motivation, self-efficacy, and self-regulation. Additionally, Lozano-Blasco, Romero-González, and Soto-Sánchez (2024) emphasized self-esteem and resilience as critical factors facilitating successful academic progress. The ability of individuals to balance their personal and professional responsibilities amidst the emotional and workload demands of doctoral studies further complicates this landscape.

Beyond individual contributions, the training programs themselves wield considerable influence, particularly concerning the mentorship provided during the dissertation process. Institutional support is of paramount importance, encompassing the opportunities and conditions offered by training institutions to foster academic socialization, which ultimately affects the retention and completion rates of doctoral students.

Lozano-Blasco et al. (2024) identified sociodemographic variables including sex and age that significantly affect doctoral student success. Moreover, Dobrowolska et al. (2021) adopted a systemic approach to analyze the quality of doctoral education, outlining three levels of evaluation: (a) structural factors,

such as the qualifications of doctoral candidates and their professors; (b) process-related factors, encompassing the contents and resources of doctoral programs; and (c) outcome-related factors, focusing on competencies acquired and participant satisfaction.

Another cluster of studies scrutinized various components of doctoral training to understand how they contribute to the development of essential research skills. Young et al. (2020) identified three pivotal processes affecting doctoral education: (a) the nature of the relationship between students and their advisors, (b) the technical characteristics of the mentoring relationship, and (c) the dissertation process and the conditions that shape it.

Further underscoring this landscape, research has highlighted that well-organized doctoral programs with diverse curricular opportunities better equip students with the development and application of critical research skills, particularly in analysis and communication, while simultaneously promoting subject-matter expertise (Hill & Thabet, 2021; Xu & Vivien Chan, 2023).

Given its role at the intersection of training, research, and society, another important theme in doctoral studies is employability outcomes for PhD graduates. This aspect remains contentious, as academic job markets often lack sufficient opportunities, leading to career trajectories that diverge from PhD holders' theoretical expectations.

These considerations prompt inquiries into the evolution of doctoral research and whether a cohesive field of study exists, particularly considering the societal relevance of doctoral degrees. This systematic literature review seeks to provide critical insights into these questions.

### **First period: Prior to 2000**

Two papers published before 2000 were included in this review. Both address different topics, which opens up issues that will continue to be addressed in later periods. The first (No. 1) refers to the link between doctoral training and future employability of doctors. The second (No. 2), on the other hand, points to the doctorate as a training program, asking about the increase in the dropout rate of students who do not continue their studies until they obtain their academic degree and their contribution to this difficulty, considering the structure and differences between the PhD and the EdD.

It is interesting that, despite the fact that both studies address different research objects, their conclusions are convergent. In both cases, the analysis of information refers to the question of what the fundamental contents and

skills should be for doctors to enter the labor market, including options that go beyond academia, as in the case of industry, or what type of professional development is involved in doctoral training, in addition to purely academic competencies.

## **Second period: 2000- 2010.**

During the following decade, the articles selected in this literature review maintained the two thematic axes described in the previous period and added a third.

Regarding the first axis, the three articles that were classified in it (N° 6, 7, and 8) reflect on the way in which the doctorate in general or certain designs of it enhance or not the labor market insertion or the link with the market. For example, Article 6 seeks to establish differences in labor market success between a traditional doctorate and an industrial doctorate. Similarly, Article 8 asks what contributions the doctorate in engineering provides to the market compared to other academically inferior degrees such as undergraduate or master's degrees. Meanwhile, seven addressed a similar situation, but in the field of law, asking whether the doctorate is the best type of training for working in higher education.

In relation to the second axis, three topics were addressed, one of which had been worked on in the previous period: What are the fundamental components and the study plan required for a quality doctoral program (N° 13)? Meanwhile, the other two papers incorporate new topics, since one deals with the analysis of the contribution offered to doctoral training by the figure of doctorate by publication (11). Article 12 reflects on a particular aspect of the doctoral training process: the existence of and contributions made by training in teaching.

From the review of articles from this period, a third area of research interest with respect to doctoral programs was identified, which is related to the link between these programs and society. This field includes regulatory and policy mechanisms linked to this type of program as well as a search to identify their social value. Two articles were included in this axis during the analysis period. The first (10) evaluates the "governance" devices of doctoral programs that have incorporated different public policies through which they identify expected academic results and incentives to achieve them. The second question (9) asks what social and economic reasons societies invest in the development of doctorates, understanding that, for this to occur, they should offer economic and social retribution.

Some argue that the production of PhDs generates benefits for society. The production process helps to generate basic knowledge from which everyone benefits, whereas the results help boost the productivity of those with whom they work. The gains to society as a whole are greater than the sum of the gains for PhDs and their immediate employers.

### **Third period: 2011 to 2015.**

The second decade of the 2000s was prolific in terms of the number of publications relevant to PhD studies. For this reason, they were divided into shorter, five-year periods. Nineteen papers published between 2011 and 2015, there were 19 papers that were analyzed. Of these, a clear majority focused on the academic aspects of the doctorate—that is, on the second axis of analysis. Within this area, one aspect that arouses interest is the supervision or mentoring relationship between the student and the professor who accompanies him/her in his/her research. Strikingly, this topic was not present in the selected texts of previous periods. The characteristics of this link were the focus of most analyses, considering that both Articles 22 and 33 analyzed the existence and approach to disagreements between the members of this link, while Article 23 evaluated the mentoring capabilities of thesis supervisors, and Article 32 studied how the institutional environment influences the characteristics of supervision.

The results of the present study imply that disagreements between doctoral supervisors and students occur, and the nature of these disagreements changes over time within doctoral education. When they occur, they can be summarized into five categories: major decisions, out-of-date supervisors, questionable advice, mediation between supervisors, and interpersonal relationships. Portions of this material may be viewed on the Internet with the written consent of the informants. (Paper 22: p. 2).

Another aspect identified in the works of this axis is the doctoral thesis, especially considering its quality attributes or aspects that should be present in its evaluation. Paper No. 21 analyzes a doctoral program to characterize its evaluation processes and advantages. Similarly, paper No. 26 proposes a set of criteria that must be safeguarded to have high-quality doctoral theses.

During this period, research addressing the doctorate by publication modality appeared. Both articles, N°17 and N°19, study its characteristics and, unlike the approach presented in the previous period, coincide in a critical judgment regarding its pragmatism and linkage with the neoliberal approach to education, considering the risks involved in doctoral training.

The articles on this axis addressed two additional topics. The first is new in relation to previous periods because they allude to aspects related to internationalization and link with the environment of doctoral programs. One (N°24) dealt with the mobility of students arriving in Australia and the training difficulties generated by these students. Another (N°16) studies the existence of networks of academics who relate to each other through their participation in doctoral theses. Other formative aspects analyzed in this period were related to strategies or focuses for doctoral training (participatory action research, N°18; systematic literature reviews, N°28), the specific reality of the doctorate in a specific area (nursing, N°43), and distinctions between types of academic and industrial doctorates (N°27).

In this period, the first axis was less present in the publications analyzed, but not for that reason. Three articles were reviewed, which, in contrast to the previous axis, maintained the focus of the analysis of the previous periods. In particular, there is a need to establish a link between attainment of a doctoral degree and future employment trajectories or opportunities. Article 14 analyses the value that doctors place on money or prestige in the institutions in which they work, while Article 32 compares the training received by doctors of nursing with the labor needs of employer institutions, as in Article 31, which analyses the phenomenon of overqualification of doctors. Finally, No. 34 returned to the different possible career paths of doctors and understood their options for employment in the private sector.

Finally, regarding the third axis, although one study was identified, its less central place in the debate was maintained. In this case, the article deals with the growth of the doctorate in a specific country, South Africa, and its implications and explanations.

#### **Fourth period: 2016 to 2020.**

In contrast to the previous period, the second half of the 2010s had a greater number of papers related to the first axis of analysis, which referred to the trajectories of PhDs and the link between PhDs and employment. Eight articles dealt with this area of interest, most of which considered the future employment of graduates from this type of programme from a critical point of view. For example, Article 42 addresses the phenomenon of overqualification, showing a mismatch between the programs, the expectations they generate, and the real conditions of the labor market to absorb this workforce. From a similar perspective, paper No. 45 shows a decrease in the possibilities for PhDs to work in academia, especially in areas other than exact sciences. Maintaining concern for the future employability of doctoral programs, papers N°48, N°49,



N°51, and N°52 do so from the perspective of the trajectories of people who undertake the doctorate, emphasizing their condition as subjects. One aspect that these papers refer to is the expectations of these people, the gaps they identify between them, and the situation of the programs in which they study or their subsequent work trajectories. The effect that this generates is analyzed by identifying the most relevant desertion of the studies themselves.

The presence of the second axis significantly decreased in publications during this period. Articles 24 and 46 analyze specific programs or particular fields of knowledge to identify strengths and weaknesses in their structure and operation. Two papers referred to the role of specific topics within the programs, such as academic entrepreneurship (N° 15 and N° 38), while the other two discussed the contribution of considering specific tools or methodologies in the training process, such as the use of technologies or coaching (N° 35 and N° 38). Article 51 seeks to generate an integral vision of the factors that favor student satisfaction with respect to the doctoral program that they are pursuing, considering pedagogical, psychosocial, and educational project variables.

Finally, the third axis has a greater presence than in the previous period. Three articles dealt with aspects related to the relationship between the doctorate and society, but again using different approaches. Article 36 analyses the phenomenon of international mobility among Chinese students, considering their contributions and risks to the development of knowledge in that country. Meanwhile, N°39 studies the growth of the doctorate in Africa in terms of other works of the previous period, asking how this can be linked to national development strategies. Item 41 specifically addressed the difficulties faced by Mexican women academics in their academic development in the U.S. academic context.

### **Fifth period: 2021 to 2024.**

In the last period of the analysis, there were fewer articles in relation to the previous ones. However, in the five selected papers, the three thematic axes accompanying this review were identified. Regarding the first, No. 53, it analyzes the doctorate and postdoctorate in engineering, asking about the attainment of permanent teaching positions and the initial salaries of these researchers' careers, and inquiring about the characteristics of their training.

Regarding the second axis, the pattern is repeated in that, despite being present, the topics addressed with respect to the training process are different from each other and from those observed in previous periods. Article 55 provides a detailed review to characterize the initiatives oriented towards

academic integrity within doctoral programs, as well as the people who participate as instructors. Meanwhile, N°57 analyzed the perceptions of doctoral students regarding a work-integrated learning (WIL) methodology.

Finally, two papers analyzed the relationship between society and the doctorate, and one of them reiterated the concerns addressed in previous periods. Specifically, Article N56 delves into the phenomenon of internationalization and growth of doctoral degrees in the world, noting a greater flow of international doctoral students, the desire of universities to become world class, and the adoption of more standardized structures and practices for doctoral education. Paper No. 54 studies the impact of the COVID 19 pandemic on doctoral students, specifically analyzing the characteristics and frequency of doctoral thesis supervision processes.

## Conclusions

The literature review demonstrates a consistent presence of the three thematic axes identified throughout the analyzed periods, indicating that research on doctoral education maintains relevance and diversity. Of these axes, the link between doctoral training and employability displayed the most sustained focus over time, revealing a stable concern for the needs and characteristics of the labor market.

There is an ongoing concern regarding the alignment, or lack thereof, between doctoral education and the expectations of various sectors. The findings suggest that while significant attention has been directed towards improving the quality and relevance of doctoral programs, there remains a pronounced issue of overqualification among graduates and a persistent gap between the skills acquired during their studies and the requirements of employers.

Moreover, the second thematic axis, which focused on the training process, did not reveal stable or recurrent research focus. Although numerous studies have investigated the factors contributing to the success or quality of doctoral programs, the findings vary widely, indicating a lack of consensus on what constitutes effective training methodologies and practices. A notable area of growth was the exploration of the student-supervisor relationship, highlighting its significance in shaping doctoral experiences and outcomes. The third thematic axis links doctoral education to the broader societal context. The review indicates a transition in focus from generalized questions about the social value of doctorates to specific inquiries regarding their role in a globalized world. This trend reflects an increased awareness of the need for doctoral programs to adapt to the changing societal demands and workforce needs.

Given these insights, the following question arises: can we speak of the doctorate as a field of study? The evidence compiled suggests that while there is a body of research addressing various aspects of doctoral education, it has not yet been consolidated into a cohesive field. Only the employability theme shows consistent recurrence as an object of study, although it lacks significant evolution in treatment and outcomes. Additionally, critical judgments emerge regarding the literature's tendency to address isolated related to doctoral programs. This highlights the need for future research to establish interdisciplinary frameworks that sufficiently encapsulate the intricate nature of doctoral training within evolving educational and societal landscapes.

To advance the research agenda on the doctorate as an area of study, further investigation into the profiles and research endeavors of those pursuing doctoral programs is warranted. Understanding their motivations, experiences, and contributions to the academic community is instrumental to determining the value and impact of doctoral education. Moreover, there is an urgent need for more robust evidence and analyses of doctoral education as a formative process, particularly considering the number of individuals pursuing advanced degrees and societal investments involved. Conversations focused on improving research training and enhancing doctoral experience should become a priority, with the educational sciences positioned to provide valuable insights and recommendations.

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# School Leadership Training: Enhancing Well-Being

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## Introduction

Comprehensive education helps current and future generations to be able to make decisions consistent with their sense of life. Its concretion depends on the deployment of all the educable dimensions of the learner and of certain cognitive and socioemotional capacities essential to face the demands of the 21st century. It also depends on educators understanding their professional practice from a purposeful leadership, based on a growth mentality, from which they can boost the unfolding of each student's potential. There is evidence that the exercise of this style promotes teaching and learning processes in which greater individual and collective flourishing prevails, manifested in: the acceptance of mistakes as a generator of positive changes and growth; the assumption of challenges; the development of greater persistence; and other positive habits that are necessary to achieve, as a community, overcoming goals (Lin *et al.*, 2022; Lyons, 2022).

The study explores the levels of flourishing, perceived emotional intelligence (PEI), grit, and growth mindset among school principals and senior staff at Normal Schools in Buenos Aires (CABA) who participated in leadership training designed to foster a growth mindset. To frame the paper's rhetorical structure, this sequence is adopted: (a) conceptual synthesis of the study's main variables; (b) overview of Normal Schools, focusing on their characteristics and (c) detailed presentation of the methodological design employed in the study.

## Flourishing, Perceived Emotional Intelligence, Grit and Growth Mindset

The flourishing approach' initial conceptual foundation is connected to ancient Greece; it was Aristotle who coined the term *eudaimonia* to refer to a full life,

expressed in growth and in finding meaning in life. Fullness, attain excellence of character, can be achieved by every person to the extent that makes rational and prudent choices, exercises persistent practice (Balaguer et al., 2025). Its focus is placed on the present, there is an explicit interest on the part of public agencies, academics and educational institutions in promoting a true comprehensive education and in fostering the flourishing of each student. It is worth mentioning the recent UNESCO reports in which it's covered from different angles (De Ruyter et al., 2022); or the Declaration of the 10 success criteria for flourishing (Kristjánsson et al., 2023).

In the eudaimonic tradition, the PERMA model aligns closely with the core principles of Positive Psychology, with its name derived from the variables that make it up: (a) Positive Emotion (PE), the experience of pleasant emotions and feelings; (b) Engagement, how the subject is involved with family, social, work, professional environment, etc.; (c) Positive Relationships (PR), the ability to have healthy bonds with the environment, social networks, give and receive support; (d) Meaning, having a reason for which to live; and (e) Accomplishment, the satisfaction of reaching a goal. (Waigel & Lemos, 2023).

PEI describes how people perceive their abilities to recognise, use, understand and regulate emotions grounded in Mayer and Salovey model: the ability to accurately perceive, use, understand, and regulate emotions to foster emotional and intellectual growth. (Fernández-Berrocal et al., 2004). They recognize: (a) attention: the degree to which attention is paid to feelings/emotions; (b) clarity; how emotions are perceived; and (c) repair, the capacity to regulate emotions.

Duckworth et al. (2007) define Grit as the ability to achieve long-term goals with passion and perseverance, overcoming difficulties. It consists of: Consistency of Interest (CI), the propensity to choose a goal and maintain it and Perseverance of Effort (PE), working with intensity, independently of obtaining external stimuli. She deepened the study by validating the Grit-O scale. Grit can be developed autonomously and through educational action (Daura & Barni, 2024). Growth mindset (GM) individuals believe that their abilities can be developed through effort, strategy and feedback, in contrast to those with a fixed mindset, who consider intelligence as a static capability. It influences how individuals deal with challenges, error and failure: while the fixed mindset tends to avoid situations that challenge their ability, the growth mindset promotes perseverance, resilience and continuous learning. In educational contexts, fostering this mindset has proven to be a key factor in the development of personal potential (Dweck, 2006).

Regarding these variables, evidence has been found on the correlation between them; grit and leadership (Doria, 2022); grit with growth mindset (Lyons, 2022) in other geographical contexts. No prior research addresses the comprehensive integration of all four constructs together. The focus of the latter could serve as a background that enriches the pedagogical project of educational institutions, enhance school climate, and strengthen teaching relationships within them.

## **Purposeful Leadership**

The concept of leadership has evolved significantly, along social, cultural and organisational dynamics. Once understood as the ability to influence through authority and control. This perspective has broadened its focus to more human/ethical dimensions, recognising the importance of values, shared vision and purpose in the running of organisations. Purposeful leadership is the ability to guide institutional action towards collective objectives that transcend individual interests. It is based on ethical values, a shared vision and a vocation of service, seeking to benefit the organization and the social environment (Fullan, 2020). The author proposes leadership focused on deep, ethical and sustainable change, transforming the institutional culture based on collective commitment and a focus on the common good, highlights leadership based on humility and constant learning. In another study, the results show a significant link between administrative leadership and teacher performance (Jáuregui Elésperu *et al.*, 2022). The term is not mentioned but it is possible to identify aligned concepts. They highlight that leadership styles fostering participation and transformation in the educational environment can be considered a form of purposeful leadership, as they seek to involve teachers in decision-making and in a shared vision. The importance of the motivation and emotional support that principals provide to teachers is stressed, emphasising the creation of a meaningful work environment and solid interpersonal relationships. Ribeiro *et al.* (2024) address the concept, noting its importance, stating that this type of leadership focuses on creating a shared sense of direction and meaning, transcending mere task administration and identify several key mechanisms to foster a positive organizational environment.

## **The Normal Schools of the Autonomous City of Buenos Aires**

The Direction of Normal Schools is part of the Ministry of Education of the CABA aiming at supporting and strengthening pedagogical and institutional administration within its coordinated centers. These institutions function as integrated academic units, offering four consecutive educational levels (initial, primary, secondary, and tertiary teacher training programs). Specifically,

prepares educators: Teacher Training in Early Childhood Education and Primary Education (officially recognized degrees). The Direction coordinates, supervises and advises the organization, promoting educational quality, professional development, and the design of innovative pedagogical actions aimed at improving learning. They promote an integrative and community approach, in which professional training is articulated with school practice, institutional projects and social commitment.

### **A workshop on purposeful leadership and growth mindset**

Since 2023, the Direction began to prioritize the welfare of its administrators and teachers through a cross-cutting project that included a workshop for management teams of its schools and focused on the development of purposeful leadership and a growth mindset. Its implementation is linked to the strategic plan of the Ministry of Education, which prioritizes the promotion of student and teacher welfare, understanding it as crucial for educational quality. The workshop spanned eight months, was delivered in a blended format, combining in-person sessions with autonomous work. In person meetings were hosted at various schools, selected by the participants. The self-regulated component was structured around creative activities, including reading, analysing texts, videos, online questionnaires, and producing a final group project that involved intermediate submissions organized as a portfolio, with specific deadlines agreed in advance, culminating in an oral presentation at the end. Assessment was procedural, formative, and summative, emphasizing active participation, completion of the assigned tasks, and the quality of the final project.

Descriptive analyses (minimum and maximum scores, mean and standard deviation) were performed to determine the levels of the variables. On the PERMA (flourishing), mean values ranged from 6.70 to 8.65 points, with the highest score being for the variable PR ( $X = 8.75$ ) (Table 1). In the TMMS-24 (PEI), the mean values varied between 25.91 and 29.28 points, the latter being the one corresponding to the Repair variable. In the Grit-O and growth mindset scales, the scores varied; in the former, between 3.52 and 4.18 points, while in the latter, being a single-factor instrument, a single value was obtained.



**Table 1.** Descriptive scores of the PERMA profile in the total sample

| Instrument     | Variables          | N  | Min S | Max S | Media        | SD   |
|----------------|--------------------|----|-------|-------|--------------|------|
| PERMA Profile  | PE                 | 74 | 3.33  | 10.00 | 8.10         | 1.22 |
|                | Engagement         | 74 | 4.33  | 10.00 | 8.29         | 1.27 |
|                | PR                 | 74 | 5.33  | 10.00 | <b>8.65</b>  | 1.00 |
|                | Meaning            | 74 | 4.00  | 7.33  | 6.70         | 0.70 |
|                | Achievement        | 74 | 5.00  | 10.00 | 8.26         | 0.90 |
|                | General Well-being | 74 | 4.69  | 9.81  | 8.44         | 0.89 |
| TMMS-24        | Attention          | 74 | 8.00  | 40.00 | 25.91        | 6.18 |
|                | Clarity            | 74 | 15.00 | 40.00 | 28.96        | 5.70 |
|                | Repair             | 74 | 8.00  | 40.00 | <b>29.28</b> | 6.36 |
| Grit-O Scale   | CI                 | 74 | 2.00  | 5.00  | 3.54         | 0.65 |
|                | PE                 | 74 | 3.00  | 5.00  | <b>4.18</b>  | 0.50 |
|                | Global Grit        | 74 | 2.58  | 4.33  | 3.52         | 0.41 |
| Growth Mindset | Growth Mindset     | 74 | 2.50  | 5.00  | <b>4.23</b>  | 0.51 |

Source: personal elaboration.

A one-way ANOVA examined gender differences in the study variables, significant differences were identified: attention (TMMS-24): participants who chose not to report gender scored higher than those identifying as male or female,  $F(2, 73) = 3.22$ ,  $p = .046$ ). In normative data, the non-specified gender mean falls within the expected range; male participants scored below, while females fell within the normative range. Clarity and Repair: no significant gender differences were found. Mean scores remained within normative levels.

On the other side, statistically significant differences were also observed in the CI variable, of the Grit-O Scale, in favor of males over those who chose not to report gender, since they reached the highest mean score [ $F(2, 73) = 4.281$ ,  $p > .018$ ]

A one-way ANOVA was conducted to assess differences in flourishing, PEI, grit, and growth mindset according to job seniority. The only statistically significant finding emerged for the PERMA "Achievement", with those holding their role for 5–6 years scoring higher than other tenure groups,  $F(3, 70) = 2.97$ ,  $p = .037$ . For clarity, Figure 3 displays only the Achievement scores.

The descriptive analyses carried out showed a profile of general well-being with a high score for the entire group, characterised by the experience of PE,

the capacity to get involved with the commitments and decisions made, the establishment of healthy relationships and the possibility of enjoying the achievements attained. Of the five dimensions of the PERMA, the one that obtained the lowest score is 'meaning', which would express the difficulty that the participants have in finding a reason to live. Regarding PEI, the administrators demonstrated adequate levels across all dimensions, with a stronger capacity for emotion regulation. Concerning grit, the CI factor scored lower compared to the PE factor. Due to the edges that the first factor guards with motivational aspects, this effect could be related to the index reached in the Meaning variable, the lack of it could decrease the motivation to prioritise long-term goals. A mean growth mindset scores around 5 (1–5 scale) suggests that participants are well-positioned to face challenges, learn from mistakes, and persist through difficulties. The variance analyses conducted to verify gender-based differences in the variables revealed statistically significant differences only in Attention, favouring those who did not disclose gender. This trait may offer both advantages and disadvantages depending on how emotional states are regulated—attending to emotions without proper regulation may lead to their amplification. Significant differences were found in the CI factor, favouring males and suggesting they may be better positioned to select and maintain long-term goals. The analyses conducted by seniority revealed statistically significant differences in the Achievement variable for those with 5–6 years in the position. This effect may stem from the knowledge and skills developed, enabling them to meet daily challenges and overcome difficulties effectively.

This study focuses on analysing the levels of flourishing, PEI, grit, and growth mindset among administrators of Schools, who participated in a pedagogical initiative centred on purposeful leadership and a growth mindset. It is important to note that, given the stage of implementation, the results presented here correspond to participants' scores from the first administration of four scales measuring the study's key variables.

## Conclusions

Following data analysis, no significant differences emerged across the variables comprising flourishing. Notably, all participants reported high overall well-being, with a mean score of 8.44 (indicative of strong personal and professional functioning). A similar pattern was observed for Growth Mindset, where all participants attained high scores and differences by gender were not significant. Regarding PEI, female scored higher across all three TMMS-24 dimensions indicating they are more adept to using and regulating emotional responses. In contrast, male administrators demonstrated greater skill in the CI

dimension, suggesting a stronger ability to set and pursue distant goals; an effect possibly related to sociodemographic influences in the local context. The subjects with between 5 and 6 years of seniority in the position were those who scored highest on the Achievement factor that integrates flourishing. This effect would reflect the fact that the work experience acquired in this period would serve to learn from the experience and enjoy the positive or negative results obtained; unlike those who are novices or veterans in the position, in whom inexperience or acquired expertise would not play in favour of savouring the learning achieved. Although these effects would be beneficial, they stand out for their innovative nature, as this is the first study carried out with this population, addressing flourishing, PEI, grit and growth mindset. They provide a 'snapshot' of the levels of each of these variables in school principals participating in a training proposal.

In relation to the limitations of the study, the possibility of having investigated other socio-demographic variables in the questionnaire designed *ad hoc* can be mentioned; and the triangulation of the evidence obtained in the first application of the scales with a second administration. Undoubtedly, the results obtained will be enriched with new questionnaires and other qualitative instruments that allow the triangulation of the information.

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# Hybrid higher education in Ecuador: post-pandemic trends

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## Introduction

Ecuador's higher education system has undergone a shift toward hybrid and virtual learning, a transformation that the COVID-19 pandemic has accelerated. These modalities offer enhanced flexibility, which is crucial for diverse student populations, including working professionals and those with mobility constraints (Álvarez-Chaves & Saborío-Taylor, 2025; Lara-Tambaco *et al.*, 2023). However, this pivot also highlights significant challenges, such as technological disparities and the need to sustain student motivation (Petchamé *et al.*, 2023). This study analyses the state of these programs in early 2025, examining their distribution, disciplinary trends, and institutional adaptations in response to the post-pandemic demand.

Before the COVID-19 pandemic, Latin America lagged in digital education, with only 19% of programs being fully online and 16% being blended. By August 2021, Brazil had only five hybrid universities nationwide (World Bank, 2021). Ecuador's 46% adoption by 2025 surpasses these baselines, although urban concentration remains a concern. Across Latin America, pre-existing structural inequalities were exacerbated during the pandemic: students from lower socioeconomic backgrounds often lacked reliable Internet, devices, or suitable learning environments, while privileged students maintained academic continuity (Ferreira *et al.*, 2017). Private institutions adapted more swiftly to technological demands than public universities, which are constrained by infrastructure and bureaucratic limitations, highlighting the region's ongoing tension between expanding access and maintaining quality (Bernasconi & Celis, 2017).

## Ecuador's higher education context

Ecuador's higher education system has undergone substantial reforms since the 2008 Constitution and the 2010 Organic Law on Higher Education (OLHE), which aimed to enhance quality and equity (Asamblea Nacional del Ecuador, 2024). However, economic austerity under President Lasso's 2021 administration, marked by a 10.9% GDP decline and reduced public spending (Curvale, 2021), as well as subsequent political instability and economic stagnation, limited educational resources. This outlook is further compounded

by pre-existing faculty shortages and curriculum misalignments with the labor market's needs (Guerrero-Quíñonez et al., 2023).

The swift adoption of technology in higher education presents opportunities for innovation and adaptability; however, it often intensifies existing socioeconomic inequalities. Students, particularly those from low-income backgrounds, face significant barriers, including balancing academic responsibilities with work and family obligations, which leads to high dropout rates (Silva-Martínez et al., 2023). Pronounced learning gaps persist between urban and rural regions, as well as across ethnic groups, underscoring the urgent need for equitable outcomes (Velasgui-Hernández et al., 2024).

The pandemic spurred the rapid adoption of hybrid and virtual models, which initially expanded access and enabled personalized learning through adaptive tools (Culqui et al., 2024). However, this digital shift is coupled with a significant digital divide. Limited internet connectivity, device scarcity, and insufficient digital skills are prevalent among students and educators, particularly in rural and underserved areas (Benalcázar et al., 2021).

Ecuador's evolving educational landscape represents a dynamic tension between technological advancement and the imperative for equity. Achieving successful and inclusive hybrid modality implementation requires not only addressing infrastructural limitations but also proactive policies to narrow the digital divide and ensure that technology serves as an equalizer rather than a new source of disparity in higher education access and quality.

## **Analytical Approach and Data Context**

This chapter draws on the national register of officially approved higher-education programs in Ecuador as of February 5, 2025. Because it includes every program ever registered—both active and inactive—the dataset functions as a population census rather than a sample, offering a comprehensive view of how the system has evolved. The information comes from SENESCYT and follows the definitions established in Ecuador's Organic Law of Higher Education (LOES), reformed in 2024, and operationalized through CES regulations in 2023. The regulatory framework distinguishes six delivery modalities, ranging from fully on-campus to fully online, with several hybrid variants that combine different proportions of face-to-face instruction, virtual components, and workplace-based learning. These official categories—not ad hoc classifications—structure the analysis throughout.

The chapter pursues three objectives: tracing how programs with virtual or hybrid modalities have evolved at both undergraduate and graduate levels

before and after the pandemic; identifying patterns across disciplinary areas, provinces, types of institutions, and financing models; and situating Ecuador's experience within the broader Latin American and international context. The analysis is descriptive. The registry provides only a snapshot of program status as of February 2025, without historical dates, limiting year-by-year analysis. However, comparing active and discontinued programs reveals a shift from predominantly in-person offerings to a more diverse digital landscape.

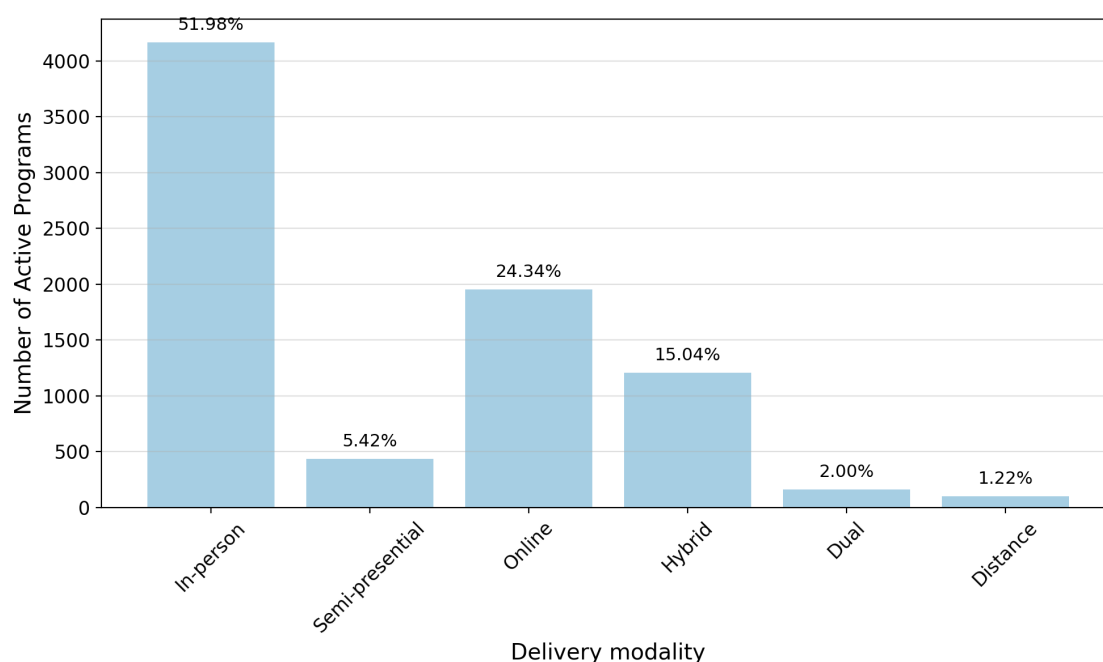
### **Trends in Ecuador's Hybrid and Virtual Higher Education**

Ecuador's national registry of 20,045 officially approved higher-education programs—including both active and discontinued offerings—reveals a transition from traditional to digital formats. The contrast between these two categories shows how recent this shift has been: among discontinued programs, 73.14% were campus-based, while only 2.46% included online or hybrid components. As of early 2025, 46.02% of active programs are non-presential—exceeding pre-pandemic baselines in Latin America, where only 19% of programs were online and 16% blended. This indicates that the growth of digital and blended modalities is a post-pandemic phenomenon.

Figure 1 situates this shift within Ecuador's current program landscape: among the 8,014 active programs registered in early 2025, traditional face-to-face delivery still accounts for just over half of the national offer (51.98%). Non-presential formats make up almost the entire remainder, complemented by a small share of dual-mode programs that combine classroom instruction with workplace learning. Compared with pre-pandemic regional patterns, Ecuador's current distribution suggests a faster and more extensive move toward digital modalities.



**Figure 1.** Active Higher Education Programs in Ecuador as of Feb 5, 2025 (N=8,014)



An analysis of Ecuador's active programs revealed structural shifts across delivery modalities. Figure 2 shows the degree-level distribution, with postgraduate programs dominating digital formats (50.27% fully online and 43.5% hybrid offerings) while comprising 27.08% of in-person programs. The inverse pattern appears in dual delivery programs, where short-cycle Technological Superior dominates (87.95%), confirming its work-based learning niche. Notably, in-person education maintains the broadest spectrum across all six program levels (including Undergraduate/Grado and Pre-grado, Technical/Technological Superior, and postgraduate tiers), suggesting the digital shift complements rather than replaces traditional modalities.<sup>1</sup>

<sup>1</sup> Ecuador's national registry preserves legacy nomenclature for undergraduate and short-cycle programs. "Grado / Tercer Nivel / Pregrado" refer to four- or five-year licenciatura degrees, while "Técnico Superior / Tecnológico Superior / Tecnológico Superior Universitario" denote two- to three-year technical or technological diplomas delivered by different provider types.

**Figure 2.** Active Higher Education Programs in Ecuador by Delivery Modality (% as of February 5, 2025)

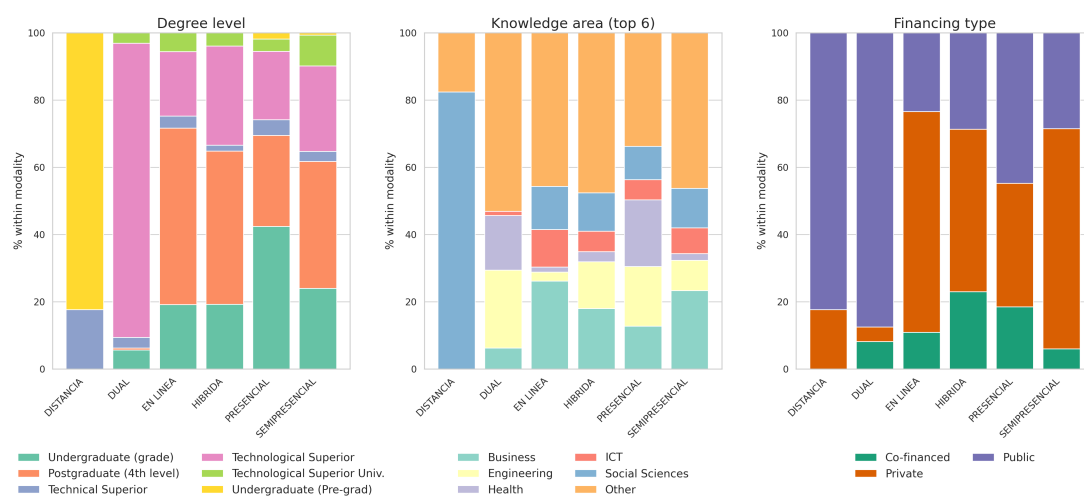


Figure 2 shows differences in how disciplines and institutions are using digital modalities in Ecuador. Information and Communication Technologies and Business and Administration are the areas most expanded in online and hybrid formats, reflecting both the demand for technology-related training and the flexibility of managerial fields. Health and Well-being remains mostly in person because of clinical requirements, while Engineering keeps a largely face-to-face base with gradual movement toward blended and online options. Education appears fairly even across formats, and the group of humanities, arts, and social sciences maintains a smaller but varied presence. These disciplinary patterns are mirrored in the institutional landscape: private universities now carry most of the growth in online and hybrid programs, whereas public institutions continue to concentrate the bulk of in-person offerings and participate more selectively in digital expansion. Co-financed providers contribute only marginally.

The geography of program delivery reflects where higher-education infrastructure is concentrated: provinces with major hubs offer the full range of modalities, while other regions tend to adopt hybrid models first, followed by online expansion. Pichincha and Guayas are Ecuador's twin higher-education hubs, offering programs across all modalities but differing in emphasis. Pichincha continues to anchor the face-to-face model and holds the largest share of hybrid programs, while Guayas leans more heavily toward fully online offerings—nearly 59% of its non-presential programs, compared to 52% in Pichincha. Outside these two hubs, provinces such as Manabí, Azuay, and Tungurahua show more hybrid than dual or distance programs, suggesting

institutions are testing blended formats before moving to fully online. Dual programs remain limited and mostly concentrated in Pichincha, Guayas, and Azuay, reflecting where technical institutes and industry partners are strongest. Traditional distance learning persists mainly in Tungurahua and Pichincha, pointing to the survival of older correspondence-style models in parts of the central region.

Among institutions with at least ten active programs, specialization in delivery mode is evident. Some providers remain classroom-based—Conservatorio Superior de Música Rimsky Korsakov offers all its programs in person, while Universidad del Río delivers nearly two-thirds of its 108 programs face-to-face. Others lean heavily toward digital formats: Universidad Bolivariana del Ecuador offers 86% of its programs virtually, and Universidad Técnica Particular de Loja delivers over half of its 109 programs online. Hybrid models also have dedicated providers, including Instituto Almirante Illingworth and the intercultural university Amawtay Wasi, both of which rely heavily or entirely on blended formats. This specialization reflects the diversification of Ecuador's higher-education landscape, with many providers adopting digital or blended models while a few retain a face-to-face identity.

The data reveal Ecuador's accelerated shift toward hybrid and virtual modalities, with nearly half of all active programs being non-presential, surpassing pre-pandemic Latin American averages of 35% (World Bank, 2021). Supported by recent regulatory frameworks (Asamblea Nacional del Ecuador, 2024), this growth reflects a pursuit of academic flexibility, as highlighted by Álvarez-Chaves and Saborío-Taylor (2025), who emphasize hybrid models' potential to enhance access without compromising pedagogical quality. However, the urban concentration of these offerings in Pichincha and Guayas, coupled with socioeconomic barriers and limited rural Internet access (SENESCYT, 2025), underscores a gap between technological expansion and educational equity, as noted by Benalcázar et al. (2021) and Silva-Martínez et al. (2023). The prevalence of private institutions in online programs aligns with Bernasconi and Celis (2017), who highlight their adaptability amid public universities' structural constraints in austerity contexts. The preference for hybrid over fully virtual modalities suggests a strategic balance between innovation and pedagogical presence, as Culqui et al. (2024) observe in Ecuador. These contrasts call for policies that promote digital expansion while ensuring inclusion, echoing World Bank (2021) recommendations for infrastructure and faculty training investments.

## Conclusions

Nearly half of Ecuador's active higher-education programs use non-presential formats, exceeding pre-pandemic Latin American baselines. The contrast between discontinued programs —over 70% campus-based— and current offerings suggests this growth is a post-pandemic phenomenon. The prevalence of hybrid modalities over fully virtual programs indicates a preference for flexible learning that combines in-person engagement with digital platforms. This pattern is most evident in Administration, Engineering, and Information and Communication Technologies, while Health programs remain largely face-to-face due to clinical requirements.

Universities have led this process, with technical and technological institutes gradually expanding hybrid options at the undergraduate level. Private institutions account for most online and hybrid programs, while public universities remain concentrated in face-to-face delivery—consistent with the economic constraints discussed earlier in this chapter. Digital programs concentrate in Pichincha and Guayas, with other provinces adopting hybrid formats before moving to online offerings.

Whether hybrid and online modalities can broaden access remains an open question. Limited rural connectivity and the fee structures of private providers may constrain who can benefit from these programs. Ecuador's experience aligns with Latin American trends in digital learning, though whether these modalities contribute to educational equity will depend on how infrastructure gaps, faculty preparation, and the diversity of student needs are addressed.

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# Quality of professional training as perceived by graduates of a Faculty of Information Science and Technology at a public university in southeastern Mexico

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## Introduction

Analyzing higher education in all its aspects and concepts is crucial to creating virtuous circles that foster greater societal development. Therefore, analyzing human capital formation and its relevance concerning employability is an important study for understanding the impact and relevance of educational programs at the higher education level.

This chapter focuses on the results of a follow-up study of graduates from the Academic Division of Information Sciences and Technologies (DACyTI) at the Juárez Autonomous University of Tabasco (UJAT), specifically their professional training and perceptions of their employment opportunities and professional performance.

The analysis focused on graduates' perceptions of the profitability of their academic training, considering not only income levels but also aspects such as job stability and security, professional development opportunities, and the alignment between the training received at the university and the demands of the labor market.

The study was conducted in a specific regional context in southeastern Mexico, where there are structural economic and social challenges, as well as asymmetries with the center and north of the country. The results enable the highlighting of graduates' experiences and utilize them as a valuable source of knowledge, providing feedback to academia and supporting and informing institutional decision-making to implement evidence-based public education policies.

The training of high-level human capital is the central focus of the mission of higher education institutions in Mexico. For this reason, this study seeks to identify elements that attest to the relevance of the educational programs offered by DACyTI.

This research presents relevant data that triggers individual and collective reflection on the importance of the university's role in training competitive human capital and its impact on the adequate labor market insertion of its graduates. The conclusions drawn will guide actions both within the UJAT and in sister public institutions facing similar challenges.

The primary objective of this research was to examine the perception of DACyTI graduates regarding the quality of their university education, spanning from undergraduate to doctoral levels. In this sense, the approach was broad, considering the aspects of their education that constitute an essential component in the formation of human capital by developing competencies, knowledge, and skills that help them better enter the labor market and thus establish links with their professional experiences after obtaining their corresponding academic degree.

Based on the above, we sought to identify the level of satisfaction that graduates have with the quality of the educational processes they experienced and the correlation with their current professional performance. We must recognize that perceptions offer relevant information about the relevance of the educational programs in which they were trained. Additionally, another objective that guided this research was to determine how graduates perceive the economic benefits of their academic training, asking questions about their income, job stability, and career trajectory. This component has enabled the visualization of the link between university education and work activity comprehensively by establishing a connection and consistency between the quantitative approach, represented by salary, and subjective and contextual assessments.

## **Public Policies on Higher Education**

This theoretical framework addresses various aspects related to public policies on quality in higher education in Mexico, the formation of human capital, and rates of return on investment in higher education, thereby contributing to the study of specific issues within a public university's Faculty in southeastern Mexico.

In the Mexican context, public education policies have been a key tool for improving the quality of higher education. These policies have addressed



aspects such as the accreditation of programs and institutions, the enhancement of competency-based education, the promotion of research and collaboration with the productive sector, and the promotion of equity in access to education.

Moreno (2017) notes that the genesis of the evolution of public policies on quality in higher education originated with the expansion of higher education, which occurred mainly in the 1970s and continued into the 1980s. It was during this period that the transition from passive to active negotiation in higher education in Mexico took place, prompted by the crisis facing the country's university system, which was related to the massification of higher education.

The solutions provided by the old management model, consisting of increased public spending on institutions that were not accountable, were unviable. The way out of the crisis was, therefore, to regain political control over social processes, an aspect that, in the case of Mexico, was directly related to the massification of higher education.

The Mexican government then took on a more active role in managing the university system, seeking mechanisms to minimize friction with the universities.

### **Human Capital Theory (HCT)**

The lack of continuity in public higher education policies poses significant challenges in southeastern Mexico. According to Becker's theory of the economics of education (1993), investment in human capital is fundamental to a country's economic development.

The intermittency of public policies, as Brunner (2007) points out, generates instability in the training of professionals, leading to the obsolescence of skills and negatively impacting regional and national competitiveness.

Aronson (2007) defines human capital as the set of intangible assets that contribute to the performance of physical capital (factories, machines). This concept emerged in the 1980s, coinciding with a shift from a focus on material assets to one on competition, which requires problem-solving, creativity, and effective decision-making.

Schultz's Human Capital Theory (1963) emphasizes the importance of quality education in improving productivity and economic growth. Declining confidence in the education system can deter investment in higher education and restrict opportunities for social and economic advancement.

Vecino and Zaldívar (2016) emphasize various concepts associated with human capital and state that it is the bearer of knowledge, which is why it must be taken into account in the expression of the value of products and services, as it has a fundamental responsibility as a differentiator between abstract and concrete work, as well as between complex and simple work. They incorporate professional training and individual skills, as well as the employment situation, in their analysis, considering that a talented person will have better levels of development about the level of knowledge accumulation achieved in their professional training, combined with their work experience and innate qualities, added to the values and ethics that allow them to make a valued contribution to the company or society, indicating their potential for the creation of new products or services.

Becker (1993) argues that individuals and society "invest" in education with the expectation of improving their future productivity and obtaining a return on that investment in terms of higher income. In general, Becker's main contributions to investment in education can be summarized in the following postulates:

- Human capital theory has contributed significantly to understanding the personal distribution of earnings and labor market phenomena.
- Investment in human capital, including education and training, is crucial for both economic development and individual earnings.
- Human capital analysis remains a vibrant field with considerable potential for further research and a deeper understanding of economic growth.
- The distribution of opportunities and skills plays a key role in the observed distribution of earnings.

The results are presented below, along with the information provided by the quantitative instrument applied to 30 graduates of the Faculty of the Higher Education Institution, as well as a comparison of the main findings with other studies related to the research topic.

### **Socio-demographic and Academic Profile**

The socio-demographic and employment data show a wide range of ages among graduates, with an average of 39.6 years and a considerable standard deviation (10.63), indicating that the population studied ranges from younger individuals who have recently graduated from the Faculty to those with more experience and professional background. It suggests a heterogeneity that

enriches the range of experiences and perspectives expressed by the respondents.

Males predominate at 63%, while the remaining 37% are women. The predominance of males at 63% in the study of Information Technology (IT) graduates raises a relevant and revealing picture of gender dynamics in this field. It is crucial to promote inclusive environments, equitable educational policies, and programs that inspire and support women from the early stages through to job placement in order to reduce this gender disparity.

Academic levels vary, with bachelor's degrees being the most common (47%), followed by master's degrees (27%), doctorates (23%), and specializations (3%). This diversity in academic degrees underscores the importance of continuing education in IT. The significant presence of graduates with postgraduate degrees is also a benchmark of the academic quality of the graduates from this Faculty, which will likely contribute to innovation and advancement in the IT industry at the state, regional, and national levels.

## **Work History**

The average number of years worked since obtaining a university degree is 13.57, showing considerable diversity in work experience.

Current monthly salaries vary widely, with an average of \$17,743.12, which is below the national average salary in Mexico (\$30,000) (CodersLink, 2023). The salary range is reported to be from \$1,200 to \$50,000.00.

The majority (83%) are employed, with a balance between permanent (50%) and temporary (40%) roles.

## **Position and Work Activities**

The roles of respondents in their professional performance vary widely, ranging from providing academic support to developing applications or managing smart devices. Their work activities are divided between operational (44%), academic (40%), and, to a lesser extent, managerial (7%).

The survey results show a diversification and breadth in the jobs held by graduates of this IT faculty, demonstrating remarkable versatility in their job functions. This heterogeneity ranges from activities involving academic functions to application development or equipment management, demonstrating the graduates' ability to handle a variety of responsibilities.

Likewise, the distribution of work activities shows a balanced distribution

between operational and academic functions, with a more minor but significant presence in managerial functions. This balance suggests that graduates not only apply their technical skills but are also involved in academic, development, and leadership activities, reflecting a comprehensive and versatile profile in the workplace.

## Perceptions of University Education

Most respondents agree that the university implements effective policies to improve educational quality.

There is a division of opinion on whether these policies are reflected in tangible improvements in teaching and learning. Belief in the alignment of government guidelines with the university's educational practices is more varied.

The survey indicates a majority perception of the effectiveness of university educational policies. However, there is a noticeable gap between this perception and the evidence of tangible improvements in teaching and learning. Additionally, opinions on the alignment of government policies with the university's educational practices vary, reflecting differing interpretations of their influence.

The research results presented above are consistent with the research of Castelar and Uribe (2001), the Economic Commission for Latin America and the Caribbean (ECLAC) and the United Nations Educational, Scientific and Cultural Organization (UNESCO) (2007), Huerta (2002), Salamanca (2015), and Silva (2008), with highlighting the need for more in-depth studies to understand the actual impact of education on vocational training and the importance of education for socioeconomic development through policies that promote equity and improve educational quality.

## Conclusions

The theoretical basis for this research is Human Capital Theory (HCT). In the case of HCT, this is specified in the theoretical assumptions of Aronson (2007), Becker (1993), Bonal (1998), Boudon (1977), Brunner (2007), Brunner and Elacqua (2003), Cannan (1928), Castillo and Karam (2015), Say (1821), Schultz (1963), Senior (1836), Stuart-Mill (1864), Tedesco (2000), Thurow (1983), Vecino and Zaldívar (2016), and Walsh (1935).

These assumptions can be summarized as follows: investment in human capital is one of the central pillars of economic development; the lack of continuity in public policies generates instability in professional training, which triggers a

loss of competitiveness; it is important to include qualitative elements in the training of individuals to increase their productivity; creativity and decision-making are fundamental in problem-solving; educational quality is closely related to productivity; in Latin America, there is no clear relationship between training and remuneration.

To significantly improve graduates' perception of the effectiveness of IT education policies, it is crucial to implement transparent communication about education policies and establish ongoing evaluations to gather student feedback. Likewise, policies must be adapted to the changing needs of the IT field, integrating practical experiences and promoting student participation in policy formulation and evaluation.

Regarding the limitations of the study, although the research provided evidence that helps in the development of other research, it also had some limitations that can be described as follows:

- The research was conducted from the perspective of graduates of the Faculty of Higher Education.
- The sample of graduates was selected in a non-probabilistic manner.
- The results were obtained through a self-reporting instrument.
- The research was approached from a quantitative perspective and could be further explored from a qualitative perspective.
- The results presented are specific to graduates of a public university in the southeastern Mexican state of Tabasco.

In summary, Human Capital Theory establishes that education is not an expense but a strategic investment that has multiplier effects and generates virtuous circles in social and economic development. This research, within the scope of its reach and limitations, reveals the importance of listening to the voice of graduates so that, in light of their work experiences, academic programs can be enriched and, as a result, better meet the needs of the market and the work environment.

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# Quality, accreditation, and teaching profile: an analysis from higher education in Chile and Latin America

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This review arises from the completion of a research project for the Master's degree in university teaching at the University of the Americas in Chile.

## Introduction

This study critically examines the relationship between the profile of university professors, the quality of higher education, and accreditation processes in the Chilean and Latin American contexts. Through an analysis of various bibliographic sources, we identify how policies guided by criteria of efficiency, standardization, and competitiveness, inherent to business economic models, have profoundly changed both the role of professors and the very meaning of university education.

One of the key elements addressed is the progressive transformation of teaching work, which has shifted from an autonomous and formative approach to a more technical and administrative one. Meeting indicators and targets, often imposed by external accreditation agencies, has placed an additional burden on teachers, shifting their pedagogical work to tasks associated with management and accountability.

It also examines how accreditation processes, far from being mere tools for continuous improvement, have become regulatory mechanisms that affect institutional autonomy and reproduce structural inequalities. Analyzing the different variables raises the need to rethink the teaching profile. Instead of focusing solely on technical skills, it is proposed to recognize teachers as actors with the capacity to influence educational processes and the ethical and social development of students. In this sense, intellectual capital is presented as a key component for institutional strengthening and for moving toward more relevant, inclusive, and contextualized educational models. Continuing education and recognition of cultural and territorial diversity emerge as fundamental aspects of this new approach.

The quality of higher education is a topic of growing relevance in Latin



America, especially in Chile, where educational reforms have transformed the academic landscape. This article aims to explore the interrelationship between teaching profiles, educational quality, and accreditation processes, analyzing how these elements have been affected by a commercial approach that prioritizes efficiency and competitiveness. In an environment where quality is measured through standardized indicators, it is essential to question how these dynamics affect not only the training of future professionals but also the identity and autonomy of teachers. This article seeks to contribute to the discussion on the need for an education that not only meets administrative criteria but also promotes holistic and critical development, adapting to the sociocultural realities of each context

Before presenting the knowledge described in various studies on the research problem, it is pertinent to understand the broad definition of the word quality, a technical meaning of the concept used in business logic. Broad, economic, dynamic, and transversal to the perception of a service as well as a product, it can therefore be defined historically by multiple authors.

Ernesto Ché Guevara (1964, cited in Borrego, 2001) defines quality as respect for the people, Parasuraman, Zeithaml and Berry (1985, 1988) understood quality as the discrepancy between what is expected and what is perceived”.

For others, it corresponds to a way of thinking, a process from start to finish, which should not include defects, with a focus 100% on the client or user. Furthermore, it is directly related to excellence. Lago de Vergara (2014), quoting Miranda et al., states that "it involves the commitment of all members of an organization to achieve the best possible product, using the best components, the best management, and the best processes" (Lago de Vergara et al., 2014, p. 158). Along these lines, García defined transferring quality assessment processes to academic institutions in higher education in 1991 as "the way of being of education that brings together the characteristics of comprehensiveness, coherence, and effectiveness" (Garcia, 1991).

By historically assessing the global, Latin American, and Chilean levels, the National Accreditation Commission (CNA) compiles information on quality assurance (QA).

In Europe, QA has tended to expand from a focus on fitness for stated purpose to a perspective of continuous improvement, to include external assessments to ensure the reliability of the agencies of the different countries and their processes, in order to support the mobility of students and graduates within the region (Comisión Nacional de acreditación [CNA-Chile], 2015)

In Chile, Barrientos and Araya, citing Bruner, mention that "the changes experienced after 1973, where public spending on education decreased between 15% and 35% and universities' own financing increased between 13.5% and 26.9% on average between 1974 and 1980" (Barrientos Oradini & Araya-Castillo, 2018). They highlight the structural changes of the last forty years since the 1980 reform, associated with the technological revolution, commodification, growing supply and demand in academia, in addition to the privatization of production and distribution of knowledge. This reform eliminated public financing, paving the way for the incorporation of companies into political decisions in education. The university law proposed in the 1980s aims to create a competitive system, consequently acquiring an increase in the level of quality and better academic management. Characterizing Chilean higher education according to Bruner and Uribe 2007:

"Due to a high degree of participation of private (non-state) universities, and because their higher education institutions compete for students, resources and prestige, while government policies intervene remotely in order to regulate certain aspects of this market" (Bruner & Uribe, 2007)

On the other hand, the Bologna Treaty, a precedent for all research related to quality in higher education, was established in 1999 in Europe and had a significant impact in Latin America and the Caribbean, aiming to enhance competitiveness that would appeal to students and teachers. It made changes to the curriculum and "adopted a system of university degrees that was easily comparable throughout Europe, which opened up the mobility of students and research professors across European universities, while promoting lifelong learning and the quality of education" (Lago de Vergara et al., 2014). At the Latin American level, Bruner (2008) among other authors mentions the Echoes of Bologna as progress, new forms of analysis, education and quality evaluation, including the possibility of promoting teacher training in addition to incorporating students' perceptions and evaluations in university quality.

Quality Accreditation processes in higher education in recent decades have been influenced by various trends in other institutions around the world. In this regard, (Bernasconi, 2003) argues that global trends, such as the growing economic value of knowledge, self-financing, and privatization, among others, are affecting Chilean universities and, to varying degrees, Latin American universities, which are beginning to adopt policies based on foreign university models.

Thus, the accreditation processes that undoubtedly seek to support the quality processes of education lead to greater demands on teachers, the number of

educational centers with headquarters in different territories grows, and thus the enrollment of these institutions increases, and thus the sustained growth of institutions, where consolidated and innovative institutions coexist with others of dubious quality, eroding social confidence in higher education and in the relative value of the degrees awarded (Pitta, 2014).

According to international research, Colombia links the importance of intellectual capital (IQ) as a fundamental value to ensure the quality of higher education institutions. In their doctoral thesis, Arrieta and Valdés (2020) mention that "management bodies are committed to developing innovative and alternative systems based on intellectual capital, which allow them to have tools that support their growth and enable the implementation of different actions in crisis situations while maintaining their nature" (Arrieta & Valdés, 2020). In relation to the above, governments have implemented quality assessment policies in higher education; accreditation of university programs and curricula, ranking and methods that ensure quality, with IQ being a determining factor for this to happen. Although there is no international consensus on how to measure intellectual capital.

Based on the background presented in research related to quality assurance in higher education and accreditation, the broadness of the concept of quality, mostly used in business logic, is demonstrated. This is a precedent to justify the commodification of education with standards like those of a product: individualistic, based on efficiency, productivity, and competitiveness. Thus, the characteristics of the historical, political, and sociocultural context are forgotten. The human, transformative, critical, and emancipatory value of education is considered secondary, very typical of European colonialist thought based on the dominant culture. The teaching role in quality as in accreditation is essential, even though, as Freire expresses in *Pedagogy of the Oppressed*, "Pedagogical action that favors the interests of the dominant classes is transmuted into a mechanism of domination and symbolic violence, imposing cultural arbitraries that favor class interests" (Freire, 1970).

In this sense, it reflects an exclusionary economic model that does not encourage student participation; rather, it rigidifies the academic curriculum, limiting both the educator and the student, and lowering quality standards in higher education. Following the evidence of the Latin American perspective and the historical-cultural approach, Vygotsky's approaches to education and his relationship of interdependence between learning and human development state that "Humans develop in different ways, because we learn differently in different contexts" (Rodríguez Arocho, 2011).

This raises a different dimension that considers the sociocultural nature of knowledge production, freeing it from rigid standards that must be met with objectively measured technical criteria.

In the opinion of some national experts, quality measurement systems seek to provide students with the necessary information to reduce information asymmetries when choosing a career or institution where they may pursue higher education (Meller, 2006), although it is not actually known whether this information is used and considered an aid by applicants.

The relationship between educational quality and academic accreditation directly influences the profile of university students, determining their competencies, their job placement, and their critical thinking within the educational system. Accreditation, as a quality assurance process, not only establishes institutional standards but also shapes the type of education students receive and the expectations society has of them (Meller, 2006; Zapata, 2004).

First, the quality of higher education impacts the development of students' analytical, research, and professional skills. According to García (1991), educational quality implies the integration of theoretical and practical knowledge that enables graduates to function in a competitive labor market. However, the commercialization of higher education, as proposed by Rodríguez Arocho (2011) and Barrientos Oradini and Araya-Castillo (2018), can generate an overly instrumental approach to teaching, prioritizing work skills over comprehensive and critical training.

In Chile, the accreditation of academic institutions and programs has become a determining criterion for the recognition and prestige of universities. Pitta (2014) points out that the quality assurance system in Chile has evolved from a voluntary approach to a mandatory model, restricting the allocation of funds and student mobility. This has led universities to prioritize strategies to meet accreditation requirements, which sometimes results in excessive standardization of teaching and a reduction in curricular flexibility. Furthermore, access to academic and professional mobility opportunities depends largely on an institution's accreditation status. For Chilean students, this means that their employability and prospects for continuing their studies abroad are strongly linked to the quality and recognition of their university (Pitta, 2014; Zapata, 2004). However, this system can also generate inequalities, as universities with greater resources are more likely to meet accreditation criteria, leaving smaller or emerging institutions at a disadvantage.

Another relevant aspect is the students' own perception of educational quality and accreditation. According to Lago de Vergara et al. (2014), while these processes seek to guarantee minimum educational standards, many students believe that accreditation does not always reflect the actual quality of teaching but rather responds more to administrative and infrastructure criteria. In short, while accreditation is an important tool for ensuring quality in higher education, it is essential that its implementation not only respond to administrative criteria, but also truly contribute to comprehensive and equitable education for all university students (Bernasconi, 2008).

One of the most obvious impacts is the increasing technological development of teaching. The emphasis on quality, understood from a business perspective, dominated by concepts such as efficiency, productivity, and competitiveness, has led teachers to respond to the technical and administrative demands of quality management systems, such as compliance with indicators, goals, and standards defined by external agencies (Parasuraman, Zeithaml, & Berry, 1985; Lago de Vergara et al., 2014).

In this sense, teachers are increasingly viewed as operators of a rigid curricular system rather than as autonomous professionals with the capacity for adaptation and pedagogical creation. This limits their ability to make contextualized and creative decisions in the classroom, restricting their work to meeting pre-established objectives (Rodríguez Arocho, 2011).

The accreditation process has included teachers as key agents for obtaining institutional recognition. Their work is not limited to teaching, but includes participation in institutional self-assessment processes, the preparation of reports, the collection of evidence, and the implementation of continuous improvement plans (Zapata, 2004). This has generated administrative overload and additional pressure to comply with accreditation requirements, which often conflict with pedagogical and training tasks.

Likewise, the tendency to measure educational quality through quantitative indicators promotes a reductionist view of the educational process, which prioritizes the achievement of measurable results over the integral development of individuals. This logic undermines the broader, more humanistic meaning of education, where the teacher is a facilitator of the student's personal, social, and cultural development (García, 1991).

On the other hand, in a highly regulated and competitive environment, teachers' autonomy is limited by the need to meet external quality criteria. Curricular standardization and the pressure to obtain accreditation can generate tensions with teachers' professional identity, forcing them to prioritize bureaucratic or technical tasks over their own pedagogical judgment (Bernasconi, 2003; Barrientos Oradini & Araya-Castillo, 2018).

Faced with these tensions, several authors have highlighted the need to redefine the role of teachers, not as passive executors of the system, but as agents of transformation. From a critical and sociocultural perspective, as proposed by Vygotsky and echoed by Rodríguez Arocho (2011), learning is closely linked to context and social interaction, which requires teachers with critical thinking, ethical commitment, and sensitivity to local realities.

The teaching profile, in this regard, should incorporate a reflective approach that questions power dynamics in evaluation and accreditation processes, promoting a people-centered, culturally relevant, and socially engaged education (Freire, cited in Gil et al., 2018). Furthermore, authors such as Arrieta and Valdés (2020) have highlighted the importance of intellectual capital as a fundamental dimension for quality assurance. This implies that teachers must constantly train and update their knowledge, not only in disciplinary content but also in innovative methodologies, educational technologies, and learning assessment.

Consequently, the teaching profile must balance technical skills with a deep ethical, critical, and contextual understanding of their work. They must be reflective, collaborative, and innovative professionals committed to transformative education that overcomes the limitations imposed by standardized and economic models.

In Latin America, the implementation of quality assurance systems has profoundly reshaped the teaching profile in higher education. This transformation has not been uniform, as each country has adapted accreditation mechanisms to its legislative frameworks, institutional structures, and sociopolitical contexts. However, common trends are observed in all cases: the increase in administrative responsibilities for teachers, the requirement for postgraduate training, and the adoption of roles linked to academic management and institutional evaluation.

## Conclusions

The relationship between teacher profile, educational quality, and academic accreditation in Chile and Latin America is a topic that has gained relevance in recent years, especially in a context where educational reforms have significantly transformed the academic landscape. This interdependence between the elements suggests that any change in one of them will inevitably impact the others, necessitating a thorough and multifaceted analysis.

First, it is important to highlight how the increasing technological and commercialization of education has redefined the role of the teacher. Historically, teachers have been considered educational agents, responsible not only for the transmission of knowledge but also for the holistic development of their students. However, in the current context, their role has been transformed, becoming operators within a curricular system that is often rigid and normative. This transformation has limited the autonomy and creativity of teachers, who are forced to comply with pre-established standards and objectives that prioritize efficiency and productivity over the comprehensive development of students. The pressure to meet quality indicators and accreditation requirements generates tensions that not only affect teachers' professional identity but also compromise their ability to implement pedagogical approaches that foster critical thinking and reflection.

In this sense, accreditation processes, although necessary to guarantee certain quality standards, have drawn significant criticism. While their objective is to ensure that educational institutions offer adequate and relevant training, they often focus on administrative and infrastructural criteria that do not always reflect the actual quality of teaching. This situation has led to a standardization of education that can limit diversity and innovation in teaching methods. Furthermore, inequalities between institutions are perpetuated, as those with greater resources find it easier to meet established requirements. This poses a significant challenge, as educational quality becomes a privilege that not everyone can achieve, eroding equity in access to quality education.

The need for a comprehensive approach to teacher training is therefore crucial. This approach must consider not only the technical competencies necessary for teaching, but also the critical and ethical skills that enable teachers to adapt to the changing realities of the educational environment. Teachers must be seen as transformative agents who foster meaningful and critical learning in their students. This implies that teacher training programs must be reviewed and updated, incorporating innovative methodologies and approaches that promote reflection and critical analysis.

A fundamental aspect in this context is intellectual capital, which emerges as an essential pillar for ensuring quality in higher education. Continuing education and teacher training are crucial for maintaining quality standards that meet the demands of the 21st century. This includes not only mastery of subject matter, but also the ability to implement innovative methodologies and effectively assess learning. Investment in teacher professional development should be considered an investment in educational quality, as well-trained and up-to-date teachers can positively impact student learning.

The Chilean and Latin American education systems therefore face the challenge of balancing the demands of quality with the need for more equitable and accessible education. Educational reforms must be oriented toward a model that values diversity and promotes active student participation in their learning process. Fostering ongoing dialogue among the various stakeholders in the education system, including teachers, students, and administrators, is vital to building a quality framework that is representative of society's needs and aspirations. This dialogue must include the voices of students, who are the primary beneficiaries of education and whose experiences and perceptions are fundamental to understanding educational quality from a comprehensive perspective.

Finally, it is essential to recognize that the relationship between teacher profile and the quality of education in the context of academic accreditation is an issue that requires collective commitment. The transformation of the education system must focus on comprehensive teacher training, making accreditation processes more flexible, and creating an environment that values diversity and innovation. Only in this way can we guarantee quality education that prepares students to face the challenges of the future, promoting not only competitiveness but also human and social development.

It is essential that educational institutions, governments, and society as a whole work collaboratively to build an educational system that not only meets administrative criteria but also fosters comprehensive and critical development. In this sense, education must be viewed as a dynamic and contextualized process that transcends the mere transmission of knowledge, promoting the development of critical, creative, and committed citizens. Educational quality, therefore, must be understood not only as an end, but to building more just, equitable, and supportive societies.



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# Digital educational technologies in Ecuador from the perspective of teachers

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## Introduction

Information and Communication Technologies (ICT) have transformed teacher-student interaction in the classroom, making it crucial to understand educators' perspectives on access, use, and impact in teaching and learning. Identifying barriers to digitalization is also key to designing effective integration strategies. It is widely assumed that digital resources enhance teaching quality and reduce social inequalities. As UNESCO (2024) emphasizes, technology is now a social necessity to ensure education as a basic human right, especially in a world increasingly affected by crises and conflicts. However, in Latin America—and particularly in Ecuador—persistent challenges hinder equitable access to ICT.

Proaño et al. (2023) found that many teachers lack proper technological training and perceive ICT effectiveness ambivalently. Medina et al. (2023) noted improved access and interaction through digitalization but highlighted ongoing challenges related to infrastructure, training, inequality, and institutional support. Similarly, Calle, Tenecota & Arévalo (2024) observed persistent digital gaps in Ecuador, especially in rural and marginalized urban areas, despite progress in connectivity and mobile device access. Data from the Instituto Nacional de Estadística y Censos (INEC, 2024) confirm this disparity: only 17.6% of rural households have technological equipment compared to 39.8% in urban areas; 48.1% have internet access versus 73.6% in urban areas; and digital illiteracy is 14.1% in rural zones compared to 1.9% in urban ones.

Internationally, Miras et al. (2023) argue that the digital divide has become a central issue in education research, impacting equity and quality. Camacho (2024) adds that high dropout rates and rural digital exclusion hinder inclusive digital citizenship, requiring differentiated policies. To analyze the factors influencing technology adoption, the study applies the Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh et al. (2003), which identifies four key determinants—performance expectancy, effort expectancy,

social influence, and facilitating conditions—along with moderating variables such as age, gender, experience, and voluntariness.

Based on this framework, the research posed the question: How do teachers perceive access, use, and impact of digital technologies in their professional practice, and what UTAUT-related factors influence their adoption? Recognizing that ICT integration is vital for improving teaching quality and that teachers are central to this process, the study aimed to analyze their perspectives on digital technology adoption in Ecuadorian education..

### **Educational vulnerability and ICT use**

Educational vulnerability refers to individuals who experience difficulties throughout their academic career, which prevents them from taking advantage of teachings in the classroom (Díaz & Pinto, 2017). The Ministry of Education of Ecuador (2024) warns that in the country there are factors that affect the quality and equity of the teaching and learning process, with the number of students in vulnerable environments being high, characterized by poverty, dysfunctional families, teenage pregnancies, child labor, etc.

However, if the use of digital tools fosters educational equity, it is imperative to promote the adoption of ICTs to support education. Because: "The school fails when it does not provide adequate responses to the educational needs of all students and does not compensate for the limitations of family or social origin that affect young people from problematic families and socioculturally disadvantaged backgrounds..." (Díaz & Pinto, 2017, p. 49).

### **Teachers' perspectives on the use of ICT in the classroom**

According to Ndibalema & Mrosso (2024), teachers' perspectives on the integration of ICTs directly influence their use in teaching. Teachers evaluate their relevance when using them in class, taking into account aspects such as ease of integration and their impact on pedagogy. For their part, students pay particular attention to the usability and perceived usefulness of ICTs (Chatterjee et al., 2024).

As such, educators' views on ICT play a decisive role in their integration in the classroom. While most teachers recognize the value of technology to improve teaching, many face barriers in its implementation due to low digital competence and limited access to technological resources, which makes it difficult to test innovative educational models (Manjarrez & Cordero, 2023; Gómez & Bustamante, 2023).

## The UTAUT model: Fundamentals and Applications

Prior to the publication of the work of Venkatesh et al. (2003), there were different models to explain technological adoption: the Technology Acceptance Model (TAM and TAM2), proposed by Davis (1989), which emphasizes the perception of usefulness and ease of use as key variables; the Motivation Model (MM), based on theories of psychology; the Theory of Reasoned Action (TRA) and the Theory of Planned Behavior (TPB), which consider social influences (Gómez & Bustamante, 2023; Pilapaxi & Llerena, 2025; Venkatesh et al., 2003).

Based on this background, Venkatesh et al. (2003) integrated elements of eight models into the UTAUT Model. The model's validity was confirmed by its developer through tests on different technologies and user groups, explaining up to 70% of the variance in the intention to use technologies. In recent years, the scientific literature has confirmed the validity of UTAUT and its extensions (UTAUT2) to analyze technological acceptance in both teachers and students, even in developing country contexts and situations of educational vulnerability (Abbad, 2021; Acosta et al., 2024).

The Unified Theory of Acceptance and Use of Technology (UTAUT) identifies several key components that influence the adoption of technology. One of them is performance expectancy, which refers to the user's perception that using a given technology will help them perform tasks more effectively or improve their overall performance. Another is effort expectancy, which relates to how easy or difficult the user believes it will be to learn and operate the technology in their daily activities. Social influence also plays a role, as it reflects the extent to which individuals perceive that people important to them—such as colleagues, supervisors, or peers—believe they should use the technology. Lastly, facilitating conditions refer to the perception that there are sufficient resources, infrastructure, and organizational support available to enable the effective use of the technology. In addition, the model incorporates four moderators (age, gender, experience, and voluntariness of use) that interact with the four main constructs and their impact may vary depending on certain factors.

### Information processing

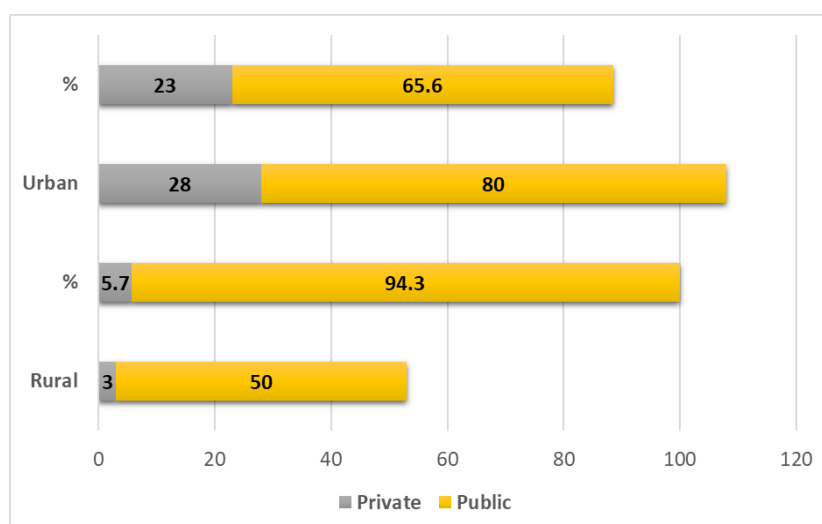
It was carried out through data mining, with the use of Orange Data Mining software, which allowed the identification of non-linear relationships, predictor variables of technological acceptance and relevant segmentations through algorithms such as decision trees and clusters.

## Sociodemographic characteristics of the teachers surveyed

Age of teachers: The majority of teachers are between 36 and 40 years old (22.8%), followed by those aged 31 to 35 (17.5%) and 41 to 45 years old (15.2%). Globally, 72% of educators surveyed are under the age of 45. Type of educational institution in which they teach: 74.9% work in public institutions (74.9%), while 17% work in private institutions. There are also teachers in Government-subsidized private schools (7%) and municipal schools (1.2%).

Location of the educational center: It was found that 69.6% of the teachers work in urban areas, while 30.4% work in rural areas. Based on the above information, when cross-referencing the data between the location of the educational center and the type of institution (Figure 1), we obtain the following result.

**Figure 1.** Type of institution and location of the educational center



In Figure 1, the proportion of teachers working in public institutions in rural areas exceeds 90%; while it is slightly higher than 60% in urban areas, that is, there is a greater private educational offer in urban environments. Therefore, if educational inequality in Ecuador manifests itself in differences between rural and urban areas (Salgado, 2025), the rural population depends on the State to obtain quality education as a way to overcome the inequalities that affect them.

Regarding the patterns of technological adoption of the surveyed teachers, it was possible to determine, through the Feature Statistic function, a descriptive and analytical summary of how the variables of the dataset behave. Thus, we have that teachers in Ecuador present certain patterns in terms of availability of

resources, training, perception of their usefulness and barriers to their implementation.

Most teachers report having access to laptops for both teaching and learning purposes, and their institutions' computer labs typically contain between 11 and 20 functioning computers. In the classroom, computers are often used as the primary teaching tool. Although the teachers have received training in digital technologies, it has generally been sporadic. Despite this, they perceive a significant positive impact of ICT on student learning. The majority strongly prefer using digital tools over traditional methods and firmly disagree with the notion that ICTs are ineffective in the classroom. They also reject the idea that digital technologies could replace teachers or dehumanize the educational process.

However, the integration of ICT still faces challenges. Poor internet connectivity remains the main barrier, and while there is some institutional support for digitalization, it is limited. Teachers report dedicating between zero and one hour per week to using technology in the classroom, indicating a relatively low level of integration. Despite these limitations, their attitudes toward teaching with technology are generally positive. They disagree with the idea that ICT creates more problems than it solves and, although they acknowledge that training alone is not always sufficient for successful implementation, they believe that digital technologies are well suited to the real needs of their educational context. Furthermore, they do not feel that ICT use increases their workload or that its integration yields insignificant results.

## **Performance Expectation**

The instrument asked teachers about how important they considered the following technological resources: artificial intelligence, virtual/augmented reality, educational videos, video games, social networks, WhatsApp and educational robotics. All were considered "Very Important" by most, with the exception of social media, which was listed as "Not Important."

The least dispersion in the responses occurred in artificial intelligence, educational videos and educational robotics, which implies that there was greater homogeneity in the responses around the value "Very important" in these cases. Table 1 below lists the teachers' perception of importance and competence in the use of each of these three digital resources.

**Table 1.** *Perception of importance and competence in the use of digital resources*

| How competent do you feel to make proper use of digital resources? | Percentage of teachers who consider VERY IMPORTANT for education consider the following digital resources: |                                             |                                               |
|--------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|---------------------------------------------|-----------------------------------------------|
|                                                                    | AI (110 teachers = 90,16 %)                                                                                | Educacional Videos (114 teachers = 93,44 %) | Educational robotics (101 teachers = 82,79 %) |
| Very competent                                                     | 35 (31,82 %)                                                                                               | 67 (58,77 %)                                | 14 (13,86 %)                                  |
| Slightly competent                                                 | 12 (10,91 %)                                                                                               | 5 (4,39 %)                                  | 47 (46,53 %)                                  |
| Not competent at all                                               | 63 (57,27 %)                                                                                               | 42 (36,84 %)                                | 40 (39,60 %)                                  |

Although most consider the three digital resources very important, they only consider themselves very competent in one of them (educational videos), possibly due to its low level of difficulty and the possibility of self-taught training in a short time and at a reduced cost. Where there is less training is in educational robotics, which may be due to the fact that it involves the investment of resources by students, so its use is not very common, especially in public institutions; while, in artificial intelligence, only 31.82% consider themselves highly qualified. This shows that, despite the perception of value that teachers can give to digital resources, they cannot be fully integrated into the classroom without adequate digital competence.

### Expectation of effort

A clustering analysis of the six survey items related to this construct was performed using the k-means algorithm. As shown in Table 2, the grouping generated three differentiated teacher profiles, which allow identifying patterns in terms of the perception of ease, digital competence and willingness to integrate digital technologies.



**Table 2.** *Qualitative interpretation of clusters*

| Cluster | Frecuency  | Profile                        | Characteristics                                                                             |
|---------|------------|--------------------------------|---------------------------------------------------------------------------------------------|
| C1      | 65 (53,3%) | High digital autonomy          | Maximum scores in all items. Teachers with great security, mastery and adaptation to ICT    |
| C2      | 43 (35,2%) | Intermediates with layout      | Positive perception, although more moderate. They recognize the need for training           |
| C3      | 14 (11,5%) | Low expectation and resistance | Low scores on all items. Teachers with integration difficulties, lower perceived competence |

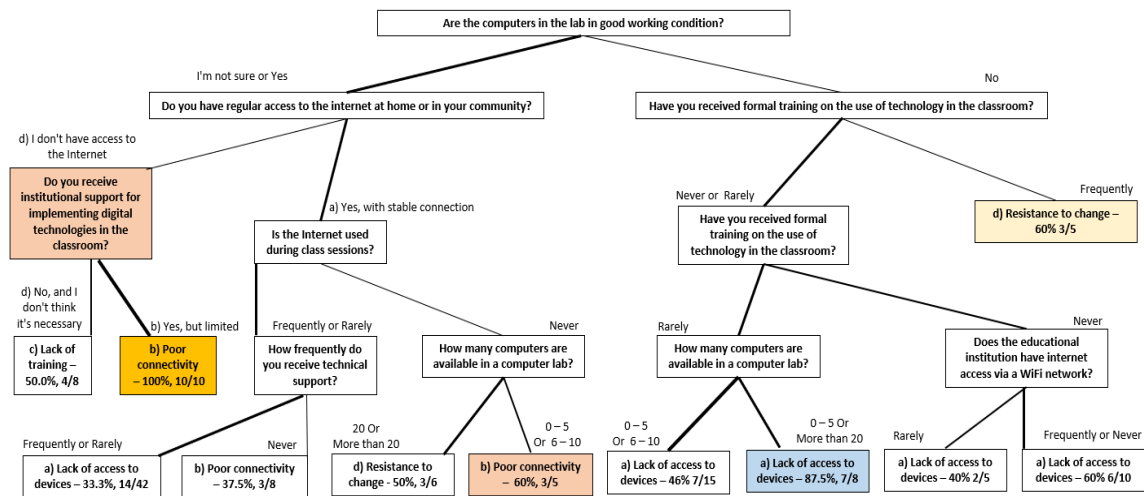
According to Table 2, the distribution by clusters showed that 53.3% of teachers are grouped in C1, with a high perception of digital competence and ease of technological integration. 35.2% fall into C2, with favorable attitudes, but specific training demand. And, 11.5% were in C3, with low self-perception of ability and greater resistance to the use of ICTs. Therefore, it can be considered that a little more than half of the respondents perceive themselves as competent in the use and integration of digital technologies. This result could be encouraging if we were not talking about a population that is studying at the fourth level, so they would be expected to have much greater self-perceived digital competence.

## Facilitating conditions

To evaluate this aspect of UTAUT, the predictive model known as Tree (decision tree) was used. To this, the survey questions related to the "Facilitating Conditions" dimension were identified, and one of them was chosen as a predictive variable, specifically: "15. What are the main barriers you face in integrating ICT into your educational practice?"

In Figure 2, we can visualize the relationships between the different items with the predictor variable. This tree predicts the main barrier that teachers face when integrating ICTs, based on their answers to questions about: Internet use in class, institutional support, state of computer labs, and technological training.

**Figure 2.** Decision tree on main barriers to ICT adoption



In the image above, each internal node represents a decision question (e.g., "Do you use the Internet during classes?"). Each branch represents a possible answer. And, each leaf (end) node shows a proportion of cases with a certain barrier (color) and the percentage and number of cases that fall into that group. The results reveal that the main perceived barrier was poor connectivity, especially among teachers who, although they have access to the Internet, describe it as unstable and do not have institutional support (100% of the nodes of the tree). Likewise, the lack of access to devices appeared as a dominant barrier among those who have not received formal training, do not have a functional computer laboratory and report little use of the Internet during classes (87.5%). Taken together, the decision tree shows that barriers are not due to a single factor, but are the result of a mixture of institutional and pedagogical conditions.

## Conclusion

The findings confirm that the integration of digital technologies in vulnerable educational contexts in Ecuador is shaped by the interrelation of multiple factors. It brings together personal dimensions (digital competence, age, willingness to change), institutional dimensions (infrastructure, training, accompaniment) and sociodemographic dimensions (location, type of institution, home connectivity). Based on the UTAUT model, teachers' perceptions of technological integration were organized and interpreted. The performance expectation analysis showed that, despite the fact that teachers recognize the importance of ICT in education, they cannot be fully exploited given a deficient digital competence. On the other hand, the expectation of effort identified that there is weakness in self-perceived digital competence and demands for training by teachers. Meanwhile, the facilitating conditions

evidenced the presence of barriers such as poor connectivity, lack of access to devices and absence of institutional policies.

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# **Design and Validation of the Neuropsychological Aptitude Test to Evaluate the Entry Profile of Children Aged Four to Five Years Entering Preschool Education**

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## **Introduction**

An entry profile evaluation in preschool offers essential information about children's level of development, cognitive and behavioral potential, and learning needs. It helps to establish a baseline for each cohort and guides the planning of educational interventions, aiming to meet the graduate profile outlined in the Honduran Preschool Curriculum (Secretaría de Educación, 2015).

Due to the lack of a validated instrument for Honduran background on this matter, many schools decide to use popular international tests. However, interpretations of test scores may not be valid since the psychometric analysis is affected by demographic and contextual variables of the population evaluated (American Educational Research Association, American Psychological Association, and National Council on Measurement in Education [AERA, APA & NCME], 2014).

In response to this problem, UPNFM by means of Unidad de Admisión y Monitoreo Académico (UAMA) [Admission and Academic Monitoring Unit], has developed and validated an instrument titled Neuropsychological Aptitude Test (NAT) designed for Honduran children between four and five years old who enter the third grade of preschool education. NAT is intended to

characterize the entry profile in terms of aptitude, defined as the set of indicators that reflects potential for learning or acquiring new skills (Stemler & Sternberg, 2013). Theoretically, its design is based on child neuropsychology, since it provides a comprehensive perspective of early childhood development (Arango Lasprilla *et al.*, 2017). Methodologically, it follows international guidelines for content and construct validity, reliability, and psychometric parameters analysis (Martínez Arias *et al.*, 2006).

## **Literature Review: Neurodevelopment in Early Childhood**

During early childhood, the brain undergoes rapid and dynamic growth, particularly in the development of the cerebral cortex, as well as in the expansion of gray and white matter in both cortical and subcortical regions. Moreover, this period is characterized by heightened synaptic plasticity supported by neurobiological processes such as neurogenesis, synaptogenesis, and myelination. Taken together, these neurodevelopmental features are directly related to learning sensitivity and the acquisition of cognitive functions. Therefore, educational intervention and neurodevelopmental assessment are essential to enhance academic achievement and identify any dysfunction (Brown & Jernigan, 2012; Howard-Jones, 2010).

Specifically, the motor system, responsible for processing sensory information and controlling movement (including speed, strength, and precision), is the first to develop (Piek *et al.*, 2012). This explains why motor skills are more stable, automatic, and coordinated by the time children begin formal education (Fletcher, 2011). Once primary movements have been mastered, the brain structures involved become available for more complex tasks such as writing, which requires refined motor control (Díaz-Jara, 2015). Therefore, assessment in this area focuses on ensuring that children are prepared for more challenging tasks that require visuospatial ability, attention, and complex psychomotor skills such as rhythm.

Another relevant cognitive function enhanced by the maturation of brain structures is memory, particularly visual and verbal short-term memory, which constitutes a fundamental component for achieving deeper learning. Any dysfunction in this area must be addressed promptly as it may affect the child's subsequent academic performance (Klingberg, 2013).

In contrast, executive functioning has a slow and progressive development, although begins to emerge in early childhood. It is manifested in the formation of a self-concept, the regulation of emotions, the adaptability to different contexts and interaction with others. Furthermore, executive functions have been related to optimal academic achievement in literacy, mathematics, and

science (Anderson & Reidy, 2012; Blair *et al.*, 2005). Therefore, it is essential to identify and address any deficiencies to minimize future problems in school performance and behavior (Schneider, 2011).

On the other hand, concerning the language development, the period from one to six years is characterized by the evolution of linguistic processing, including an increase in vocabulary and the ability to infer both the semantic and the syntactic use of language (Fletcher, 2011). Particularly, in terms of morphosyntax, by the age of five, children have already developed the ability to understand grammatical rules and the production of complex sentences. By the age of six, children with typical neurodevelopment have already acquired most of the phonemes in the Spanish language. Likewise, their level of verbal comprehension is much higher than their oral verbal expression. (Roselli *et al.*, 2014). Language assessment is essential, as it is related to overall cognitive development. Any dysfunction in the different areas of language must be identified on time, so that it can receive appropriate treatment (Hoover *et al.*, 2011).

In summary, sensorimotor, executive functions, memory, and language are important neuropsychological domains to evaluate in early childhood. Thus, aligning NAT to child neuropsychology perspective will provide relevant information about children developmental levels and based on it, make informed decisions that will contribute to their academic success.

### **Evidence of Validity based on Test Content**

To accomplish the first objective of content validity, a comprehensive review of neurodevelopmental theory was carried out, and the most relevant international and regional neuropsychological assessment instruments aimed at children were explored. A multidisciplinary team of UPNFM professors specializing in Neuroeducation, Psychometrics, Psychology, Inclusive Education, and Preschool Education discussed the definition and structure of the construct in two meetings. Ultimately, a consensus was established, leading to the identification of four dimensions composed of 16 subdimensions that defined the construct's structure.

The next step involved establishing indicators to define each subdimension's observable and measurable behaviors. To achieve this, eight high-achieving students and three professors from UPNFM's Inclusive Education, Counseling, and Preschool Education programs participated in two workshops, where subdimensions were assigned and they had to write ten indicators for each. The final product was a TS with approximately 160 indicators.



Following the completion of the initial draft of the TS, two workshops were held to obtain an external consensus and verify the congruence between the TS and the knowledge of experts in the field. A total of 15 judges (professors from the aforementioned programs) participated in this activity. They were trained about the purpose of the test, the construct's definition and structure, and their role as judges. The specialists filled out a rubric in which they rated on a scale of 1 to 3 (1 = poor, 2 = moderate, and 3 = high) whether the indicators, subdimensions, and dimensions met the criteria of sufficiency, clarity, coherence, and relevance. Kendall's  $W$  coefficient was calculated as a measure of agreement to assess consistency across multiple evaluators.

The sufficiency criterion was rated globally for each dimension. All values obtained were statistically significant ( $p < 0.001$ ), indicating that the agreement levels are not aleatory. Memory ( $W = 0.885$ ) and Executive Functions ( $W = 0.632$ ) presented a strong agreement, suggesting that the judges agreed that the indicators belonged and were sufficient to obtain the measurement according to the dimension they represent. Language ( $W = 0.455$ ) obtained a moderate agreement, which indicates some variability from judges when assessing the sufficiency of the indicators to operationalize the dimension. Finally, Sensorimotor Development ( $W = 0.253$ ) showed low agreement, which suggests important discrepancies among the judges when evaluating this dimension. In summary, the values obtained indicated an acceptable level of agreement for the sufficiency criterion in most of the dimensions evaluated; however, Sensorimotor Development required review and reformulation of indicators.

For the other criteria (clarity, coherence, and relevance), Kendall's  $W$  coefficient was calculated for each indicator. This led to different decisions based on  $W$ , such as approved without modification ( $W > 0.30$  and  $p < 0.05$ ), approved with modifications ( $W > 0.30$  and  $p > 0.05$ ), and discarded ( $W < 0.30$  and  $p > 0.05$ ). As a result, each subdimension was constituted by approximately five indicators. To maintain the representativeness of each subdimension, new indicators were elaborated where necessary.

Later, a workshop was conducted for the item writing stage, involving six UPNFM professors specializing in Psychopedagogy, Physical Education, Preschool Education, and Language. Additionally, individual follow-up and feedback were provided to ensure quality standards. Items were reviewed based on the construct's representativeness, relevance to the target population, clarity, relevance, and logical consistency with the indicator, subdimension, and dimension aimed to measure. Approximately three tasks were aligned to each indicator. As a result, a pool of 202 tasks was created that

met the quality criteria.

A first version of NAT was developed and consisted of two non-equivalent forms, each with 50 tasks. A pilot study was conducted to assess the adequacy and quality of the test administration process, including resources, manual format, answer sheet layout, spatial organization, activity duration, and training needs for evaluators. The sample included 20 second-grade children from a preschool in Tegucigalpa. Six evaluators, all properly trained, participated. An in-depth analysis of video recordings of two complete evaluations, log notes, and a focus group discussion were crucial sources of information to identify key areas for improvement. As a result, a revised and refined second version of NAT was designed with two non-equivalent forms, each with 50 tasks. Overall, the process followed in this each stage allowed for obtaining solid empirical sources of validity based on its content.

### **Evidence of validity based on Internal Structure**

To accomplish the study's second objective, two additional pilot studies were implemented to make a gradual selection of the best functioning items. The second pilot study analyzed the items' psychometric properties based on CTT. NAT was administered to 186 second-grade children across six preschools in Tegucigalpa. Ten trained UPNFM high-achieving students served as evaluators. Items with acceptable psychometric parameters ( $r_{bp} > 0.30$  and  $0.30 \leq p \leq 0.80$ ) were selected to comprise the preliminary version of NAT, which consisted of a single form including 35 tasks which contained a total of 50 items.

Subsequently, a last pilot study was conducted with a sample of 378 second-grade preschool children from ten schools in Tegucigalpa. Only 339 composed the final dataset due to missing values in 39 cases. An EFA was performed to identify the relationships between the items and analyze the internal structure of the dimensions. Due to sample size and complexity structure each dimension was analyzed separately in EFA (Ferrando & Lorenzo-Seva, 2014).

First, univariate statistics were verified to analyze items' heterogeneity and their ability to contribute to the common variance (Ferrando et al., 2022). Items with low variance were excluded ( $\sigma^2 < 0.10$ ) (Ferrando & Aguiano-Carrasco, 2010). Additionally, univariate normality was evaluated; symmetry values ranged from -1.752 to 1.547, while kurtosis values ranged from -1.997 to 1.063. Since these exceed an absolute value of 1, it was decided to implement a nonlinear model based on tetrachoric correlations (Ferrando & Lorenzo-Seva, 2014). Regarding multivariate normality, Mardia indices indicated that symmetry was not statistically significant for any dimensions ( $p > 0.05$ ), suggesting the data's

distribution was not biased to neither side. In contrast, kurtosis values were significant ( $p = 0.0000$ ) for all dimensions, indicating that multivariate normality cannot be assumed. In sum, these values supported the implementation of a robust factorization method, such as the Morgana Analysis, based on Unweighted Least Squares. This method is less restrictive in its assumptions of normality and includes a specific treatment of the correlation between residual values, thereby improving the fit indices (Ferrando *et al.*, 2023).

The common variance and correlations were analyzed to assess the feasibility of performing an EFA, using Kaiser-Meyer-Olkin (KMO) sampling adequacy tests and Bartlett's sphericity test. The values of the determinant of the correlation matrix ranged between 0.0029 and 0.0645, which are within the suggested ranges ( $|R| > 0.00001$ ), confirming suitable correlation between the items without risk of multicollinearity; thus, EFA was appropriate. Bartlett's statistic was significant for all dimensions ( $p < .001$ ), which allowed to reject the null hypothesis that the correlation matrix is an identity matrix, confirming that the items are significantly related. Likewise, KMO indices ranged from 0.7301 to 0.7683. These values exceed the suggested value ( $KMO > 0.70$ ) (Ferrando & Anguiano-Carrasco, 2010), which indicates that the dataset is adequate for the EFA.

The preliminary selection of items to include in EFA was based on the Measure of Sampling Adequacy (MSA). The MSA values for each dimension were as follows: Visuospatial (seven items) ranged from 0.64 to 0.93, Psychomotricity (six items) ranged from 0.63 to 0.86, Language (14 items) ranged from 0.64 to 0.86, and Executive Functions (nine items) ranged from 0.66 to 0.84. These values are above the reference threshold ( $MSA > 0.50$ ) (Ferrando *et al.*, 2022); therefore, a total of 36 items were suitable for inclusion in the EFA. A parallel analysis was performed for each dimension to determine the optimal number of factors. The results indicated that all dimensions had a unidimensional structure since only the explained variance of the first factor was greater than the 95th percentile of the random simulations. Additionally, the Expected a Posteriori (EAP) reliability and the Factor Determination Index (FDI) in all dimensions showed that the measurement was stable and accurate ( $EAP > 0.85$ ,  $FDI > 0.90$ ). Taken together, these values indicated that each dimension was well defined and its scores can be interpreted with confidence.

Regarding the factor loading, all items had acceptable values ( $\lambda > 0.30$ ) in their corresponding dimension. Loadings in Visuospatial ranged from 0.318 to 0.836, Psychomotricity ranged from 0.38 to 0.94, Language ranged from 0.324 to 0.721, and Executive Functions ranged from 0.459 to 0.815. Likewise, communalities were within the accepted threshold ( $h^2 > 0.10$ ) in all dimensions

(Ferrando *et al.*, 2022). Finally, to evaluate the adequacy of the factorial solution, the magnitude of the residual correlations was analyzed through Weighted Root Mean Square Residual (WRMR). Likewise, the relative fit of the model concerning its complexity was verified using the Root Mean Square Error of Approximation (RMSEA). In addition, the comparative fit of the empirical model in contrast to the null independence model was analyzed through the Non-Normed Fit Index (NNFI). The values obtained in all dimensions indicated that the adjustment was acceptable according to the established criteria ( $WRMR < 1$ ,  $RMSEA \leq 0.05$ ,  $NNFI \geq 0.95$ ).

It is important to clarify that the final empirical structure differed from the theoretical definition, since Memory and Executive Functions dimensions were combined. Likewise, Sensorimotor dimension was divided into two different dimensions: Visuospatial Ability and Psychomotricity. On the other hand, all items related to Emotional Regulation and Planning, which belonged to the Executive Function dimension, were removed from the analysis. The Language dimension was well represented. Despite obtaining a slightly different structure from the initial theoretical proposal, it does not significantly affect the test content or the construct representativeness. Overall, the results show acceptable sampling adequacy values and good fit indices according to the established criteria, resulting into four dimensions. Notwithstanding, because EFA was implemented separately for each dimension relations between them can't be studied.

### Item's psychometric parameter

Item parameters were evaluated through CTT. In terms of difficulty, Visuospatial presented an average of  $p = 0.57$ , with items ranging from 0.33 to 0.83. Psychomotricity showed an average of  $p = 0.43$ , ranging from 0.19 to 0.76. The average difficulty for Language was  $p = 0.49$ , with items ranging between 0.29 and 0.74. Finally, Executive Functions presented an average of  $p = 0.44$ , ranging from 0.20 and 0.58. Overall, the items showed acceptable difficulty values according to the recommended range ( $0.30 \leq p \leq 0.80$ ) (Navas, 2001), which indicates an adequate distribution in terms of the level of items' complexity. However, five items were distanced from this interval. Conversely items had discrimination values between 0.22 and 0.56. Of the 36 items analyzed, 82% presented acceptable discrimination ( $r_{bp} > 0.30$ ), while the remaining 18% showed moderate discrimination level ( $0.20 \leq r_{bp} \leq 0.30$ ) (Navas Ara, 2001). Lastly reliability values obtained through McDonald's  $\alpha$  ranged between 0.67 and 0.75. Language ( $\alpha \geq 0.75$ ) and Executive Functions ( $\alpha \geq 0.73$ ) reach adequate levels ( $\alpha \geq 0.70$ ), while Visuospatial ( $\alpha \geq 0.67$ ) and Psychomotricity ( $\alpha \geq 0.68$ ) were slightly below the suggested criterion. In

summary, the results showed that, overall, items had appropriate difficulty and discrimination parameters, as well as acceptable reliability in each dimension, according to the CTT criteria.

## Conclusions

This study aimed to design and validate a test to assess neuropsychological aptitude for entry profile to the third grade of preschool education in Honduras. The construct's definition, dimensional structure, and items were developed following rigorous psychometric standards. Thus, strong evidence of content validity, internal structure, and psychometric properties was gathered. It was possible to validate TS, which included four dimensions composed of 16 subdimensions. The development of the TS and review of the items led to the conclusion that both were derived from and aligned with the definition of neuropsychological aptitude and are well-supported by evidence of content validity. Additionally, the EFA allowed the researchers to define a valid structure of NAT with four dimensions with a total of 26 tasks containing 36 items. Although the empirical structure showed differences from the theoretical structure, its general reliability was confirmed. NAT is valid, and the scores are reliable for descriptive purposes. However, reviewing items with low adjustment, especially in Psychomotricity, is recommended before their application in educational decisions of high consequences.

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# Comparative Analysis of Governance Models in Europe and Latin America for the Decarbonization of Their Economies

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## Introduction

The decarbonization of economies is one of the greatest contemporary challenges due to the impact that greenhouse gas emissions have on global climate change. As the urgency to mitigate this phenomenon increases, countries around the world are adopting measures to reduce their dependence on fossil fuels and promote the use of renewable energies. However, the implementation of these strategies varies considerably between regions, influenced by particular political, economic, and social factors (Olcina, 2021).

Europe, as a leader in environmental policy, has implemented a robust regulatory framework that seeks to move toward a sustainable, low-emission economy through cooperation between countries and supranational bodies. Policies and strategies have been developed to promote energy transition and sustainability. On the other hand, Latin America faces unique challenges, such as dependence on non-renewable energy sources, unequal access to technology, and the lack of coherent, long-term public policies in many countries, which mean that the region is still in the early stages of decarbonization, despite its enormous potential for the development of clean energy (Cecillon, 2021).

The central issue of this research is the disparity in governance models for the decarbonization of economies between Europe and Latin America. Despite international efforts to address climate change, there are notable differences in the implementation and results of decarbonization policies in these two regions. Europe, with more advanced economies, has developed more integrated and effective governance models to reduce carbon emissions. In



contrast, Latin America faces significant challenges, such as a lack of adequate infrastructure, political instability, and economic constraints, which hinder the effective adoption of similar policies (Tarra and Restrepo, 2021).

The principles behind these differences include variations in economic development, institutional capacity, and levels of investment in clean technologies, where Europe has been able to implement stronger decarbonization strategies thanks to its economic resources and institutional capacity. Latin America, on the other hand, faces structural and financial constraints that affect the effectiveness of its decarbonization policies (Ortiz et al., 2022).

The research question guiding this analysis is: How do governance models for the decarbonization of economies in Europe and Latin America compare in terms of effectiveness, and what are the causal factors that explain these differences?

The purpose of this study is to conduct a comparative analysis between governance models in Europe and Latin America focused on the decarbonization of their economies, seeking to identify the main differences and similarities in the strategies and policies implemented, evaluate their effectiveness in reducing emissions and transitioning to a green economy, and offer recommendations that can be adapted to the specific contexts of Latin America to accelerate its decarbonization process. It aims to be a reflection on the current state of both models and a practical guide to strengthening environmental policies in the Latin American region.

### **Analysis of the main policies and strategies adopted in the governance models for both regions**

As part of the analysis to understand global progress in sustainability, a strategic selection of countries was made in both Europe and Latin America, regions that have shown an active commitment to decarbonization. This selection was based on the identification of nations that have implemented relevant energy transition policies, such as tax incentives for renewable energy, energy efficiency regulations, and transport electrification programs. The objective was to assess how each country adapts its strategies to its economic, political, and social context to reduce emissions and promote low-carbon development.

Subsequently, a comparison was made between the strategies implemented, analyzing their impact, scalability, and replicability. This assessment identified key similarities and differences between regional approaches, as well as the

conditions that have favored the success of certain policies. Based on this comparison, conclusions were drawn about which measures have been most effective in reducing environmental impact, highlighting good practices that could serve as a reference for other countries in the process of designing or improving their own decarbonization strategies.

The selection of European and Latin American countries was based on their efforts to address the challenges of climate change and advance decarbonization. Additional details on the key policies implemented in each country, as well as their objectives and achievements, are provided below.

**Table 1.** *Policy analysis of Europe .*

| Europe  |                                                                                                                         |                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                |
|---------|-------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Country | Main Objectives                                                                                                         | Strategies Adopted                                                                                                                                                                                                                                              | Results and Achievements                                                                                                                                                                       |
| Germany | Reduce GHG emissions by 80-95% by 2050 and achieve 60% renewable energy in electricity by 2035 (Valencia et al., 2022). | <ul style="list-style-type: none"> <li>• Tax incentives for renewable energy (wind, solar, biomass).</li> <li>• Phasing out coal by 2038.</li> <li>• Promotion of electric transport.</li> <li>• Research and development of new clean technologies.</li> </ul> | <ul style="list-style-type: none"> <li>• Significant increase in renewable energy capacity, especially wind power.</li> <li>• 35% reduction in CO<sub>2</sub> emissions since 1990.</li> </ul> |
| France  | Reduce CO <sub>2</sub> emissions by 40% by 2030 and achieve carbon neutrality by 2050 (Porcelli and Martínez, 2022).    | <ul style="list-style-type: none"> <li>• Incentives for energy efficiency in buildings and industries.</li> <li>• Promotion of renewable energies (wind and solar).</li> <li>• Integration of energy systems at the European level.</li> </ul>                  | <ul style="list-style-type: none"> <li>• 70% of electricity from renewable sources by 2023.</li> <li>• Promotion of electric vehicles.</li> </ul>                                              |
| Spain   | Reduce greenhouse gas emissions by 55% by 2030 and achieve climate neutrality by                                        | <ul style="list-style-type: none"> <li>• Expansion of solar and wind power generation capacity.</li> <li>• Phasing out nuclear energy and coal use.</li> <li>• Subsidies to</li> </ul>                                                                          | <ul style="list-style-type: none"> <li>• In 2023, 50% of electricity generated came from renewable sources.</li> <li>• 38% reduction in CO<sub>2</sub></li> </ul>                              |

2050 (Tomatis, 2020). encourage the purchase of electric vehicles and energy efficiency in homes. emissions compared to 1990.

|                    |                                                                                                                |                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                            |
|--------------------|----------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Netherlands</b> | Reduce carbon dioxide emissions by 49% by 2030 and achieve climate neutrality by 2050 (Villegas et al., 2022). | <ul style="list-style-type: none"><li>• Transition to the use of renewable energies, particularly offshore wind and solar.</li><li>• Decarbonization of the transport and industry sectors.</li><li>• Investment in the development of green hydrogen and carbon capture and storage technologies.</li></ul> | <ul style="list-style-type: none"><li>• By 2023, 40% of electricity generated came from renewable sources.</li><li>• 30% reduction in CO<sub>2</sub> emissions compared to 1990.</li></ul> |
|--------------------|----------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

**Source:** Own elaboration.

According to the above (Table 1), Germany, France, Spain, and the Netherlands have made significant progress in their decarbonization processes thanks to national policies focused on energy transition that have included tax incentives, investments in research and development of clean technologies, as well as the promotion of energy efficiency and the use of renewable energies such as solar and wind, consolidating their leadership in reducing greenhouse gas emissions (Mena, 2023).

**Table 2.** *Analysis of Latin American policies .*

**Latin America**

| Country | Main Objectives                                                                              | Strategies Adopted                                                                                                                                                                                                                                               | Results and Achievements                                                                                                                                                     |
|---------|----------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Chile   | Ensure that at least 70% of electricity comes from renewable sources by 2050 (Guzmán, 2023). | <ul style="list-style-type: none"><li>• Tax incentives and subsidies for renewable energy (solar and wind).</li><li>• Development of distributed energy infrastructure (residential solar panels).</li><li>• Promotion of public-private partnerships.</li></ul> | <ul style="list-style-type: none"><li>• 40% increase in installed renewable energy capacity over the last five years.</li><li>• Chile is a leader in solar energy.</li></ul> |

|                 |                                                                                               |                                                                                                                                                                                                                                              |                                                                                                                                                                                                                           |
|-----------------|-----------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Mexico</b>   | Achieve 35% of renewable energy in the energy matrix by 2024 (Quinteros et al., 2024).        | <ul style="list-style-type: none"> <li>• Promotion of solar and wind energy projects.</li> <li>• Tax incentives for the adoption of clean technologies.</li> <li>• Develop infrastructure for electric vehicles.</li> </ul>                  | <ul style="list-style-type: none"> <li>• 20% of electricity from renewable sources by 2024.</li> <li>• Growth in wind power capacity.</li> </ul>                                                                          |
| <b>Brazil</b>   | Generate at least 45% of total energy from renewable sources by 2030 (Aguar and Rojas, 2023). | <ul style="list-style-type: none"> <li>• Investment in hydroelectric, wind, and solar energy.</li> <li>• Promotion of biofuels and electric vehicles.</li> <li>• Government support for sustainable projects.</li> </ul>                     | <ul style="list-style-type: none"> <li>• More than 80% of electricity comes from renewable sources, with a high share of hydroelectric power.</li> <li>• Growth in wind and solar capacity.</li> </ul>                    |
| <b>Colombia</b> | Achieve 30% of electricity generation from renewable sources by 2030 (Urbano et al., 2023).   | <ul style="list-style-type: none"> <li>• Development of solar and wind farms.</li> <li>• Tax incentives for investments in clean energy.</li> <li>• Modernization of the electricity grid and promotion of sustainable transport.</li> </ul> | <ul style="list-style-type: none"> <li>• Increase in solar and wind generation capacity.</li> <li>• Gradual reduction of dependence on fossil fuels and greater share of renewable energies in the energy mix.</li> </ul> |

**Source:** Own elaboration.

According to the results in Table 2, Chile and Mexico, within the Latin American context, made significant progress in promoting solar and wind energy, with both countries standing out for attracting foreign investment and strengthening their technological infrastructures to drive the energy transition. For their part, Brazil and Colombia combined various renewable sources, such as hydroelectric, wind, and solar, complemented by incentives to promote sustainable transport.

The comparative analysis of the policies implemented in the selected countries revealed essential similarities and differences, with common elements including

the use of tax incentives, the development of energy infrastructure, and the promotion of electric vehicles. However, the particularities of each nation were conditioned by their natural resources, technological capabilities, and socioeconomic context.

This shows that, although the main objective of reducing emissions is shared, the strategies for achieving it vary according to the specific characteristics and needs of each country. Sociopolitical, economic, and environmental factors influence the strategies adopted.

### **Similarities in regional approaches**

All the countries analyzed implemented tax incentives to promote the use of renewable energies, facilitating the attraction of investment in sustainable projects. Germany and France stood out for their subsidies for solar and wind energy installations, while Spain promoted support programs for self-consumption and energy communities. On the other hand, the Netherlands incentivized offshore wind energy and energy efficiency. In Latin America, Chile and Mexico facilitated access to financing for solar and wind projects, while Brazil promoted bioenergy and hydroelectric power. For its part, Colombia implemented tax incentives for companies that invested in renewable energy and energy efficiency (Contreras et al., 2022).

Most countries set clear, long-term targets for reducing greenhouse gas (GHG) emissions, aligning themselves with international climate change agreements in which France, Germany, Spain, and the Netherlands set the goal of achieving carbon neutrality by 2050. In Latin America, Chile, Mexico, and Brazil set targets to increase the use of renewable energy and reduce emissions, while Colombia committed to reducing its GHG emissions by 51% by 2030 and achieving carbon neutrality by 2050 (Muñoz, 2022).

Although the selected countries share several objectives and strategies, there are also significant differences in their approaches to decarbonization. These differences are the result of the specific political, economic, and social conditions of each country and region, which determine the implementation and success of policies. Some of the main differences are highlighted below:

- **Scale and speed of implementation:** In Europe, countries such as Germany, France, and the Netherlands leveraged their advanced energy infrastructure to implement energy transition policies more quickly and on a larger scale. Germany excelled in the development of wind energy, especially in coastal areas, while the Netherlands promoted offshore wind

energy projects and France combined nuclear and renewable energy to reduce its carbon emissions.

In Latin America, Chile and Mexico made rapid progress in installing solar and wind energy, but faced challenges related to energy distribution and electrical infrastructure, especially in rural areas. Brazil, with its well-established hydroelectric infrastructure, diversified its energy matrix with bioenergy and wind energy. On the other hand, Colombia, although it made progress in solar and wind energy projects, showed a more gradual pace due to its high dependence on hydroelectric power and the challenges associated with expanding the electricity grid (Gómez, 2024).

- **Focus on Wind vs. Solar Energy:** European countries showed greater diversification in their energy sources. Germany and the Netherlands focused mainly on wind energy, both onshore and offshore, while France combined nuclear energy with renewable sources, and Spain excelled in solar, wind, and solar thermal energy, taking advantage of its sunny climate.

In Latin America, Chile led the development of solar energy, thanks to the favorable conditions of the Atacama Desert, while Mexico combined solar and wind energy, with significant growth in the north of the country. Brazil diversified its matrix with hydroelectric, bioenergy, and wind power, while Colombia focused on complementing its hydroelectric generation with solar and wind projects in regions such as La Guajira (Reinoso, 2023).

- **Public-Private Collaboration:** In Europe, governments played a central role in the energy transition through strict regulations, subsidies, and clean energy support plans. Germany and France implemented state-led policies, while the Netherlands and Spain combined government leadership with public-private partnerships.

In Latin America, private investment and international collaboration were key to driving the energy transition. Chile and Mexico attracted foreign investment through tax incentives and simplified administrative processes, Brazil leveraged private sector participation in bioenergy and wind farm projects, while Colombia incentivized investment in renewable energy through tax benefits, seeking to attract both domestic and international companies (Muñoz, 2022).

Overall, the energy transition showed remarkable progress in both Europe and Latin America, although with marked differences due to the economic, social, and technological context of each region. European countries such as Germany, France, the Netherlands, and Spain led this process thanks to their

advanced infrastructure, solid government policies, and greater diversification of their renewable sources.

In contrast, Latin American countries such as Chile, Mexico, Brazil, and Colombia also made significant progress, although they faced challenges related to the modernization of their electricity grids, dependence on fossil fuels, and the need to attract foreign investment. However, the development of clearer regulatory frameworks and the progressive adoption of clean energies, such as solar, wind, and hydroelectric power, demonstrated their commitment to sustainability and reducing carbon emissions.

### **Assessment of the components that contribute to the success or failure of decarbonization policies in the countries analyzed**

In order to gain an in-depth understanding of what makes decarbonization policies effective, we identified the key components that influence their success or failure. The factors analyzed include the availability and management of financing, the level of public acceptance and participation, and the clarity and consistency of existing regulations. These elements were systematically evaluated to determine how they interact with each other and how important they are in the efficient implementation of climate strategies.

Based on the analysis of specific cases, both the achievements and obstacles encountered during the implementation of various policies were reviewed. This review revealed common patterns among the factors that contributed to success and those that led to the stagnation or failure of certain initiatives. Based on these findings, best practices were defined that could be replicated or adapted in similar contexts, and key areas for improvement were identified to strengthen current and future policies on sustainability and emissions reduction.

To evaluate the components that favor the success or failure of decarbonization policies, it is necessary to identify the most relevant factors that affect their implementation. These factors are based on key variables that can determine the effectiveness of policies in different countries. The key components identified are as follows:

- **Financing:** The availability of economic resources and access to sources of financing, both public and private, played a decisive role in the development of projects aimed at reducing carbon emissions. In Europe, countries such as Germany and France made significant progress thanks to solid state investment in renewable energies. In contrast, in Latin America, private sector participation and public-private partnerships were

essential due to government budget constraints. For example, in Mexico and Chile, these collaborations drove the expansion of solar and wind energy. Similarly, in Brazil, financing for sustainable projects was facilitated, while in Colombia, fiscal constraints limited investment in this area.

- **Public Support:** Social acceptance and participation were key factors in the success of decarbonization policies, as public support facilitated the implementation of environmental measures. In Europe, countries such as Germany, France, and Spain had a high level of environmental awareness, which favored the transition to clean energy sources. In Latin America, on the other hand, the degree of support varied according to the sociocultural context and perceptions of climate change. Chile and Brazil stood out for their awareness campaigns promoting the acceptance of renewable energies. In Mexico and Colombia, however, dependence on fossil fuels generated divided opinions, which posed a challenge for the consolidation of decarbonization policies.
- **Clarity of Regulations:** The existence of a coherent and stable legal framework was essential to ensure the effective implementation of environmental strategies and attract sustainable investments. In Europe, Germany, France, and Spain were characterized by clear and consistent regulations that facilitated the development of clean energy and low-carbon technologies. In Latin America, Chile stood out for its solid regulatory framework, which allowed for the consolidation of solar and wind energy projects. However, in Mexico, energy reforms generated uncertainty in the private sector, while in Brazil and Colombia, political and economic instability hindered the continuity of environmental policies, affecting their long-term effectiveness.

Based on the above, the results of the policies adopted in the selected countries are reviewed to determine which factors have contributed to the success or failure of these policies, with the following analysis identifying the key elements that influence the effectiveness of these policies. The main achievements and challenges faced by each country in its transition to a more sustainable economy are presented below (Table 3).



**Table 3. Analysis of Successes and Failures**

| Country     | Successes                                                                                                                               | Failures                                                                                                                                                         |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Germany     | Heavy investment in renewable energy.                                                                                                   | Dependence on coal in some regions.                                                                                                                              |
| France      | 35% reduction in emissions since 1990.<br>70% of electricity comes from renewable sources.<br>Effective promotion of electric vehicles. | High costs of the energy transition.<br>Limited implementation of energy efficiency in poor sectors.<br>Slow transition of heavy industry to clean technologies. |
| Netherlands | Advanced infrastructure for bicycles and sustainable mobility.<br>Reduction in natural gas use.                                         | Slow transition to renewable energies.<br>Challenges in reducing industrial emissions.                                                                           |
| Spain       | Rapid growth in solar and wind energy.                                                                                                  | Dependence on imported natural gas.                                                                                                                              |
| Chile       | Decarbonization policies in key sectors.<br>Global leadership in solar energy.<br>40% growth in renewable energy capacity.              | Challenges in modernizing public transport.<br>Lack of infrastructure in rural areas to integrate renewable energy.                                              |
| Mexico      | Significant expansion of wind energy in the north of the country.<br>Development of infrastructure for electric vehicles.               | Lack of coordination between federal and state governments.<br>Dependence on fossil fuels.                                                                       |
| Brazil      | Largest producer of biofuels worldwide.<br>Increased use of hydroelectric power.                                                        | Deforestation in the Amazon affects climate goals.<br>Partial dependence on fossil fuels.                                                                        |

|          |                                             |                                                        |
|----------|---------------------------------------------|--------------------------------------------------------|
| Colombia | Increase in solar and wind energy projects. | High dependence on oil and coal.                       |
|          | Legal framework to reduce carbon emissions. | Challenges in implementing sustainable transportation. |

**Source:** Own elaboration.

According to the above, each country has made significant progress in its transition to cleaner energy, but still faces considerable challenges. Effective policy implementation will depend on overcoming context-specific obstacles, such as the energy transition in industrial sectors and infrastructure improvement in rural areas.

On the other hand, identifying best practices in decarbonization policies is essential to learn from the experiences of other countries and adapt successful strategies to local contexts. Below are the practices that have shown good results in the countries analyzed and those areas where current policies can be improved (Table 4).

**Table 4.** *Determination of best practices .*

| Best Practice                            | Countries that implemented it              | Areas for Improvement                                                        | Countries that Need to Improve    |
|------------------------------------------|--------------------------------------------|------------------------------------------------------------------------------|-----------------------------------|
| Promotion of public-private partnerships | Germany, France, Netherlands, Spain        | Implementation of consistent policies between federal and local governments. | Mexico, Chile, Colombia, Brazil   |
| Energy diversification                   | Germany, France, Netherlands, Spain        | Expanding electrical infrastructure in rural areas.                          | Chile, Mexico, Colombia, Brazil   |
| Robust tax incentives                    | Chile, Mexico, Netherlands, Spain          | Promote support for heavy industrial sectors.                                | France, Germany, Colombia, Brazil |
| Education and public awareness           | France, Germany, Netherlands, Spain, Chile | Integration of federal and local policies.                                   | Mexico, Colombia, Brazil          |

**Source:** Own elaboration.

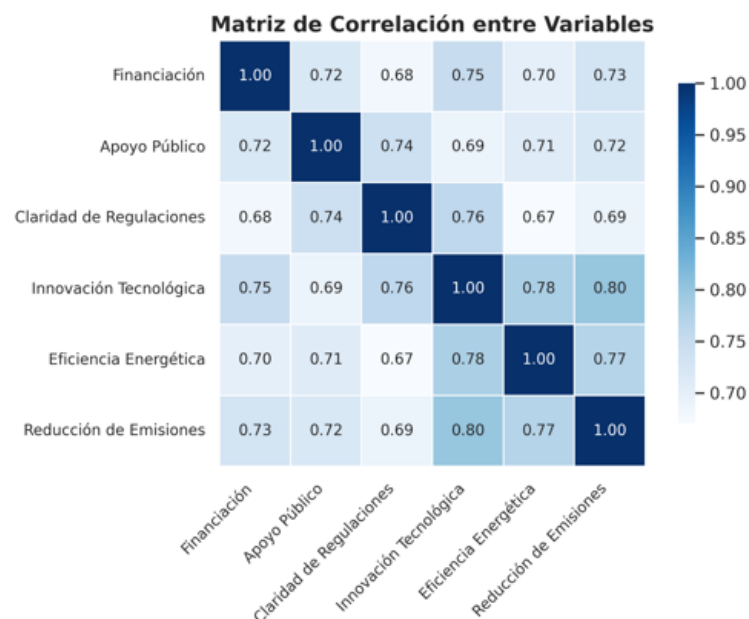
Finally, the best practices identified highlight that the success of decarbonization policies is deeply linked to effective cooperation between the public and private sectors, as well as to the diversification of energy sources. In

addition, the establishment of appropriate tax incentives plays a crucial role in the transition to clean energy, where education and public awareness are also key factors in generating social and political support for these initiatives. However, despite the progress made in various countries, significant challenges remain, particularly in areas such as energy infrastructure and cohesion between different levels of government. Accordingly, the following correlation matrix (Table 5) was used to identify the relationship between key components (financing, public support, regulatory clarity) and the success or failure of decarbonization policies.

To develop this matrix, variables such as investment in renewable energy, social acceptance, regulatory stability, level of technological innovation, energy efficiency, and emissions reduction were considered, using data from government reports, previous studies, and international databases. Therefore, the calculation method used was Pearson's correlation coefficient due to the quantitative nature of the data. The values in Table 5 were interpreted as follows: a correlation close to 1 indicates a strong positive relationship between the variables, while values close to 0 represent weak or no relationships. On the other hand, a negative correlation suggests an inverse relationship between the factors.

Table 5 presents the correlation coefficients obtained between the factors analyzed:

**Table 5.** *Correlation matrix between variables.*



The specific results of the matrix are presented in the following table:

**Table 6. Matrix results .**

| Relationship analyzed                            | Correlation Coefficient | Interpretation                              |
|--------------------------------------------------|-------------------------|---------------------------------------------|
| Technological Innovation and Emissions Reduction | 0.80                    | Strong positive relationship                |
| Energy Efficiency and Emissions Reduction        | 0.77                    | Positive and moderately strong relationship |
| Financing and Technological Innovation           | 0.75                    | Positive and moderately strong relationship |
| Public Support and Regulatory Clarity            | 0.74                    | Positive and moderately strong relationship |
| Financing and Emissions Reduction                | 0.73                    | Positive and moderate relationship          |
| Public Support and Emissions Reduction           | 0.72                    | Positive and moderate relationship          |

The values indicate positive and moderate to strong correlations between the components. The strongest relationship was found between technological innovation and emissions reduction (0.80), suggesting that technological advances played a crucial role in reducing environmental impact. Similarly, energy efficiency showed a significant relationship with emissions reduction (0.77) and technological innovation (0.78), highlighting its importance in resource optimization.

In comparative terms, European countries stood out for having a higher correlation between these factors due to their sustainable investments, citizen support, and consistent legal frameworks. In Latin America, the relationship between public support and financing was most significant in Chile and Brazil due to awareness campaigns and public-private collaboration, although regulatory instability limited its impact in Mexico and Colombia.

These findings underscore the importance of strengthening cooperation between the public and private sectors, ensuring stable regulatory frameworks, promoting technological innovation, and encouraging citizen participation to consolidate effective long-term decarbonization policies.

### **Proposal for best practices and recommendations for optimizing public decarbonization strategies**

Based on a comparative analysis of policies and the identification of key factors for their success, an optimized model proposal (Table 7) was developed to guide countries in the design and implementation of decarbonization

strategies. This simplified but technical model is based on principles of efficiency, sustainability, and adaptability, allowing governments to structure effective policies that fit their institutional, economic, and social capacities. The goal is to provide a practical tool that facilitates decision-making and maximizes the positive impact on emissions reduction.

To complement the model, general recommendations were developed that are tailored to the specific characteristics of each region, prioritizing those practices with the greatest potential for implementation according to the local context. These suggestions seek to be realistic and applicable, considering common constraints such as the availability of financing, infrastructure, and human capital.

From a technical perspective, strategies were designed that integrated sustainability and operational efficiency, promoting the use of clean technologies, the circular economy, and energy management systems.

**Table 7.** *Proposed optimized model .*

| Element                   | Description                                                                    | Specific Actions                                                                                                                                                                         | Expected Results                                                                               |
|---------------------------|--------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|
| Initial Diagnosis         | Assessment of carbon emission processes and sources.                           | <ul style="list-style-type: none"> <li>Conduct LCA to identify critical emission points.</li> <li>Map operational processes and evaluate technological and economic capacity.</li> </ul> | Identification of critical areas for improvement and an accurate database for decision-making. |
| Model Design              | Creation of an integrated model for operational efficiency and sustainability. | <ul style="list-style-type: none"> <li>Implement linear programming, lean manufacturing concepts, and KPIs for emissions and energy consumption efficiency.</li> </ul>                   | More efficient operations, reduced emissions, and a scalable model.                            |
| Process Optimization      | Improvement of energy and operational efficiency.                              | <ul style="list-style-type: none"> <li>Implement management systems based on ISO 50001, redesign production flows, and optimize logistics.</li> </ul>                                    | 10-20% reduction in energy consumption and lower operating costs.                              |
| Integrated Sustainability | Integration of sustainability throughout the value chain.                      | <ul style="list-style-type: none"> <li>Fostering the circular economy, promoting public-private partnerships, and designing incentives for renewable energy.</li> </ul>                  | Reduction of waste, increased use of renewable energy, and cross-sector collaboration.         |
| Training and Technical    | and                                                                            |                                                                                                                                                                                          | Greater commitment                                                                             |

|                                       |                                                             |                                                                                                                                                          |                                                                                          |
|---------------------------------------|-------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| Awareness                             | cultural training for key actors.                           | <ul style="list-style-type: none"> <li>• Train government teams, conduct awareness campaigns, and offer incentives for clean technologies.</li> </ul>    | from key stakeholders and social acceptance of initiatives.                              |
| Gradual Implementation                | Progressive rollout based on cost-benefit criteria.         | <ul style="list-style-type: none"> <li>• Prioritize sectors with the greatest impact, carry out pilot projects, and secure financing.</li> </ul>         | Significant reduction in emissions and validated results prior to scaling up.            |
| Monitoring and continuous improvement | Performance tracking through audits and monitoring systems. | <ul style="list-style-type: none"> <li>• Implement real-time measurements, conduct periodic audits, and adjust strategies based on data.</li> </ul>      | Measurable results and dynamic adjustments to maximize efficiency.                       |
| Regulatory and Policy Framework       | Develop public policies based on the designed model.        | <ul style="list-style-type: none"> <li>• Regulate emissions, offer tax incentives, and establish national targets with monitoring indicators.</li> </ul> | Public policies aligned with decarbonization and greater adoption of clean technologies. |

Thus, the proposal is to consolidate a comprehensive model that promotes decarbonization through process optimization, efficient use of resources, and integration of clean technologies, where the initial assessment through Life Cycle Assessment (LCA) would identify critical emission points, facilitating the design of specific actions aimed at mitigating environmental impact. Likewise, the application of tools such as linear programming and lean manufacturing would ensure greater operational efficiency, contributing to the reduction of energy consumption and associated costs.

The implementation of management systems based on the ISO 50001 standard would be essential to optimize production flows and improve energy efficiency. In addition, it is suggested that the circular economy be promoted and public-private partnerships be established to strengthen sustainability throughout the value chain, promoting a more rational use of resources and a reduction in waste generated. Therefore, training key actors, both technically and culturally, would facilitate acceptance of and commitment to decarbonization strategies, thus ensuring their effective long-term implementation.

On the other hand, a gradual implementation is proposed that would allow for prioritizing the sectors with the greatest impact, ensuring tangible results in the initial stages and facilitating the obtaining of financing for their scaling up. Continuous monitoring, through periodic audits and real-time measurement systems, would provide accurate information to adjust strategies and maximize their efficiency. Finally, the development of a solid regulatory framework,

complemented by tax incentives and clear national targets, would ensure the viability and sustainability of the proposed model, aligning the actions of the public and private sectors toward a common goal of reducing emissions.

## Conclusions

Analysis of the policies and strategies adopted in the selected countries in Europe and Latin America shows that, despite differences in levels of development and socio-political context, both groups have made significant progress in their decarbonization efforts. In Europe, countries such as Germany and France have implemented more advanced policies, with a strong focus on energy efficiency and the integration of renewable energies, thanks to a more consolidated energy infrastructure. In Latin America, countries such as Chile and Mexico have also made remarkable progress, particularly in the solar and wind energy sectors, despite facing challenges in terms of infrastructure and energy distribution, especially in rural areas.

Both regions share a common approach of encouraging the use of clean energy through subsidies, tax incentives, and energy diversification strategies. However, the most notable differences are in the speed and scale of implementation, with Europe being more advanced due to its technological maturity and well-established public policies, while Latin America is in a phase of expansion with a greater emphasis on public-private collaboration to strengthen its implementation capacity.

An assessment of the key components for the success or failure of decarbonization policies shows that factors such as financing, public support, and regulatory clarity are fundamental to the implementation of these policies. While countries such as Germany and France have made significant progress thanks to public investment, social support, and solid regulatory frameworks, Latin American nations such as Chile and Mexico face challenges related to energy infrastructure and coordination between levels of government, where overcoming these obstacles is crucial to ensuring policy effectiveness and moving toward a low-carbon economy.

The proposal to optimize public decarbonization strategies, based on industrial engineering principles, focuses on integrating sustainability and operational efficiency through tools such as life cycle analysis, linear programming, and efficient system design. It identifies the main sources of carbon emissions and addresses inefficiencies in key sectors such as industry, transportation, and agriculture, enabling an adaptable model that prioritizes energy efficiency, promotes the circular economy, and facilitates the transition to cleaner and more sustainable energy sources.

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# Artificial intelligence and statistical quality control in manufacturing

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## Introduction

In modern industrial environments, ensuring high levels of product quality is a competitive advantage and a requirement for customer satisfaction. To perform statistical quality control in manufacturing, data is traditionally collected through physical measurements or visual observation by quality inspectors. These measurements are usually carried out at the end of the process, off the production line, which limits the ability to identify faults in time. This process is usually done by sampling, collecting low volumes of data, which increases the risk that certain defects will not be detected. These traditional methods assume stable conditions and tend to focus on the analysis of individual variables, which has been effective for decades for relatively simple processes. However, processes now involve multiple stages, high dimensionality of variables, dynamic and uncertain environments, and strong interdependencies between different stages and parameters of the process (Ismail, M., Mostafa, N., & El-assal, A., 2022). In this new context, the question arises:

How can artificial intelligence (AI) be integrated with quality control to address current limitations and achieve higher levels of quality? To answer this question, we seek to analyze recent contributions of AI techniques to quality control in manufacturing, evaluating how they address the problems of the traditional approach, presenting recent scientific evidence and practical examples of how AI and machine learning (ML) are improving defect detection, process monitoring, and continuous improvement in manufacturing. To achieve this objective, the chapter is structured as follows: The first section describes the traditional approach to statistical quality control and its current limitations. The second section introduces artificial intelligence and machine learning. The third section explains how these AI techniques are being integrated into quality control activities in industrial plants. The fourth section discusses the practical challenges of implementing these solutions in real production environments, and finally, it projects the future trends and directions that will guide the integration of AI and quality control. This analysis is linked to STEM education

by showing that the implementation of artificial intelligence in manufacturing requires professionals with integrated skills in quality engineering and data science.

## Statistical Quality Control

Statistical quality control (SQC) allows variations in production processes to be detected and ensures that products meet predefined specifications. It has a reactive approach and is based on sampling and statistical analysis of process data, and mostly product data. Among the most commonly used traditional tools are control charts, such as the X-R (mean-range) chart, the X-S (mean-standard deviation) chart, and the CUSUM chart. These allow quality variables to be monitored over time, detecting changes that may indicate deviations in the process. These charts are fed with data taken from sampling inspections, usually at the end of the production line, where a sample of units is selected and evaluated to see if they meet the established limits. These techniques allow for the identification of abnormal conditions and corrective action to be taken before defects become widespread. These techniques stand out for their simplicity of interpretation; a control chart allows an engineer to quickly see if a process is "under control." In traditional environments with relatively stable and low-complexity processes, these methods work well and have proven their effectiveness (Ismail, M., Mostafa, N., & El-assal, A., 2022).

Despite its benefits, the traditional approach to quality control has significant limitations in today's scenarios. First, quality data is obtained through physical measurements or visual inspection at the end of the process, i.e., once the product is already finished. This means that defects are identified late, when potentially non-compliant parts have already been produced, resulting in rework or waste. Furthermore, to reduce costs, inspection is often done by sampling, analyzing only a fraction of the total production. This limits the volume of available data and carries a risk: defects or variations may go unnoticed if they are not observed in the inspected sample. As a result, sporadic or systemic quality problems may be detected late or not at all.

Another critical limitation is the univariate approach of the method. Conventional control charts ( ) typically monitor a single quality variable at a time, assuming that the stability of a process can be assessed by observing each quality characteristic separately. However, production processes involve multiple interrelated variables (temperature, pressure, speed, dimensions, material properties, etc.), whose combined interaction influences the final quality. In the traditional approach, there are multivariate control charts (such as Hotelling's  $T^2$  statistic), but they face difficulties when the dimensionality

increases or when the relationship between variables is not linear. As a result, traditional CEC tends to ignore correlations or combined effects between parameters, potentially leaving certain anomalous conditions undetected.

Additionally, modern processes often consist of multiple linked stages (multi-stage manufacturing), where the output of one stage is the input of the next. In these cases, the final quality of a product is the cumulative result of the variations that occurred in all previous stages. Recent research indicates that in a multi-stage manufacturing system (MMS), multiple factors from different stages have interactive and cumulative effects on the quality of the final product (Ismail, M., Mostafa, N., & El-assal, A., 2022). Consequently, traditional techniques are insufficient to address current problems in highly complex environments.

Production speed in manufacturing has also increased considerably with automation, resulting in a much greater volume of data being generated than before. However, large manufacturing data sets tend to be underutilized if traditional sampling practices continue to be used.

In summary, the traditional approach to statistical quality control has served as a basis for decades and is still useful in many processes; however, it presents significant opportunities for improvement in the face of modern manufacturing demands. Highly instrumented, interconnected, and complex processes require new paradigms for monitoring and quality assurance (Colosimo, B. et al., 2024).

## **Artificial Intelligence and Machine Learning in Manufacturing**

Artificial Intelligence (AI) seeks to develop systems capable of performing tasks that normally require human intelligence, such as learning, reasoning, or decision-making. Within AI, machine learning (ML) stands out as a set of techniques that allow systems to learn patterns from data rather than being explicitly programmed. In the context of manufacturing, AI has various applications: from algorithms capable of classifying products to computer vision systems that automatically inspect a process.

In recent years, interest in applying AI and ML to manufacturing operations has grown exponentially. Chen et al. (2023) point out that ML is playing a critical role in the digitization of manufacturing operations toward Industry 4.0. This increase in attention is due to the fact that ML techniques have proven effective in solving problems with varying levels of complexity and performance. Unlike classical statistical tools, which often require strong assumptions (data normality, linearity, etc.), many ML algorithms can handle

nonlinear relationships, complex distributions, and noisy or high-dimensional data. For example, decision tree, random forest, or neural network algorithms can model interactions between dozens of process variables to predict an outcome.

There are different machine learning paradigms applicable to quality control. In supervised learning, algorithms are trained with labeled examples to then classify new cases or predict numerical values. This category includes techniques such as support vector machines (SVM), decision trees, deep neural networks, etc., which can be trained to recognize process conditions that lead to defects. Unsupervised learning, on the other hand, is useful for detecting anomalies or unprecedented patterns without the need for known defect labels. Another area is reinforcement learning, in which an agent learns to make sequential decisions by optimizing an accumulated reward.

It is important to mention that AI in manufacturing is not limited to the analysis of numerical data from sensors; it also includes fields such as computer vision and artificial intelligence combined with robotics for inspection. AI vision systems can examine parts with high-resolution cameras to identify surface defects (scratches, pores, discoloration) much more consistently and quickly than human inspection.

An important point is that AI does not aim to replace human expertise, but rather to augment it. Far from supplanting human judgment, AI helps by processing data and presenting useful information, so that engineers can focus their knowledge on solving problems rather than looking for them. This human-AI collaboration is transforming manufacturing processes in various industries (automotive, manufacturing, food, etc.), allowing for expanded inspection coverage and predictive analytics without the need to devote additional manpower to routine tasks. In general, AI acts as an "assistant" that monitors countless parameters and flags risks, while humans maintain control over final decisions and contribute context and creativity to solutions. AI and machine learning offer advanced analytical capabilities that complement and extend traditional statistical quality control techniques. With ML, it is possible to handle large Industry 4.0 data sets, detect complex multivariate patterns, and make predictions.

## **Integrating AI into quality control**

The integration of artificial intelligence into quality control represents an opportunity to manage and improve production processes. Instead of monitoring quality at the end of the process using isolated statistical methods, modern plants seek to incorporate intelligent systems that operate in parallel

with the production process, collecting data in real time, analyzing it, and issuing alerts autonomously or semi-autonomously. This integration is facilitated by the combination of several Industry 4.0 technologies: IoT (Internet of Things) sensors in machines that transmit data instantly, computing infrastructure (in the cloud or at the edge) to process the information, and AI algorithms trained to recognize quality conditions. Hereinafter, this integration will be referred to as intelligent quality control (IQC).

A first aspect of IQC is real-time data capture at each stage of the process. Thanks to sensors and data acquisition systems, critical characteristics can be measured at each stage of production. For example, Shi (2023) describes a metal stamping line where each press can be equipped with force sensors that measure the pressure applied in each pressing cycle, while vibration sensors monitor the condition of the machine. The continuously collected data is used to identify small deviations and make automatic adjustments before defects occur. This approach requires simultaneously analyzing multiple data streams and comparing them with historical patterns to make decisions in a very short time window.

Intelligent quality control is also evident in intelligent monitoring systems (IMS). Olajiga et al. (2024) state that IMS composed of IoT, AI, and Big Data technologies enable proactive defect detection. This means that the system does not wait for a defect to appear, but rather identifies trends or anomalous deviations in process variables that predict a defect, allowing alerts to be generated before it occurs. A concrete example is provided by Colosimo et al. (2024), who describe the application of AI in additive manufacturing processes (3D printing): by capturing video during layer printing and analyzing it with vision algorithms, it is possible to monitor the deposition/ ssion process in real time and identify hot spots or irregularities that would eventually cause defects in the part. By detecting these anomalous conditions during layer-by-layer construction, the system can adjust energy parameters or pause the process, preventing the part from ending up with an internal defect.

Another important issue is that AI allows multidimensional data from various sources to be integrated to evaluate quality. In a 4.0 quality control system, all data recorded throughout the process can be associated with each unit produced. In this regard, Uyan et al. (2023) point out that an Industry 4.0 quality system can link data from all measurement points in the process to each individual part and its inspection results, resulting in multidimensional data, which, when analyzed by classification algorithms, would allow the identification of combinations of process configurations that generate defects. In other words, AI can discover interactions between variables that, taken

together, are problematic. For example, it could discover that a certain batch of raw material combined with a particular oven temperature setting and a specific cooling time, taken together, lead to a defect that does not appear under other combinations. With this information, engineers can adjust conditions or avoid certain combinations of parameters to prevent the defect.

Another recent study shows the efficiency in resource use when integrating AI into quality monitoring schemes. Ismail, M., Mostafa, N., & El-assal, A. (2022) introduced an intelligent monitoring and control framework, combining predictive models with physical inspection. In their approach, an ML model predicts in real time the probability of quality deviation at each stage; when the probability is low, a physical inspection can be omitted (relying on the model), and only when the model indicates a possible problem is a human or instrumental inspection performed. In this way, they manage to reduce the volume and cost of unnecessary inspections. According to the authors, this hybrid approach saved substantial resources in a semiconductor manufacturing case. This is a clear example of how AI acts as an intelligent filter that concentrates human inspection efforts where they are most needed.

Another use of artificial intelligence is predictive equipment maintenance, which focuses on the health of machinery and has a direct impact on product quality, since machines in poor condition often produce defective parts. Some companies are using AI to monitor equipment and predict failures, preventing the manufacture of defective batches under abnormal conditions. One example is the BMW Group plant in Regensburg, where they implemented an AI-supported predictive maintenance system to monitor transport technology on the assembly line (BMW GROUP, 2023). This system has identified potential failures in vehicle transport equipment in advance, preventing more than 500 minutes of vehicle production interruptions per year. As a result, production continuity is maintained, and variations induced by technical failures (vibrations, misalignments) that could lead to assembly defects are prevented. In other words, the quality of the final product is safeguarded by keeping the equipment in optimal condition.

Furthermore, AI participates in the solution and active control of failures. This is possible because in highly automated environments, cyber-physical systems (CPS) capable of acting on the process are available, and AI can adjust parameters in real time without human intervention. Chen et al. (2023) point out that, with CPS installed, AI not only identifies anomalies but can also make autonomous decisions to adjust the process in real time, enabling autonomous quality control management. This enhances the concept of continuous improvement, given that traditionally, continuous improvement that sought to



plan, do, verify, and act depended on humans periodically analyzing quality data and proposing corrective actions. With integrated AI, the PDCA cycle can occur at an accelerated pace and with minimal human intervention: models analyze data in real time, detect deviations or trends, identify probable root causes, and execute corrective actions. In this way, the continuous improvement cycle is automated. Some companies are already making progress with this approach. For example, Bosch uses AI in the manufacture of fuel injectors to maintain high standards of precision and reduce response time in error correction. In other words, when a deviation in the quality of an injector is detected, Bosch's intelligent system can adjust the machinery parameters before that deviation results in defective parts. With traditional control, detecting and correcting this deviation could have taken days (until quality personnel analyzed data and maintenance personnel made adjustments), during which time defective parts would have been produced.

The vision of intelligent quality control suggests that, over time, factories could achieve **"zero defect"** production. AI analyzes so many control points that it is capable of detecting the slightest deviation (in the micrometer range, even smaller than the thickness of a human hair, when measuring tiny components) and reporting it immediately (BOSCH., 2024), preventing it from spreading along the line. This means that even defects that were previously considered natural variations in the process, and therefore uncontrollable, can now be better controlled.

The above cases were selected for their practical relevance, level of implementation, and sectoral diversity, which illustrates the cross-cutting applicability of intelligent quality control as a proactive and predictive system. Based on the analysis presented, a conceptual framework for intelligent quality control (IQC) with three levels is proposed: (1) Digital data capture throughout the process; (2) Multivariate predictive analysis with ML; and (3) Autonomous or assisted response on critical process configuration parameters. This framework allows quality control to be scaled from reactive systems to adaptive platforms that integrate monitoring, decision-making, and correction.

## Implementation challenges

While there are many advantages to incorporating AI into quality control, putting this integration into practice poses several challenges in the technological, organizational, and human fields. Addressing these challenges is necessary for companies to take advantage of new technologies without compromising their operations or confidence in their quality systems.

First, adopting AI in industrial processes usually requires a significant

investment in infrastructure and development. Production lines need to be equipped with additional sensors, data acquisition systems, computing capabilities (local servers, cloud infrastructure, etc.), and specialized software. In addition, integrating an AI system with existing systems such as ERP can involve customization costs. Organizations must justify these expenses economically with clear savings or improvements, so knowing the potential economic benefits of implementing technologies is a key necessity (Stadnicka, D., Şep et al., 2022). Although, in the long term, intelligent quality control can generate significant savings (less rework, less waste, fewer downtimes), quantifying this in advance is not easy. This financial challenge can hinder implementation, especially in small or medium-sized companies with tighter margins. Some strategies to overcome this could be to start with low-cost pilot projects to demonstrate results in one process or line before scaling up to the entire plant. Also, AI solutions offered by third parties (e.g., systems such as Rosepetal from AIS Vision Systems, which can be purchased as a service) can be leveraged instead of developing everything in-house.

According to Stadnicka et al. (2022), the lack of training and shortage of specialized talent represent a challenge for implementing artificial intelligence in manufacturing, as professionals who are proficient in data science, programming, and machine learning algorithms are required. Skills such as the ability to identify areas suitable for AI technologies are also required, as is a comprehensive view of the data lifecycle, from capture to use. Currently, both employees and university students are not fully prepared to operate AI-based industrial systems. In addition, resistance to change persists in some companies, motivated by fears that technology will replace human functions. Technological change requires cultural and educational support. In response, many organizations are investing in continuing education, collaborating with universities to update curricula, incorporating new profiles such as data scientists, and forming multidisciplinary teams that integrate experts in quality and AI.

A third challenge is integration with existing systems, which arises from the fact that today's factories typically have a variety of information systems, such as ERP for resource planning, MES for manufacturing execution, PLM for product lifecycle management, among others. Integrating an AI layer that takes data from different sources and then returns results to the production plant can present compatibility and interoperability barriers. Many factories have older machines that were not designed for connectivity, so that first they need to be upgraded or adapted so that they can provide data to the AI system. There is also a need to standardize data collection and analysis (Stadnicka et al., 2022). In addition, integrating the results of an ML algorithm

into machine control in real time may require modifying the control logic (PLC) or having an advanced control system that accepts external inputs, which adds complexity. On the other hand, handling large volumes of data requires robust infrastructure; some companies hesitate to send all data to the cloud and prefer to analyze data locally in the factory (or even on the machine) so as not to depend on external connections and to ensure rapid response times. In conclusion, from a technological point of view, a well-planned architecture is required that integrates sensors, networks, storage, and computing in an integrated manner. Even so, getting all the components to "talk" to each other and the overall system to work in sync is a challenge that requires knowledge of systems engineering, IoT, and industrial engineering.

The fourth challenge is data quality, because an AI system is only as good as the data it receives. It must be ensured that the data coming from the plant is clean and well structured for use by the algorithms. The right amount and quality of data must be obtained, following appropriate collection guidelines (Stadnicka et al., 2022). Data with noise, errors caused by sensors, missing values, or temporal desynchronization can lead to erroneous conclusions from the model. For example, if a temperature sensor is out of calibration and sends erroneous values, an ML system could falsely infer a correlation with defects that does not actually exist. Oversampling or undersampling techniques (as applied by Uyan et al. 2023 in their smelting study) may be necessary to handle the data. Managing historical data is also a challenge: decisions must be made about how much history is relevant to store and use without incurring unnecessary costs, and how to label data when conditions change (change of raw material, operator, etc.). Implementing AI systems therefore involves managing the data lifecycle: generation, collection, storage, cleaning, analysis, and feedback.

Another challenge is cybersecurity because as more production data is collected and transmitted (sometimes to clouds or external servers), concerns about information security grow. Production data can be sensitive for a company, as it reveals information about its know-how, defect rates, process capabilities, etc. A security breach could expose trade secrets or reputation-damaging data (such as if it were leaked that a certain batch had a high defect rate before being corrected). Therefore, ensuring cybersecurity is essential in the implementation of AI (Olajiga et al., 2024). Privacy concerns also arise when sharing data with other actors in the supply chain, such as suppliers or customers, or even with AI platform providers. In this regard, the implementation of edge computing solutions (computing close to the data source) and strict access control policies become relevant. In addition, data integrity must be protected: any malicious alteration could lead to erroneous

decisions (for example, if someone manipulated sensor readings, the AI could "believe" that everything is fine when it is not, or vice versa). Therefore, companies must invest in securing data, training staff in best practices, and keeping defenses up to date.

Finally, trust in the AI system is a challenge because engineers and managers must be convinced to trust the AI's recommendations or decisions. Companies will not accept changes to the process unless they are solidly justified. There are also technical limitations to AI models, which can be overfitted (they can adapt too much to the training data and fail to generalize); there can also be an imbalance in learning data because defects are rare events in industrial processes, which makes it difficult to teach that data to the model; processes can also change over time, and the model loses validity if it is not updated. Another limitation is that an ML model is sometimes a difficult-to-interpret "black box" that does not explain the reasoning behind a recommendation. The lack of interpretability of certain algorithms can raise doubts and slow down

decisions to take action. That is why there is growing interest in explainable AI (XAI) techniques that help translate the model's internal signals into an understandable form (for example, indicating which variables led to a part being classified as defective). To address this challenge, any new quality control system must be thoroughly validated: the company must be sure that the AI will not overlook actual defects (minimizing false negatives) or generate excessive false alarms (false positives) that unnecessarily interrupt production. This validation requires time, pilot testing, and model adjustment, which involves investment in time and technology before the full benefits can be realized.

In summary, overcoming these challenges requires a comprehensive strategy: planned investment, training and change management for staff, updating and integration of technical systems, robust data governance and security measures, and well-controlled pilot testing to build confidence in the new systems. Companies that overcome these obstacles will be able to achieve higher and more consistent quality.

## **Future prospects**

One of the most promising prospects is the consolidation of a predictive and adaptive approach to quality. Instead of detecting defects only when they appear at the end of the process, future systems will seek to predict changes in quality before they occur and act accordingly. Mayer and Jochem (2024) highlight that leveraging ML applications for predictive process control

represents a technological evolution that would enable manufacturers to better address the complexities of process variability, ensuring consistent compliance with quality specifications. In practical terms, this translates into production plants capable of responding nimbly to changing conditions: highly adaptable processes that adjust their parameters in real time guided by algorithms, maintaining quality without human intervention. The expected benefits include being able to predict a drop in process quality before it occurs, optimize resource allocation, and anticipate problems before they impact output. Therefore, the idea of "zero defects" could be achieved not only by reacting quickly to problems, but also by proactively avoiding them through data intelligence.

Another key perspective is the growing collaboration between humans and AI in the field of quality, which some call Quality 5.0, a concept borrowed from Industry 5.0, which is human-centered. It is about leveraging the complementary strengths of humans and machines, where AI offers computing power and analysis of large volumes of information, while humans contribute judgment, creativity, and tacit knowledge. In the future, there will be hybrid quality teams: inspectors and technicians working with AI assistants. Intelligent quality control software will act as an assistant to quality managers. An inspector empowered by AI- t analyze thousands of pieces of production data daily (an activity that would be impossible manually) and could focus on improvement strategies rather than repetitive checking tasks.

Another trend is the incorporation of more natural and intuitive interfaces for interacting with AI systems. Systems such as Rosepetal from AIS Vision Systems (2023) mention the possibility of non-expert users modifying workflows using natural language. In the future, quality engineers could have "conversations" with AI, asking it in everyday language to investigate a hypothesis, such as "What happens if I raise the oven temperature by 5 degrees?" or requesting a summary of the main causes of failures for the week. This will democratize the use of AI, making it more accessible and removing the technical barrier to better leveraging it. The result will be that more people in the organization will be able to benefit from AI in their daily decisions, not just data scientists. Likewise, the explainability of AI will likely improve. Future AI-powered quality control systems will be able to provide plain-language explanations of why a certain decision was made, increasing trust and facilitating its use in regulated environments. For example, a system could indicate: "This batch was flagged as potentially defective because the oven temperature profile was unusual at minute 10, which according to the model has preceded hardness defects in 95% of similar cases."

Another future direction is closer integration between quality control and business intelligence. With the complete digitization of quality, the data collected will feed not only into immediate process control, but also into business intelligence systems: quality can be correlated with customer satisfaction, costs, supplier performance, etc., thanks to the fact that quality information will be in digital format. This will enable holistic decision-making, such as deciding on product design changes based on analysis of manufacturing defect data, or identifying opportunities for improvement in employee training by correlating the occurrence of defects with the operator's level of experience.

In terms of specific technologies, more sophisticated deep learning algorithms could emerge to model complex relationships in production lines, or generative models that can simulate process scenarios to predict outcomes (AI-powered digital twins). Edge computing will also take center stage, with smart microcontrollers and specialized chips installed directly on machines to run AI models instantly, without relying on the cloud, reducing response times and increasing reliability.

One perspective linked to STEM education is that the training of future industrial engineers should include subjects such as data science applied to quality, intelligent process control, etc. The aforementioned skills gap will gradually diminish with new generations of professionals who will already have comprehensive knowledge of classical statistics and AI. This, in turn, will accelerate innovation, as there will be more people capable of designing and carrying out projects that integrate AI.

On the other hand, it will contribute to the sustainability of manufacturing. By reducing defects, waste of materials and energy invested in rejected parts is avoided, which is environmentally positive. By optimizing processes in real time, resources (machines, time, labor) are used more efficiently. And by ensuring consistent quality, product life is extended and consumer confidence is improved. All of this fits in with the trends toward more sustainable and responsible manufacturing.

In short, the future looks set to be dominated by highly automated quality systems that are supervised and enhanced by humans, with AI at every stage of the production chain. This will result in smarter, more flexible factories focused on unlimited continuous improvement and " " supported by the synergy between advanced data analytics and human expertise.

## Conclusions

In conclusion, the integration of artificial intelligence with statistical quality control is improving traditional quality assurance methods in manufacturing. This chapter formulated a research question aimed at understanding how AI techniques can transform quality control in manufacturing and what the benefits, challenges, and prospects of such a transformation are.

First, the framework of the traditional approach to statistical quality control was established, highlighting its historical contributions, but also its limitations in today's industrial environments characterized by high complexity, multidimensional data, and the need for immediacy. On the other hand, it was shown that AI is capable of analyzing large volumes of data in real time, discovering hidden patterns, and learning from experience.

The central section on AI integration in quality control addressed specific cases, from early defect detection and quality prediction in multi-stage lines to industrial implementations of predictive maintenance at BMW and analysis platforms at Bosch, which empirically support AI's contribution to achieving improvements in quality control. The examples illustrated that AI can be used to detect deviations before they result in defective products, correlate data from multiple sources to understand complex root causes, and make automatic adjustments to processes, closing the control loop autonomously. These capabilities translate into real benefits: reduced defects, less downtime, cost savings on inspections, process optimization, and, ultimately, more efficient quality control. Thus, the research question was answered positively: the integration of AI effectively improves and transforms quality control, providing a more responsive and adaptive system.

However, there are not only benefits, but also challenges in implementation. Here, it was concluded that, in order to reap the benefits of AI in quality, it is essential to carefully manage factors such as financial investment, staff training, infrastructure upgrades, data quality and security, and cultural acceptance of change. These challenges explain why adoption is neither immediate nor widespread in industries. However, it was also shown that challenges can be overcome through clear strategies such as starting with pilot projects, demonstrating return on investment, fostering a data culture in the organization, ensuring cybersecurity, and building trust through transparency and explanation of AI models.

Finally, when exploring future prospects, a future was predicted in which systems will be more predictive, possibly achieving the goal of zero defects. The idea of effective collaboration between humans and AI was also

emphasized, where technology enhances human capabilities rather than replacing them, opening up a more strategic, informed, and effective stage of quality management. In addition, it was highlighted that evolution will continue to drive the need for interdisciplinary STEM training, so that future professionals possess both a foundation in statistics and quality as well as mastery of data science and AI. Overall, the outlook is optimistic: more competitive, secure, and sustainable industrial operations could be achieved.

In conclusion, although current advances demonstrate the potential of artificial intelligence in improving quality control, there are still technical, human, and organizational challenges to overcome. It is necessary to develop robust validation frameworks for predictive models, integrate explainability mechanisms (XAI), and foster interdisciplinary skills in engineering, data science, and manufacturing systems. Looking ahead, it is recommended to advance comparative studies ( ) between traditional and AI techniques, as well as to design specific industrial standards for their ethical and reliable implementation. The evolution toward intelligent quality control will be gradual but irreversible, and will be closely linked to the technical training of new professionals within the framework of STEM education.

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# Pedagogical innovation in interventional radiology: application of the Spatial i.o metaverse for cooperative learning

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## Introduction

Health sciences education is undergoing a profound transformation driven by technological advances and new generations of students with high digital literacy (Kandamaran et al., 2022). Today's learning environments demand active methodologies that promote student participation, collaboration, and autonomy. In this context, cooperative learning theory holds that knowledge is constructed more effectively when working in teams than individually, as peer interaction encourages communication, shared reflection, and joint problem solving (Pan et al., 2023). Its implementation in higher education and s been shown to improve attitude, academic and clinical performance, and increase student satisfaction (Lee et al., 2025).

At the same time, the incorporation of virtual reality (VR) and other immersive technologies into university education has opened up new possibilities for facilitating cooperative learning (Wang et al., 2023). The COVID-19 pandemic accelerated the adoption of digital environments, transforming traditional face-to-face classes into virtual experiences that required adaptability and creativity from teachers and students (Peters et al., 2023). Despite initial difficulties—such as limited communication, technological anxiety, or lack of experience—

this change prompted the exploration of new interactive tools that transcended two-dimensional videoconferencing, giving way to innovations such as augmented, mixed, and virtual reality (De Gagne et al., 2023).

In the field of interventional radiology, practical teaching and simulation are essential for developing clinical and communication skills. Immersive environments allow real-world contexts to be recreated where students can practice procedures, interact with equipment, and make clinical decisions in real time without compromising patient safety (Fowler et al., 2023). These collaborative experiences foster interdisciplinary work and professional communication, essential skills in complex hospital settings (Peter et al., 2024).

Likewise, teaching methods based on games, simulators, and mobile applications have been shown to increase motivation, participation, and knowledge retention (Banerjee et al., 2023). In this scenario, the metaverse emerges as an interactive three-dimensional environment that enables cooperative learning through avatars, social interaction, and shared activities. Platforms such as Spatial allow for the design of customized educational scenarios, simulating clinical rooms or laboratories, and promoting collaboration between students from different disciplines (Spatial, 2024).

In this way, the convergence between cooperative learning and the metaverse offers an innovative educational model capable of integrating clinical practice, social interaction, and technological immersion. This proposal redefines the teaching of interventional radiology by transferring the educational experience to a collaborative, flexible digital space adapted to the needs of new generations of healthcare professionals.

Cooperative learning (CL) has been widely studied as a student-centered pedagogical strategy that promotes active participation and teamwork. Johnson et al. (1999) and Fathman & Kessler (1993) established its foundations, highlighting positive interdependence, interaction, social skills, group reflection, heterogeneity, evaluation, and mentoring as essential dimensions for its effective application. This methodology not only improves academic performance but also strengthens communication skills, shared responsibility, and conflict resolution (Cruz et al., 2022; Gómez et al., 2023).

In the health sciences, where multidisciplinary work is essential, CL takes on special relevance. Several studies show that cooperation between students from different disciplines improves understanding of professional roles, the quality of clinical work, and patient safety (Fowler et al., 2023). In addition, it

fosters social and leadership skills that are difficult to acquire in competitive or individualistic environments (Flores and Hernández, 2020).

However, its effective implementation requires trained mediators to guide group dynamics and ensure fair assessment. Woods and Chen (2010) point out the importance of using rubrics, self-assessments, and peer assessments to promote individual and collective reflection. Nevertheless, limitations such as teacher resistance, lack of time, and the difficulty of designing authentic cooperative activities in virtual environments still persist (Gonzales et al., 2015).

In recent years, immersive technologies have revitalized cooperative learning strategies. Virtual reality (VR), augmented reality (AR), and mixed reality (MR) facilitate the creation of simulated scenarios where students can interact, practice clinical skills, and solve cases as a team (De Gagne et al., 2023). These tools are especially valuable in practical subjects such as interventional radiology, where clinical risks and equipment costs limit in-person practice (Aguado and Sendra, 2023).

Recent literature highlights the metaverse as an advanced extension of virtual reality that allows three-dimensional interaction through avatars. Initially conceived by Stephenson (1992) in *Snow Crash* and taken up by contemporary platforms such as *Spatial*, the metaverse is establishing itself as a shared, persistent, and decentralized environment (Chen et al., 2023). Its educational potential lies in the possibility of recreating interactive virtual classrooms, fostering collaboration, and reducing geographical and logistical barriers (Zakarnah et al., 2024).

The rise of the metaverse in educational research is recent but exponential: while between 2019 and 2021 there were few academic references, from 2022 onwards there was a significant increase in publications, especially in Asia and North America (Gómez et al., 2024). In Latin America, its implementation remains limited by technological costs and language barriers, although progress is being made in medical education (Pakrash et al., 2023).

In the field of interventional radiology, the metaverse can replicate complex clinical procedures and promote cooperative learning among students through clinical simulations, case discussions, and shared decision-making. In addition, avatars allow for personalization of the experience, strengthening user identity and interaction (Kyriltsias & Grigoriou, 2021). Recent research shows that the use of playful and immersive environments improves attention, knowledge retention, and student motivation (Vest et al., 2020; Mobley et al., 2023).

The **Spatial** platform is a prime example of accessibility and flexibility. It allows for the creation of collaborative rooms, the integration of three-dimensional models, and synchronous interaction between students through personalized avatars (Britton, 2023). In addition, its technical features, such as compatibility with virtual reality devices and web access, facilitate the inclusion of diverse participants without requiring specialized equipment (Spatial, 2024). This makes it a viable tool for universities with limited resources seeking to innovate in medical education.

In summary, the literature shows that cooperative learning, enhanced by the metaverse, represents a paradigm shift in health education. However, its adoption faces challenges: teacher training, technological infrastructure, evaluation of results, and cultural adaptation. Research is needed to empirically analyze the impacts of the metaverse on the acquisition of clinical and socio-emotional skills, especially in Latin American contexts. The integration of platforms such as Spatial may mark the beginning of a new era in medical education, where collaboration, immersion, and technology converge to transform the training of future health professionals.

Therefore, the objective of this research is to evaluate the effect of using the Spatial i.o metaverse as a cooperative learning environment for university students of interventional radiology.

The study sample consisted of 36 fifth-year medical technology students enrolled in the Interventional Radiology course at a public university in Lima, Peru. The average age was 22.08 years ( $SD = 3.597$ ), with a range between 18 and 34 years. In terms of gender, 50% ( $n=18$ ) were male and 50% ( $n=18$ ) were female. All participants had access to electronic devices (laptop or mobile phone) and a stable internet connection, which ensured the proper use of the *Spatial i.o* metaverse during the educational sessions.

In relation to the initial descriptive statistics, the pre-test results showed that the cooperative learning scores were similar in both groups (control and experimental). However, after the implementation of the educational program in the metaverse, a considerable increase was observed in the experimental group, reflecting the positive impact of the immersive experience on the development of cooperative learning.

### Overall level of cooperative learning

In the pre-test evaluation, the control group scored 88.9% at the high level and 11.1% at the medium level. The experimental group, on the other hand, scored 94.4% at the high level, 5.6% at the medium level, and 5% at the low level.

After the educational intervention, the post-test showed a substantial improvement in the experimental group, reaching 94.4% at the high level and 5.6% at the medium level, with no low levels. In contrast, the control group decreased its proportion at the high level (56%) and increased at the medium level (44%).

These results reflect that the implementation of **the Spatial i.o metaverse** contributed to strengthening cooperation, interaction, and collaborative work among students, which translated into a higher level of overall cooperative learning.

## Dimensions of cooperative learning

### Positive interdependence

In the pre-test evaluation, the control group scored 88.9% and the experimental group scored 94.4% at the high level. In the post-test, the scores were 77.8% and 83.3%, respectively. The results of the inferential analysis using the **Mann-Whitney U** test showed a significant difference in the post-test ( $p=0.022 < 0.05$ ), which shows that the immersive environment fostered collaboration and mutual dependence among the members of the experimental group.

### Interaction

In the interaction dimension, the control group scored 77.8% and the experimental group scored 72.2% at the high level during the pre-test. After the intervention, the values rose to 83.3% in the experimental group and fell to 55.6% in the control group. Inferential analysis showed a significant difference in the post-test ( $p=0.006 < 0.05$ ), indicating that the metaverse allowed for greater communicative exchange and active participation in group activities.

### Social skills

Before the intervention, the high-level percentages were 94.4% for the control group and 83.3% for the experimental group. After the educational program, the experimental group reached **100% at the high level**, while the control group decreased to 61.1%. The statistical significance value was  $p=0.000$ , showing a significant change. This suggests that the immersive experience in the metaverse strengthened interpersonal skills, empathy, and assertive communication in students.

## Heterogeneity

In this dimension, both groups started with high performance levels (88.9% and 94.4%, respectively). In the post-test, the values remained relatively stable, with 83.3% in the control group and 88.9% in the experimental group. The inferential analysis yielded a **p-value of 0.279**, indicating that there were no statistically significant differences between the two groups. This stability may be due to the fact that the composition of the groups (mix of gender, performance, and skills) remained constant throughout the sessions, limiting the expected variations.

## Group reflection

The results showed that, in the pre-test, the control and experimental groups had high levels of 61.1% and 66.7%, respectively. In the post-test, the experimental group significantly increased its high level to 88.9%, while the control group decreased to 44.4%. The inferential analysis yielded a **p=0.002**, confirming a significant difference. This finding suggests that the virtual environment allowed for greater exchange of ideas, self-assessment, and collective feedback.

## Evaluation

In the evaluation dimension, the groups showed a high level in the pre-test of 77.8% (control) and 88.9% (experimental). In the post-test, the experimental group maintained a higher performance (83.3%) than the control group (50%). The **p-value of 0.020** indicates a significant difference, showing that the use of the metaverse promoted more participatory and reflective self-assessment.

## Tutoring

In the tutoring dimension, the pre-test results were similar between both groups (88.9% and 77.8% at a high level). However, in the post-test, the experimental group reached **88.9%** at a high level, while the control group decreased to 44.4%. The inferential analysis showed **p=0.000**, reflecting that teacher mediation within the metaverse favored personalized guidance, continuous orientation, and student autonomy.

## General comparative analysis

The overall analysis using the Mann-Whitney U test showed that, in the pre-test, the means were 18.44 (control) and 18.56 (experimental), with no significant differences (**p=0.988 > 0.05**). After the educational program was implemented, the means changed to 12.56 (control) and 24.44 (experimental),

with a p-value of  $0.000 < 0.05$ , demonstrating a statistically significant increase in the experimental group.

These results confirm the general hypothesis, establishing that the implementation of an educational metaverse based on Interventional Radiology significantly improves cooperative learning in Medical Technology students.

**Table 1**

*Summary of inferential results*

| No . | Dimension                | p value Pre-test | p value Post test | Significance    |
|------|--------------------------|------------------|-------------------|-----------------|
| 1    | Positive interdependence | 0.888            | 0.022             | Significant     |
| 2    | Interaction              | 0.888            | 0.006             | Significant     |
| 3    | Social skills            | 0.606            | 0.000             | Significant     |
| 4    | Heterogeneity            | 0.791            | 0.279             | Not significant |
| 5    | Group reflection         | 0.805            | 0.002             | Significant     |
| 6    | Evaluation               | 0.443            | 0.020             | Significant     |
| 7    | Tutoring                 | 0.888            | 0.000             | Significant     |

**Source:** Own elaboration.

**Note:**  $p > 0.05$  = not significant;  $p < 0.05$  = significant.

## General interpretation of the findings

The results show that the Spatial i.o metaverse is an innovative tool that enhances cooperative learning dynamics in higher education settings, especially in technical and practical subjects such as interventional radiology.

The increase in levels of positive interdependence, interaction, social skills, group reflection, evaluation, and mentoring demonstrates that immersive environments promote student engagement, assertive communication, and a sense of shared responsibility in achieving common goals. The only dimension without a significant difference, heterogeneity, suggests that group diversity alone does not guarantee an increase in cooperative learning, but rather requires more intentional pedagogical management on the part of the teacher.

Likewise, the statistical values reflect that interactive three-dimensional spaces, such as the portals in Spatial, promoted active learning, with greater participation, reflection, and cohesion among students. Real-time feedback and the figure of the teacher as a virtual mediator strengthened the sense of community and improved the quality of teamwork.



Overall, the results support the idea that the integration of the educational metaverse not only optimizes cooperative learning but also contributes to the development of the digital and socio-emotional skills necessary for contemporary professional practice in health sciences.

The results of this research show that the design of an educational metaverse based on interventional radiology had a positive and significant impact on students' cooperative learning, reaching a bilateral significance level of  $p=0.000$ . This finding supports the general hypothesis and demonstrates the effectiveness of using the *Spatial i.o.* metaverse as a three-dimensional virtual environment to promote cooperation, communication, and peer interaction in higher education settings.

Coinciding with the findings reported by Wang et al. (2023), who developed 18 virtual educational sessions and found a significant improvement in student participation and collaboration ( $p=0.015$ ), in this study, 15 sessions were conducted in *Spatial i.o.*, and high motivation and willingness were also observed among the students in the experimental group. Likewise, research such as that of Rudholpi et al. (2024) and Mystakidis (2022) highlight the ability of educational metaverses—such as *Second Life* or *Spatial i.o.*—to eliminate geographical barriers and create immersive experiences that foster social interaction and academic cooperation, aspects reflected in the improvement of the dimensions of *interaction* and *positive interdependence* ( $p=0.006$  and  $p=0.022$ , respectively).

Similarly, Hu et al. (2023) and Singh and Tinmaz (2024) showed that digital collaboration platforms improve reflection, motivation, and ethical decision-making, which is consistent with the results of the present study, where the dimensions of *group reflection* ( $p=0.002$ ) and *social skills* ( $p=0.000$ ) showed statistically significant changes. This suggests that working in 3D environments facilitates the development of soft skills essential for professional practice in health sciences.

Regarding *teacher mentoring*, the findings are consistent with those of Sia et al. (2021), who highlighted the importance of pedagogical support in collaborative teaching. In this study, the *mentoring* dimension reached a value of  $p=0.000$ , demonstrating that the role of the teacher as a virtual mediator was fundamental in guiding and resolving students' doubts in real time.

On the other hand, the *heterogeneity* dimension did not show statistical significance ( $p=0.279$ ). This result may be related to the difficulty some students have in adapting to working with peers of different academic levels or

abilities, which coincides with the observations of Mora (2020), who indicates that heterogeneous groups require more active teacher mediation to generate productive cognitive conflict.

Research by Peña and Rodríguez (2023), García (2023), and Quintana (2022) also corroborates that the use of virtual environments and open educational resources increases the dimensions of cooperative learning, a finding that is replicated in this study with significance in *positive interdependence, interaction, social skills, and group reflection*. According to Álvarez (2022) and Flores (2020), the consolidation of these competencies favors not only academic performance but also professional development in collaborative clinical contexts.

Among the limitations of the study are the small sample size, as it involved a single academic group, and technical difficulties related to the connectivity of some students. Despite this, the validity of the results and the active participation of all members during the sessions were maintained. For future studies, it is recommended to expand the population and explore other areas of health sciences with similar immersive methodologies.

## Conclusions

Interventional radiology requires professionals capable of working in multidisciplinary teams, combining technical skills with strong social skills. The educational metaverse is an innovative strategy that strengthens cooperative learning, encourages communication, shared responsibility, and collaborative work in virtual environments.

Teacher support within these spaces is essential to ensure meaningful learning and formative assessment. In conclusion, the use of the Spatial i.o metaverse not only enhances cooperative learning in higher education, but also represents a step towards the digital transformation of the training process in health sciences, promoting more participatory and inclusive teaching that is adapted to contemporary technological challenges.

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# Ethics as the Foundation for the Appropriate Use of IA in Universities

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## Introduction

The advent of Generative Artificial Intelligence (AI) in higher education presents both challenges and opportunities, demanding profound reflection and a commitment to ethical principles for its integration. AI is poised to redefine pedagogical, learning, and research methodologies. The critical discourse centers on integrating AI while preserving core academic values such as integrity, originality, critical thinking, and equity. This article advocates for a shift from fear-based responses to appropriate governance and personal responsibility, proposing a framework rooted in virtue ethics for ethical deployment, and acknowledging AI's impact on students, faculty, and institutions.

For students, AI offers unprecedented academic support, personalizing learning, providing immediate feedback, and acting as an intelligent tutor. Its content generation capabilities can also support academic projects. However, risks include incentivizing plagiarism or impersonation due to the human-like quality of generated content. AI may also foster dependency, undermining critical thinking and original thought, and can produce inaccurate information or fabricated references “hallucinations”. Transparency regarding AI's mechanisms is essential for trust and understanding its limitations and biases.

For faculty, AI holds promise for transforming teaching and research by supporting scholarly activities like literature reviews and data analysis, and by relieving repetitive administrative duties. The widespread use of conversational AI and translation tools by faculty demonstrates its potential. Challenges include a significant “digital divide”, with many educators reporting no AI training. Pressures to publish may also lead to unethical behaviors. Mitigation requires rigorous adherence to transparency and reproducibility, disclosing AI use, and continuous professional development.

From an institutional standpoint, universities can use AI to enhance administrative efficiency and strategic decision-making. This integration, however, carries substantial ethical responsibilities, particularly concerning data security and privacy. Robust cybersecurity and legal frameworks are needed for

sensitive data handling. A core ethical concern is the perpetuation of biases and discriminatory outcomes from AI-driven processes, which can affect admissions or evaluations. Algorithmic audit mechanisms are imperative to address biases and ensure fairness. Faculty concerns include plagiarism (37.5%), erosion of critical skills (46.32%), and over-dependence on technology (38.24%) (Sánchez, Perdomo & Estevez, 2024, p. 18). However, faculty also encounter serious challenges. The “digital divide” is palpable: 74.26% of educators report receiving no training in AI, only 2.94% consider their training “adequate”, and 22.79% find it insufficient (Sánchez, Perdomo & Estevez, 2024, p. 19). Among faculty, the most cited concerns include plagiarism (37.5%), erosion of critical skills (46.32%), and overdependence on technology (38.24%) (Sánchez, Perdomo & Estevez, 2024, p. 21).

The ethical orientation of digital transformation is a central concern of our technological era. While innovation reshapes life and society, we must critically assess how technology is used. Machines lack conscience and depend on the values of their creators and users. Despite progress, human values surpass technical capability; technology is a tool meant to serve, not replace, the principles that define quality of life and human transcendence. Material needs matter, but meaning and the pursuit of our full potential remain essential. As Maslow notes, cited in Polo (2023), material sufficiency is necessary but does not encompass the totality of human needs.

Luciano Floridi (2014) posits a “fourth revolution” in his philosophy of information: the profound transformation of human self-conception by digital technology, which reshapes individual behavior and societal structures. The digital revolution is nascent, and its full magnitude remains difficult to ascertain. Life is nearly unimaginable without digital services, and AI has rapidly moved from laboratories to everyday applications. Given its rapid evolution and unpredictable ramifications, AI can be wielded ethically or unethically. Floridi argues we have a moral obligation to direct AI's development to benefit humanity and the planet, stating that “AI is the continuation of intelligence by other means” (Floridi, 2019, p. 49).

Floridi proposes five foundational principles for AI ethics (2021, p. 82): (1) beneficence (p. 60), (2) non-maleficence (p. 62), (3) autonomy (p. 62), (4) justice (p. 62), and (5) explainability (p. 64). Beneficence requires AI to promote the common good, while non-maleficence ensures it avoids harm. Autonomy mandates that human decision-making is not diminished by AI, with humans retaining ultimate authority over delegation to machines. Justice ensures AI serves all individuals equitably, not solely for economic growth unless that growth is fair and sustainable. Explainability demands transparent and

intelligible AI processes to facilitate accountability. The challenge is distinguishing soft ethics (moral norms outside legal enforcement) from hard ethics (underpinning regulatory frameworks), underscoring that ethics consistently transcends legality. Digital transformation is fundamentally an ethical undertaking, and institutions embracing this dual responsibility will integrate technological advancement with human values for genuine human progress.

Floridi also proposes seven essential factors (Floridi *et cols*, 2021):

**Falsifiability and Incremental Deployment:** Requires a deployment cycle ensuring critical requirements are falsifiable and tested incrementally, with readiness to halt or modify if unwanted effects appear.

**Safeguards Against the Manipulation of Predictors:** Designers should implement safeguards against inappropriate skewing by non-causal indicators and limit knowledge of input-output effects to prevent manipulation.

**Receiver-Contextualized Intervention:** Software must respect user autonomy, balancing current and future benefits. Designers should consult users, understand their characteristics, and respect their right to ignore or modify interventions.

**Receiver-Contextualized Explanation and Transparent Purposes:** AI applications should be explainable and their purposes transparent. The Level of Abstraction (LoA) is key for explanations, dependent on what is explained and to whom. A theory comprises a System, Purpose, Level of Abstraction, Model, and Structure.

**Privacy Protection and Data Subject Consent:** Privacy is essential for safety and human dignity; deprivatizing records without consent violates dignity.

**Situational Fairness:** AI projects must remove irrelevant ethically important factors and include necessary ones for inclusiveness or safety. The risk of biases embedded and reinforced by erroneous reinforcement learning is pronounced, especially with opaque AI decision-making systems.

**Human-Friendly Semanticization:** AI must enable humans to curate “semantic capital” to give meaning to things, crucial for autonomy. Designers should not hinder this ability.

These seven factors are often intertwined and co-dependent (Floridi *et cols*, 2021). From a bioethical perspective, the precautionary principle is crucial for



managing emerging technologies, and acknowledging their unpredictability. Anticipating potential problems is essential for effective responses. Human non-technological capacities compassion, moral conscience, and empathy enable harmonious coexistence. Ethical approaches like those from the EU's High-Level Expert Group on AI or UNESCO reinforce these human capabilities (UNESCO, 2022).

Effective governance, with "balanced policy and flexible guidelines", is required to leverage AI's potential in universities, recognizing individual academic autonomy and the need for a coherent institutional framework. Cacho makes an interesting proposal in this regard (Cacho, 2024).

The first line of action is establishing clear and detailed AI codes of ethics. These codes should define expected behavior, delineate unacceptable conduct, and specify penalties for malpractice in AI use by all university members. They must be dynamic, continuously reviewed, and adapted due to rapid technological evolution. Beyond prohibiting plagiarism and impersonation, they should promote proper attribution, transparency in AI use, and respect for intellectual property and data privacy.

The second line of action is creating multidisciplinary university ethics committees. Composed of experts in technology, ethics, law, pedagogy, and various disciplines, these committees are indispensable for analyzing ethical challenges from multiple perspectives and ensuring a comprehensive approach to AI decision-making. Their functions should include:

- Supervision and Evaluation: Monitoring AI policy implementation and rigorously evaluating their ethical impact.
- Advisory: Providing clear guidance on ethical AI use and support in resolving dilemmas.
- Policy Formulation: Actively participating in formulating and continuously reviewing AI-related guidelines and codes of conduct.
- Awareness and Education: Promoting ethical AI awareness through workshops, seminars, and accessible educational resources.
- Complaint Management: Establishing a clear mechanism for receiving and resolving complaints related to unethical AI use.

## **Ideas for the Ethical Use of AI in Universities**

Beyond mere regulation, promoting the ethical and constructive integration of AI into educational processes is imperative, aiming to maximize benefits while minimizing risks. (Prifti, Morley, Novelli & Floridi, 2024).

### **Personalization of Learning**

The integration of chatbots and virtual assistants in education offers real-time academic support by answering frequently asked questions, providing resources, and facilitating administrative access. This not only enhances the student experience but also frees faculty to focus on more complex and value-added tasks within the teaching and learning process.

At the same time, artificial intelligence enables the creation of personalized learning materials, adjusting difficulty, format, and examples to suit individual student needs. However, this level of personalization brings important ethical risks. It is essential to prevent algorithms from creating “filter bubbles” or “echo chambers” that limit exposure to diverse perspectives. To ensure a critical and inclusive education, AI tools must promote a plurality of ideas rather than reinforcing existing biases or beliefs.

### **Automation of Repetitive Tasks and Formative Assessment**

AI can be effectively used to automate the creation of exercises and quizzes, as well as to provide instant feedback, fostering continuous and responsive learning. This streamlines the assessment process and helps students engage with content more actively through immediate evaluation and reinforcement.

However, when AI is used to support grading, it is essential that clear rubrics and transparent criteria are established. Teachers must retain full control over final assessments, with AI serving strictly as a supportive tool. Importantly, automation should not dehumanize the learning experience. There must always be room for qualitative assessment, meaningful teacher-student interaction, and the cultivation of skills that algorithms cannot easily measure. Systems that assign grades without human oversight should be rigorously avoided to preserve the integrity and depth of the educational process.

### **Fostering Creativity and Research**

AI offers powerful tools for creating accessible multimedia content, including automated translations and subtitles, which support diverse student populations and encourage internationalization. It also enables the development of immersive simulations and virtual environments, allowing

students to safely practice skills in realistic, engaging settings. Additionally, AI can assist in research by streamlining literature reviews, generating preliminary hypotheses, and supporting data analysis.

Nonetheless, it is crucial to frame AI as a means to enhance creativity and productivity, rather than replace human authorship or originality. In academic research, transparency is essential: any use of AI must be explicitly disclosed, including its specific role in the research methodology, to ensure clarity, accountability, and reproducibility.

## **Development of 21st Century Skills**

To ensure meaningful learning in the age of AI, academic tasks should be intentionally designed to promote complex thinking, such as engaging in debates, articulating ideas verbally in synchronous settings, and analyzing content that AI struggles to interpret, like images or data visualizations. These types of activities help develop higher-order cognitive skills that go beyond what AI can replicate.

Equally important is the development of comprehensive AI literacy programs for the entire university community. These should cover AI's capabilities and limitations, its potential biases, and the ethical implications of its use, while fostering critical evaluation of AI-generated content. Educators must also actively guide students in transparently sharing their use of AI, enabling formative assessment and encouraging essential skills like question formulation, source verification, and bias recognition—ultimately promoting a responsible and collaborative approach to AI in education.

## **Dangers of Unethical Use and How to Avoid Them: A Deep Ethical Perspective**

The risks of unethical AI use extend beyond plagiarism, threatening the university's mission as noted below (Sánchez, Perdomo & Estevez, 2024).

### **Plagiarism and Impersonation**

AI's ability to quickly generate coherent texts poses a significant risk to academic integrity, as it may lead to unoriginal work being submitted as personal effort, thereby undermining intellectual development and the value of academic work.

To address this, institutions must adopt a multifaceted approach. First, assessments should be redesigned to emphasize tasks that AI cannot easily replicate—such as applied research, critical case analysis, oral presentations,

debates, or fieldwork combined with personal reflection. Second, transparency must be mandatory: students should be required to clearly disclose any use of AI in their academic work, specifying how and to what extent it was used. Finally, AI detection tools can serve as a useful complement, but they must always be supported by the teacher's judgment and a deep understanding of the student's learning process.

### **Loss of Critical Skills and Over-Reliance**

The systematic delegation of cognitive tasks to AI risks hindering the development of essential skills such as critical thinking, problem-solving, creativity, and original argumentation—potentially leading to a form of “intellectual laziness” among students.

To counter this, educational strategies must prioritize metacognition, encouraging students to reflect on their own thinking and understand how AI can complement—rather than replace—their cognitive efforts. Problem-based learning should also be emphasized, with tasks that require formulating complex questions, critically evaluating AI-generated responses, and synthesizing information from diverse sources, ultimately surpassing AI through independent analysis and judgment. In parallel, robust AI literacy programs are essential, equipping students with a clear understanding of AI's capabilities, limitations (such as hallucinations and biases), and the distinction between appropriate and inappropriate uses, thereby fostering critical and responsible engagement with these technologies.

### **Propagation of Biases and Misinformation**

Generative AI models, trained on massive datasets, inevitably reflect societal biases, which can lead to the reinforcement of stereotypes, discrimination, and misinformation. This poses a serious threat in academic contexts, where objectivity, accuracy, and truthfulness are essential.

To mitigate these risks, institutions must implement thorough algorithm audits, particularly when AI is used in sensitive areas such as student selection or evaluation. Equally important is critical education: both students and educators should be trained to recognize potential biases in AI-generated content and to verify information rigorously. Promoting the use of verified academic databases and reliable sources alongside AI tools is essential, ensuring that accuracy and scholarly integrity take precedence over convenience.

## **Lack of Transparency and “Black Box” Phenomenon**

Many AI models operate as “black boxes,” with opaque decision-making processes that make it difficult to understand how specific outputs are generated. This lack of transparency poses significant challenges for accountability, trust, and informed use, particularly in academic and educational contexts.

To address this, it is crucial to promote the development of explainable AI (XAI) systems that offer users insight into how decisions are made. AI developers and service providers should be required to provide clear, detailed documentation about training data, model architecture, and known limitations. Additionally, integrating ethical AI design into academic curricula will help prepare future professionals to create more transparent, fair, and accountable technologies.

## **Personal Responsibility in Light of MacIntyre’s Virtue Ethics**

In the evolving landscape of technological advancement, personal responsibility is the cornerstone of ethical AI use in universities. From Alasdair MacIntyre's (1999) virtue ethics perspective, the challenge is not just establishing external rules but cultivating intellectual and moral virtues within each university member. MacIntyre argues ethics is based on pursuing excellence through social practices with inherent internal goods. Academia, as a social practice, possesses clear internal goods like the pursuit of truth, originality, and critical thinking. AI integration must strengthen these virtues.

### **Intellectual Honesty**

This virtue manifests in recognizing one's own work versus AI-assisted work, and resisting misappropriation or impersonation of authorship. For teachers, it means transparency about AI use in research and teaching, fostering an environment where integrity is a deeply held value.

### **Critical Thinking**

A cardinal academic virtue, it involves questioning, analyzing, and evaluating information irrespective of source. In AI in education, this translates to discerning veracity and biases in AI-generated information and not passively relying on its content. Fostering this virtue is paramount for AI to be a learning tool, not a substitute for intellectual effort. Educators must model and design activities demanding this critical attitude.

## Prudence (Phronesis)

Practical wisdom for correct action in complex situations. In AI use, prudence involves anticipating ethical consequences of implementation, making informed decisions on when, how, and for what purposes to use AI, and weighing benefits against risks. This is essential for education policymakers anticipating long-term impacts.

## Responsibility

Taking ownership for consequences of actions and decisions regarding AI use. It goes beyond plagiarism, involving understanding AI's broader impact on society and intellectual development. Universities must create AI education policies ensuring teachers and students are competent in technical handling and grasp ethical and social implications.

Cultivating these virtues is essential. Faculty have a vital pedagogical role in guiding students to internalize these virtues, beyond technical AI use. Academic integrity is not merely rule compliance but a profound commitment to embodying higher education values, intrinsically woven into academic identity.

## Conclusions

Every human volitional act is ethical. Digital ethics emerged with the proliferation of ICTs, the Internet, and social media, addressing complex moral dilemmas from AI deployment. In an era of eroding universal ethical norms, digital ethics must provide guiding principles for digital interactions, whose far-reaching impact can obscure profound ethical implications at micro and macro levels. While technology propels human advancement, its power demands responsibility; "with great power comes great responsibility" is acutely relevant. Living in Society 5.0 obliges rapid innovation anchored in robust ethical frameworks upholding human dignity and reflecting our identity as a moral species, ensuring technological advancement enhances, not erodes, human experience.

Technological progress must be guided by ethical integrity to ensure it serves the common good, respects human dignity, and aligns with collective wisdom. Ethics is not an obstacle to innovation but its essential foundation, especially in a digital age where actions can have far-reaching and unintended consequences. As Jonas (1979) noted, our "technological civilization" requires a new ethical paradigm that responds to the complex and often indirect impact of ICTs. The rapid evolution of technology frequently outpaces legal

frameworks, making legislation necessary but insufficient. Ultimately, a society grounded in ethical maturity would require less regulation, as individuals would act responsibly for the common good without relying solely on legal constraints.

This academic elaboration highlights the interplay among ethics, technology, and human agency, emphasizing the necessity of a vigilant, ethically attuned posture for the digital future. An institution's vision inherently encompasses ethical commitments voluntary obligations beyond legal requirements. Once articulated, these become moral imperatives, obliging the institution to uphold them. These frameworks are meticulously crafted by individuals, making ethical responsibility intensely personal. A corrupt institution reflects its members' moral failings and collective decisions. To secure ethical integrity, organizations must cultivate principled leadership and foster a culture of ethical responsibility at every level. Ethical conduct must stem from deep-seated personal convictions, not just regulatory compliance. The singular pursuit of success, often aligned with utilitarian frameworks, contravenes genuine ethical principles, resorting to normative structures simulating legitimacy or ambiguously distributing responsibility.

As we transition into the 5.0 technological revolution, accomplishments must be matched by unwavering ethical rigor. Pride in innovation is warranted only if ethics are intrinsically woven into its implementation. Technology must unequivocally serve humanity, never the reverse. This discussion encapsulates the connections between individual ethical accountability and institutional conduct, underscoring the necessity of harmonizing technological advancement with enduring ethical principles. This affirms the critical importance of ethical values every individual must internalize and enact personally and professionally. Technological advancement must reinforce, not overshadow, the ethical dimension of human decision-making. The pervasive influence of innovation can regrettably foster a misguided belief that technology offers panacea for all human dilemmas. While many challenges may be technologically addressed, deeper existential questions concerning happiness and purpose are fundamentally ethical. Therefore, it is essential not to marginalize ethics but to purposefully elevate and fortify its role in a technology-shaped world.

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# Humans vs. Machines: Who Grades Best?

## Evaluating AI Reliability in ESL/CLIL Writing Assessment

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### Introduction

In an era where artificial intelligence is becoming a trusted partner in classrooms, the age-old debate resurfaces: can machines outperform humans? In many possible scenarios, when it comes to processing speed and algorithmic precision, many may conclude machines currently do; however, at least for the time being, we, humans, are still unmatched in our ability to interpret complexity, adapt to nuance, and make holistic judgments.

Nowhere is this human-machine contrast more evident than in education, where new technologies are rapidly redefining long-standing practices. Among them, assessment—once the domain of trained educators—is increasingly being supported, and sometimes replaced, by algorithmic systems. Are machines, specifically AI, better in the nuanced art of assessment? For educators navigating the complex landscape of ESL, especially in specific educational contexts such as Content and Language Integrated Learning (CLIL) or English for Academic Purposes (EAP) settings, and in regard to specific language skills (e.g. writing or speaking), this question is no longer theoretical, it is pressing and practical; the conversation has already shifted from all the possible ‘ifs’, to the necessary ‘whens’ and ‘hows’. At the intersection of foreign language teaching, learning and educational technologies lie some crucial inquiries: does AI have the precision, fairness, and insight to rival experienced teachers in grading? Are teacher biases stronger than those of (allegedly) objective AI assessment? Can educators delegate this historically challenging complex task to a machine?

The implications of these predicaments are far-reaching. In a world where educational technologies are advancing at lightning speed, understanding AI’s potential as a grading ally is more than academic curiosity; it is a step toward redefining how we teach, assess, and prepare students for the future. The question here is whether AI is ready enough to complement or even enhance the grading process, or whether its limitations reaffirm the irreplaceable value

of human insight. However, the stakes are not just about grades but about trust, innovation, and the transformative potential of teaching itself.

By exposing the strengths and shortcomings of both evaluators, I aim to provide peer educators with a nuanced lens through which to view the role of AI as an alternative tool to be utilized in language assessment. The race is certainly on—humans versus machines—but the true winner is neither of both contestants, but the future of education.

### **Context: The Rise of AI in Educational Settings, Particularly in Assessment**

The integration of artificial intelligence (AI) into educational settings has rapidly evolved over the past decade, transforming how educators and institutions approach teaching, learning, and assessment. While AI's use in adaptive learning platforms and intelligent tutoring systems has been widely studied (Chen *et al.*, 2020; Holmes *et al.*, 2019; Luckin *et al.*, 2016) and can be traced back to the 70s (Carbonell, 1970), its role in assessment is gaining significant attention. AI-driven assessment tools promise to address long-standing challenges in education, such as grading consistency, scalability, and the provision of timely, actionable feedback.

In a bigger market scale, research focuses on how AI can enhance language proficiency test development and on how to ensure these tests, including prominent exams such as IELTS or TOEIC, remain relevant. In the case of IELTS, Dr. Tony Clark, Head of IELTS Research at Cambridge University Press & Assessment, emphasizes the importance of understanding the impact of generative AI on assessment practices (Cambridge University Press & Assessment, n.d.-b). Additionally, discussions have been held on the ethical considerations of using AI in language proficiency testing, particularly in higher education admissions. Dr. Carla Pastorino-Campos, Senior Research Manager at Cambridge University Press & Assessment, highlights the need to balance AI's opportunities with potential risks to ensure fair and valid assessments (Cambridge University Press & Assessment, n.d.-a). On the other hand, considering other exams, specific studies on AI integration in TOEIC assessments are limited, where AI-powered platforms have been developed to predict test-takers' scores on exams like TOEIC and TOEFL. For instance, the AISATS platform (Potential Plus, n.d.) utilizes AI to provide forecasts of test-takers' scores with accuracy comparable to human interviewers. For now, this technology is specifically offering detailed assessments of speaking skills, contributing to more efficient and scalable evaluation processes.

Considering a smaller, individual teacher level, one of the key drivers of AI adoption in assessment is the need to manage increasing student populations while maintaining high standards of evaluation. Traditional assessment methods, which heavily rely on human evaluators, are often subject to time and subjectivity. In contrast, AI systems can quickly analyze large amounts of data and provide a consistent assessment based on predefined criteria. For instance, a study conducted by Ruseti *et al.* (2024) shows how automated essay scoring (AES) systems, powered by advanced natural language processing (NLP) technologies, demonstrate the ability to grade essays efficiently and detect linguistic patterns, showing the proficiency of students.

AI's potential in educational assessment extends beyond mere grading. Modern systems are increasingly capable of delivering personalized feedback, identifying specific areas of improvement, and adapting to individual learner needs. This aligns with a broader pedagogical shift toward formative assessment practices, which emphasize continuous feedback over summative evaluation. Through AI, educators can provide students with a more dynamic and supportive learning experience, enabling them to address weaknesses in real-time (Campos, 2025).

Nevertheless, the use of AI in assessment has brought up significant debate, particularly regarding its limitations in understanding context and intent. Critics argue that, while AI systems offer consistency in grading, they often fail to grasp the nuanced meanings behind student responses or the subtleties of human communication, which human evaluators can interpret effectively (Lundgren, 2024). This limitation raises questions about the reliability of AI in fully replicating the complex thought processes involved in grading. Another pressing concern is the issue of fairness and bias in AI algorithms. As Pinto *et al.* (2023) state, diverse student groups may be treated unfairly by AI systems that unintentionally reinforce or increase biases seen in training data. In addition to technical and fairness issues, the ethical implications of AI adoption in education require careful consideration. Educators and institutions must address these challenges to ensure that student data is protected and that the use of AI in assessment aligns with ethical standards and educational values. In this evolving landscape, comparing AI's capabilities to traditional human grading methods is essential to understanding its potential and limitations. By investigating key metrics such as grading consistency, accuracy, and feedback quality, there will be a clearer picture of the complementary roles that AI and human evaluators can play in enhancing educational assessment.

## Setting the Match: Teacher vs. AI Model

In order to measure the reach AI can have for the average teacher, not counting specific AI modules, professional corporate AI-driven assessments or AES, ChatGPT 4o was the AI of choice. In terms of the sample, 171 writing pieces (i.e. short reports) were assessed from a Business Data Description CLIL course made by university students in their first and second year at a private university in Japan. The assignment included 9-point evaluation criteria students had to fulfill, which were previously informed to the assignment submission through multiple means. Students developed the assignment in class under the instruction of the teacher who consequently graded the task. The criteria were mainly based on content, with the exception of the first criterion, which focused on a stylistic requirement (paragraph structure). The same assignment sample was subsequently graded by an AI tool, namely ChatGPT 4o, following the same criteria and considerations used by the instructor. Even though the assessment was ultimately numerically marked, to evaluate the accuracy of the AI assessment, a fulfillment approach (yes/no) was adopted to see whether AI could precisely and objectively discriminate the students' achievement level in the task.

The rationale behind selecting a binary yes/no approach over a graded scale to evaluate each criterion's fulfillment was primarily to enhance the clarity and objectivity in AI assessment. Using a straightforward binary judgment reduces ambiguity and allows for clearer comparisons between human and AI evaluations. This decision is particularly appropriate given that each rubric criterion represents specific, discrete conditions that either are or are not met, making nuanced gradations less meaningful in this context. Additionally, it simplifies statistical analyses and strengthens reliability when measuring agreement between raters. It's worth mentioning that students received several types of feedback during the process (Campos, 2024) which helped them perform and improve their assignment. This feedback included pre-class oral feedback, which summarized the common mistakes found in former assignments, as well as in-class real-time feedback, based on writing samples submitted to an online shared text software file, and post-assignment comments, based on the students' achievement. There was also a fourth layer of feedback based on AI, where students checked their written assignments against the informed criteria. The prompt was provided by the instructor, and students tested their assignment before submission in order to fill the criteria gaps and correct linguistic mistakes pointed out by the AI. As the fourth layer of feedback was a self-regulated learning method, the degree in which students used or applied the feedback received was not supervised; however, students submitted weekly their Writing Journal report (not assessed) into the

university LSM, which included their first draft, the feedback received by ChatGPT (4o) and their final version. Therefore, within the writing process, before the assignment final submission, there had already been an AI pre-assessment stage. However, this chapter does not aim to discuss the efficiency of the AI pre-assessment used as a supplementary feedback tool, as discussed by Campos (2024) in his study, but whether this AI could objectively provide a fair and reliable assessment of the final submissions in terms of accuracy.

## Where Humans and AI Agree and Where They Don't

To evaluate the level of agreement between teacher and AI assessments for each of the nine rubric criteria, percent agreement, Cohen's kappa, and the McNemar test were calculated for all 171 student assignments. The percent agreement between raters varied notably by criterion, as seen in Table 1, ranging from 57.1% (Criterion 7) to 90.6% (Criterion 4). Cohen's kappa values indicated generally fair to moderate agreement, with values spanning from  $\kappa = 0.05$  (Criterion 3) to  $\kappa = 0.53$  (Criterion 8), suggesting that while the raters agreed more than chance on some criteria, agreement was only modest overall. The McNemar test identified statistically significant differences in the scoring patterns between teacher and AI on most criteria (Criteria 1–3, 6–9,  $p < .05$ ), indicating that the two raters did not simply disagree randomly, but often in a consistent direction. Only Criteria 4 ( $p = .21$ ) and 5 ( $p = .58$ ) showed no significant differences, suggesting a higher degree of alignment on those aspects of the rubric. Overall, these findings indicate that while AI and human raters often reach similar judgments for some criteria, notable disparities persist, particularly on items that involve a certain level of subjectivity, highlighting areas where AI assessment diverges most from traditional teacher evaluation.

**Table 1.** Inter-Rater Agreement and Significance Testing for Teacher and AI Assessments Across Nine Writing Criteria ( $N = 171$ )

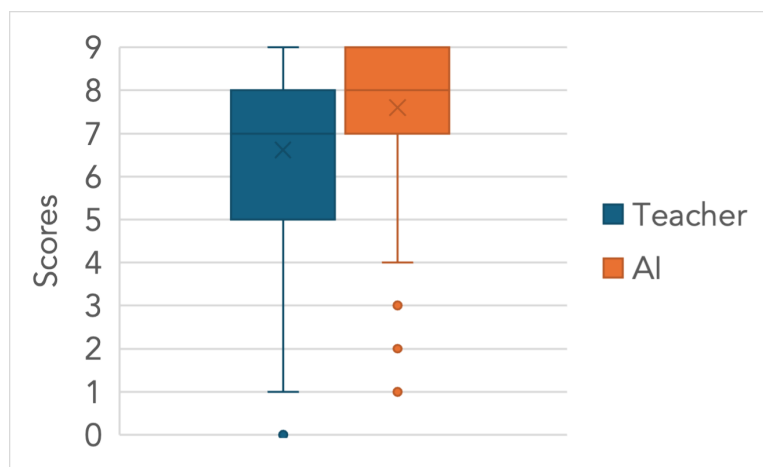
| Criterion | Percent Agreement | Cohen's Kappa | McNemar $p$ -value |
|-----------|-------------------|---------------|--------------------|
| 1         | 87.1%             | 0.31          | 0.035              |
| 2         | 80.6%             | 0.38          | 0.035              |
| 3         | 83.5%             | 0.05          | < .001             |
| 4         | 90.6%             | 0.45          | 0.21               |
| 5         | 82.4%             | 0.22          | 0.58               |
| 6         | 70.0%             | 0.27          | < .001             |
| 7         | 57.1%             | 0.17          | < .001             |
| 8         | 77.1%             | 0.53          | < .001             |
| 9         | 69.4%             | 0.24          | < .001             |

$p < .05$

Cohen's Kappa values provide a standardized measure of agreement that corrects for chance, and thus offer practical insight into the level of consistency between raters. In practical terms, values between 0.41 and 0.60 indicate a "moderate" agreement, suggesting that the AI and human rater generally align, though differences remain noticeable. Values between 0.21 and 0.40 reflect "fair" agreement, implying that while raters share some common ground, discrepancies are frequent enough to warrant caution when interpreting AI assessments. Values close to or below 0.20 suggest only slight or minimal agreement, highlighting areas where human judgment and AI differ substantially.

As shown in Figure 1, AI ratings demonstrate a generally higher distribution compared to teacher assessments, including higher median and mean scores. Additionally, teacher-assigned scores exhibit a slightly broader range and more variability, reflecting potentially greater subjectivity or variation in human judgment relative to AI grading consistency.

**Figure 1.** Box plot comparing total assessment scores assigned by the Teacher and AI.



Descriptive statistics for the overall scores (Table 2) indicated that the teacher's ratings had a mean of 6.68 (SD = 1.91) and a median of 7.0, while the AI ratings were slightly higher, with a mean of 7.62 (SD = 1.77) and a median of 8.0. This pattern corroborates that the AI tended to assign higher total scores compared to the human rater. A paired-samples t-test indicated that this difference was statistically significant,  $t(170) = -8.22$ ,  $p < .001$ , with a medium effect size (Cohen's  $d_z = -0.63$ ). This result remained significant using the Wilcoxon signed-rank test ( $p < .001$ ).

**Table 2.** Descriptive Statistics for Teacher and AI Total Assessment Scores (0–9) (N = 171)

| Rater   | Mean | Median | SD   |
|---------|------|--------|------|
| Teacher | 6.68 | 7.0    | 1.91 |
| AI      | 7.62 | 8.0    | 1.77 |

## What Does This Mean for Classroom Assessment?

This chapter aims to address critical questions, specifically regarding AI's potential to rival human judgment in ESL assessment contexts, particularly within CLIL settings. The findings presented here, aligning with broader educational research (e.g., Chen et al., 2020; Holmes et al., 2019; Ruseti et al., 2024), highlight both strengths and limitations in using AI-driven grading tools.

The moderate level of agreement (Cohen's Kappa ranging from fair to moderate) between AI and human graders supports earlier observations (Lundgren, 2024; Pinto et al., 2023) that, while AI can closely approximate human grading for clearly defined, objective criteria, discrepancies are evident when evaluating more subjective or nuanced criteria. For instance, criteria requiring judgment about textual coherence, context awareness, or subtle interpretation posed notable challenges for AI. This aligns with the concerns mentioned regarding AI's limitations in fully grasping nuances and intentions behind students' writing (Lundgren, 2024).

Moreover, the statistically significant differences revealed by the McNemar tests (Table 1) indicate a systematic divergence rather than random disagreements between human and AI assessments. This could reflect inherent teacher biases or nuanced interpretations of the criteria that AI algorithms are currently unable to replicate consistently (Pinto et al., 2023). The implications here are twofold: first, while AI can increase objectivity and reduce grading workload, it remains limited in areas where holistic judgment and understanding of student context are critical. Second, this divergence invites educators to reflect on their grading practices and underlying assumptions about fairness and consistency.

As illustrated in Figure 1, the AI tended to assign slightly higher scores than the human rater, with a narrower score distribution. This could be indicative of a general tendency of the AI to interpret criteria fulfillment more strictly or liberally depending on the prompt provided (Lundgren, 2024). Such differences in scoring distributions underscore the necessity for clearly defined

rubrics and calibration procedures if AI grading systems are to be integrated into ESL or CLIL contexts effectively.

Practically, these findings suggest that AI, represented here by ChatGPT-4o, could be most effectively employed in tandem with human evaluators rather than as a complete replacement, supporting findings from recent educational AI research (e.g., Almusharraf & Alotaibi, 2023; Ruseti *et al.*, 2024). For example, using AI as a preliminary screening tool or formative assessment method could help reduce educators' workloads and provide quicker feedback cycles for students. This agrees with formative assessment practices highlighted earlier, where continuous, personalized feedback can significantly improve learning outcomes (Campos, 2024, 2025; Holmes *et al.*, 2019).

Nevertheless, integrating AI into grading processes requires addressing several ethical and practical considerations. Specifically, biases embedded in AI training data might lead to unfair treatment of certain student groups (Pinto *et al.*, 2023). Additionally, reliance on AI-driven assessment systems may inadvertently devalue human judgment and pedagogical expertise in the long run (Luckin *et al.*, 2016). Thus, educators must critically evaluate how to balance AI's benefits in efficiency and consistency against potential drawbacks in terms of fairness, pedagogical insight, and learner equity.

Finally, the limitations of this study should be explicitly noted, including the use of a single AI model, the context-specific nature of the grading rubric, and the study's restriction to one educational institution. Future research might beneficially investigate a broader array of writing contexts, educational settings, and AI tools to assess the generalizability of the findings presented here.

## **The Win: Working Side-by-Side**

This chapter explored whether AI assessment tools, specifically ChatGPT-4o, could reliably match or surpass human evaluators in ESL grading within a CLIL educational context. The quantitative analysis demonstrated that while AI grading exhibited moderate to fair agreement with human judgment across most criteria, notable differences persisted, particularly in areas requiring nuanced, subjective interpretation.

Findings suggest that AI assessment tools excel in providing consistency, objectivity, and efficiency, making them highly valuable in formative assessment roles or preliminary grading tasks. However, AI currently falls short of fully capturing complex linguistic nuances and holistic judgment inherent in human evaluation. These limitations reaffirm the irreplaceable value of



experienced educators' insight and judgment, underscoring the importance of collaborative human–AI assessment approaches rather than exclusive reliance on one or the other.

Practically, educators should use AI as a complementary tool, optimizing its strengths while being mindful of its inherent limitations and potential biases. Future integration of AI into ESL assessment must proceed cautiously, guided by clearly defined rubrics, regular calibration with human judgment, and continuous ethical reflection.

Ultimately, the "race" between humans and machines in assessment is less about determining a clear winner and more about achieving optimal synergy between human expertise and technological innovation, thus genuinely transforming educational assessment practices for the better.

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### Assessment criteria for business data short reports

- 1) The description and analysis of the data are written only in one paragraph.
- 2) The student stated how many motorcycles were sold last year.
- 3) The student explained how previous sales data can inform decisions about ordering next year's inventory.
- 4) The student reported the source of the data.
- 5) The student described [with figures] which classes of motorcycles were in high demand.
- 6) The student described [with figures] which classes of motorcycles faced weaker demand.
- 7) The student identified which models of motorcycles have the highest chance of selling.
- 8) The student identified how many motorcycle units should be ordered.
- 9) The student explained who is the target customer for these motorcycles.

# Global inclusive trends in higher education: content analysis and case study

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## Introduction

Higher education is the pinnacle of educational levels, providing opportunities to expand efforts in the production of knowledge. Its strength lies in a process of collective construction, with the intention of achieving global results. Administrative educational direction, available financial resources, technological elements, the organizational system, social convenience, and pedagogical guidelines are factors that determine the quality of university education; academic processes are crucial for generating a comprehensive view of knowledge supported by solid curricula (León et al., 2021).

People with special needs face barriers to accessing education; those with hearing impairments lack sign language interpreters, there are no accessible pathways for wheelchair users, and those with visual impairments cannot use computers with reading software; therefore, disability must be addressed from a social perspective. UNESCO established inclusive policies and, through the Higher Education Report 2022, identifies key principles for educational transformation. It also proposes forming a revitalized coalition in support of the 2030 Agenda and a horizon toward 2050.

Academic dynamics are shaped by the knowledge validated by each discipline and transmitted through the university curriculum. States face the challenge of ensuring that all students are educated and participate in an environment of equality. Institutions face a profound challenge that they must address from diverse disciplinary perspectives and design content to deliver learning (Acosta-Silva et al., 2021; Brunner et al., 2020). From a humanized perspective, it is necessary to create and promote inclusion in academic education (Barrientos-Báez et al., 2020).

Neurodiversity, from a social perspective, has gained relevance and importance in higher education, making it necessary to understand its intrinsic relationship with learning in inclusive and equitable spaces. The number of neurodivergent students seeking professional careers is increasing, requiring higher education institutions to adapt their pedagogical practices to the needs

of this group of students (Syharat et al., 2023). This evolution implies a deeper understanding of what neurodiversity means and how it impacts the university experience as a whole.

Training methods for neurodivergent youth are based on inadequate inclusive thinking and limited teaching skills that prevent the reduction of existing barriers. Practicing educators have a misperception of the term inclusion, focusing on integrative training and neglecting inclusive teaching (La Cruz-Pérez et al., 2022).

### **Case studies in higher education**

In the Latin American context, educational efforts have presented limitations and a limited presence of ICTs, so efforts are being sought to reform and adapt educational systems with the support of public policies based on social paradigms (Bullón, 2021). In Brazil, laws have been enacted that seek to regulate the inclusion of people with disabilities in society, but they have not been fully implemented. Furthermore, socioeconomic factors have been identified as influencing the optimal development of the population with some type of disability (CASEM, 2022; Souza et al., 2025). Based on the analysis, it is possible to construct cases in Peru, Mexico, and Chile.

In Chile, inclusion has gained relevance, positioning itself on the national agenda, but it previously faced multiple debates regarding its definition, which have not yet reached a broad consensus. Currently, teaching strategies for democratic classroom climates are being applied, hence the recommendation that university institutions design a profile with a collective vision for educators to provide quality teaching (Castillo, 2021).

Research on higher education in Mexico indicates that its integration has been recent due to the various barriers and problems encountered in administrative management. There is still no standard model, so each institution designs mechanisms according to specific scenarios (Rodríguez, 2025). In Peru, access to education is limited due to factors such as poverty, the economy, and disability. Although regulations exist, practical curricula appropriate to the context are required.

### **Context description**

We encounter psychological difficulties generated by academic stress, social pressure, isolation, and a lack of support, which is detrimental if professional help is not sought. The group of people with various difficulties experiences significant barriers to university education; in this sense, all existing limitations

affect students' academic and personal lives.

Teachers play an essential role with students; however, they lack in-depth observation, as each sees education as a separate world. They lack the criteria to welcome and understand those with certain particular characteristics. Curricular programming fails to consider appropriate strategies to achieve objectives and open up a range of opportunities for students. Students feel that, like everyone else, they exercise their right to grow as individuals and professionals.

Practical teaching applies models that facilitate a deeper understanding of the subject matter (Rosica et al., 2022). Motivating participation through collaboration with an inclusive approach is crucial; Likewise, academic progress is presented in group circles with clear roles assigned to each member, which require adjustment and adaptation to the interests of each student, which must be developed in comfortable and safe environments. In order for a teacher to achieve a positive attitude with broad competencies, he or she requires ongoing training that impacts the university experience (Arnáiz-Sánchez et al., 2022).

**Figura 1.** Principles to shape the future of higher education



Trends in inclusive training in higher education published in Latin America during the period 2019-2025; In Mexico, according to INEGI (2024), only 12.2% of people with disabilities are expected to enter university in 2023 to pursue a professional career. Casen (Libertad y Desarrollo, 2023, 3 de agosto) found that, in Chile, 38.2% of young people between the ages of 18 and 24 come from low-income backgrounds and seek opportunities in higher education.

In the case of Peru, between 20% and 40% of university students experience academic stress, with a higher incidence among women who experience anxiety and depression. According to the Demographic and Family Health Survey (Endes 2022), 32.3% of young people aged 15 to 29 experience mental or emotional health problems, with women experiencing them the most (30.2%), compared to men (22.9%). 23% of the young population feels discouraged, depressed, sad, or hopeless, and 5.6% had thoughts of death or self-harm. According to the INEI-ENAH0 (Instituto Nacional de Estadística e Informática 2024), nationally, only 5% of people with some type of disability pursue a professional career. In urban settings, only 6%, and in rural areas, 1%, access higher education.

Of the Latin American population, a large portion may be neurodivergent. Young people with level 2 autism enter higher education within six years of completing secondary school; however, only 39% will graduate. There is a discrepancy between the support students with autism need and the assistance they receive. Support focuses solely on academic subjects, which does not meet their needs (Rosica et al., 2022). In Peru, 15,625 people have autism spectrum disorder (ASD), 90.6% of whom are under 11 years old. This neurodevelopmental disorder causes difficulties in communication and social interaction.

Theories on global trends: From a social perspective, academic stress is seen at a high level among university students. A comprehensive approach is required that includes time management, seeking support, practicing relaxation techniques, adopting healthy habits, and developing active breaks. Monitor and adopt effective coping strategies (motivational breathing). Take regular breaks (with a 10-minute break per academic hour). Group work and class discussions are challenging and affect mental health.

The term neurodiversity is an element of intrinsic value in higher education, as it considers the challenges and strengths of each neurodivergent student and creates equitable and nurturing environments. Therefore, embracing neurodiversity is not just an opportunity that university communities should foster. Higher education has yet to achieve a significant transformation.

Propose inclusive education in the field of science and technology: From the perceptions gathered from three professors, they point out that promoting equitable and fair education enhances creativity and diversity in the technological solutions developed by the country's future professionals. Inclusion should not be a complement, but rather a structural foundation in Peruvian university education, particularly in key development areas such as

Electronics and Computer Science.

They also emphasize that learning based on collaborative activities presents some controversial conditions related to factors such as how group members are determined and how professors intervene, which require evaluation in training contexts. Likewise, it is important to examine the external environments that generate challenges in teaching practice and some barriers stemming from students' language skills.

They also propose the development of a Comprehensive Program for Inclusive Education in Science and Technology, considering three main axes: (1) Technological and curricular accessibility: adapting electronics and computer labs with assistive tools such as screen readers, accessible programming software, haptic devices, and ergonomic stations for technical practices.

(2) Ongoing teacher training: training teachers in universal design for learning (UDL) and inclusive active methodologies (such as collaborative project-based learning and adapted gamification), with a focus on the diversity of abilities and learning styles. (3) Specialized tutoring and a support community: creating teams of tutors and mentors among teachers, advanced students, and graduates with experience in inclusion, who provide personalized support for students' academic and emotional progress.

According to Salas y Pavón (2022) global trends seek to respond to the growing demand in university settings. Technology, artificial intelligence (AI), and nanotechnology have been part of educational processes in recent periods, demonstrating achievements in hybrid and virtual training, sustained by the implementation of technological support infrastructures and the development of learning methods based on computer modules (Fidalgo-Blanco et al., 2022).

In Latin America, según Tapia et al. (2025) various trends are being applied in training instructions to achieve learning, using ICTs, through in-person, virtual, or hybrid classes. However, the group requiring academic support is not identified, there are weaknesses and barriers to serving students based on their disabilities, and teachers do not adapt educational models.

Disability is related to limitations in functioning in community-type environments based on age and culture. Diversity and linguistics for communication and sensory-motor aspects coexist with abilities, requiring support for improvement (Luckasson, 2002). The interaction in society of an individual with a certain disability generates inconveniences by representing conflict or generating attitudes in the environment by not accepting the

differences of this group of people (Vásquez, 2019).

For Sepúlveda and Castillo (2021), the teaching professional must have personal skills, formative empowerment, and experience; this need has been declared in the technical roundtables promoted by the organizations in charge of the educational system seeking to adapt educational models. Strengthening identity will give meaning to the teaching practice.

In Chile, according to Castillo (2021), inclusion is in transition; the decrees promulgated only focus on individualized work; there is still a need to build an inclusive culture that must be strengthened through pedagogical reflection, abandoning exclusionary actions. Some Mexican universities lack guidelines on inclusion and educational equity. Educational models have only recently been integrated due to various barriers and problems stemming from divergences in administrative procedures. It is also noteworthy that a standard model still does not exist (Rodríguez, 2025).

For Martínez (2021), team-based actions allow for the development of emotional skills at university centers. Cooperation with equal treatment eliminates divergences. A consensus on distributing tasks and working together is very important. According to Haregu et al. (2024), intercultural competencies positively impact the cultural diversity of higher education students.

Academic training requires achieving higher standards, applying creativity, socialization, and, above all, critical thinking, accompanied by socio-emotional skills and abilities (Zambrano-Álava et al., 2020). The role of the teacher must be based on pedagogical competencies and leadership to ensure optimal teaching to the group of students with specific requirements through differentiated plans and interdisciplinary collaboration where professionals participate in the ongoing support process (Monge and Gómez, 2020).

The limitations presented in the construct of this study are the scarce information on inclusion at the university stage (young people and adults), greater involvement of university institutions is still required to achieve the objectives within a framework of inclusivity proposed by UNESCO, therefore new research is required to complement lines of inclusive trends.

## Conclusions

Global trends respond to the growing demand in the university environment. Technology, artificial intelligence (AI), and nanotechnology have enabled achievements in hybrid and virtual education with the development of learning



methods based on computer modules. Higher education is a form of social recognition.

In Latin America, instruction is provided through the use of ICTs, through in-person, virtual, or hybrid classes; however, the group requiring academic support is not identified, there are weaknesses and barriers to serving students due to their disabilities, and teachers do not adapt educational models. There are attitudinal barriers of social origin, including attitudes, beliefs, or prejudices that limit or hinder the participation of a person with ASD.

Inclusive education in Mexico was complex, and it took decades for political and social transformations to emerge in the face of challenges and resistance. Significant progress has been made in the implementation of national programs that recognize and value the right to education for all, but structural, social, and cultural barriers affecting higher education levels are still evident.

In Chile, progress toward inclusion is still underway, but the process is slow. Enacted regulatory decrees focus solely on individualized work. The construction of an inclusive culture is still pending, and it must be strengthened through pedagogical reflection and the abandonment of exclusionary practices.

In Peru, information on disabilities among university students is scarce and dispersed, making it difficult to identify the student population excluded due to disability or social inequality. Given this situation, government officials must assume the responsibility of providing quality education for all without distinction.

The evident limitation is the scarcity of information on inclusion at the university level; therefore, new research is needed to complement the trends with inclusive approaches. Future work should propose perspectives on software designed to assist people with special needs, with web accessibility and alternative and augmentative communication tools that facilitate learning and social participation.

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# **Inclusive Education in University Music Programs: Policies, Teaching Practices, and Experiences of Students with Disabilities in Argentina**

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## **Introduction**

The inclusion of students with disabilities in university music education constitutes an ethical imperative in the contemporary Argentine educational context (Andino and Pedrozo de la Vega, 2022). This commitment is based on the United Nations Convention on the Rights of Persons with Disabilities, which establishes the right to an inclusive education that guarantees equal opportunities and full participation (United Nations, 2013; Damiani Pellegrini, 2023). In the specific field of higher music education, inclusion transcends physical access to classrooms, requiring the adaptation of pedagogical methodologies that recognize the diversity of abilities and learning styles (Díaz Vélez, 2018; Boltrino, 2006).

Despite regulatory advances, the effective implementation of inclusive policies faces complex challenges linked to negative social representations and teaching practices rooted in traditional models (Figari and Fernández Unsain, 2023; Maizares, 2015). This study critically examines the tensions between institutional policies, pedagogical practices, and student trajectories in the Music Department of a public university in the Cuyo region, where the performative nature of the discipline generates unique challenges for substantive inclusion.

## **Disability Models**

Disability models are crucial to understanding the social dynamics and structures that impact this group. Studying the Presidential, Medical, and Social models reveals how these perspectives influence social perceptions and institutional practices, as well as their impact on inclusive policies.

The Presidential Model, according to Maizares (2015), is characterized by a paternalistic approach that views people with disabilities as subjects of pity and dependency. This approach emphasizes assistance and benevolence, treating these individuals as objects of charity rather than citizens with rights. This narrative reinforces a negative and marginalizing view of disability, limiting the agency and identity of people with disabilities.

In contrast, the Medical Model conceptualizes disability by focusing on the individual. From this perspective, disability is interpreted as an impairment that must be diagnosed and treated, leading people with disabilities to be viewed primarily as patients rather than as individuals with rights. This model fosters a reductionist view of disability, ignoring the social context and barriers that contribute to exclusion (Maizares, 2015).

On the other hand, the Social Model proposes a paradigm shift by interpreting disability as a social construct. According to this model, physical, social, and attitudinal barriers are what truly limit the participation of people with disabilities, beyond their individual circumstances. This approach, supported by Figari and Fernández Unsain (2023), questions how social representations of disability are constructed and maintained, urging us to reconsider how they are perceived over time. Disability is not merely a characteristic of the individual, but an experience influenced by the cultural and social environment. This underscores the urgency of transforming the social structures that limit and exclude.

The Convention on the Rights of Persons with Disabilities, founded on these concepts, marks a milestone in the fight for human rights. Damiani Pellegrini (2023) argues that this legal instrument not only promotes inclusion and equal rights, but also challenges the notion of disability as a social stigma.

The discussion on accessibility, described by Guzmán Ferrer (2024), considers accessibility as a fundamental element of public space, highlighting its crucial role in building environments that promote the well-being and active participation of all people. This analysis makes it clear that these models have profound implications for how the experiences of people with disabilities are lived and perceived. Inclusion requires a commitment to cultural and social transformation, recognizing people with disabilities as active subjects in the construction of their identity and rights.

## **Inclusion Paradigms**

The inclusion paradigm represents an educational approach that seeks to eliminate the limitations imposed by traditional conceptions of disability. The

exclusion paradigm manifests itself through the segregation of people with disabilities, treating them as elements that must be isolated to protect society (Skliar, n.d.). On the other hand, the integration paradigm attempts to incorporate these people into society through a normalization that seeks to "fix" their differences to fit a pre-established model, without effectively addressing the social barriers they face.

In contrast, the inclusion paradigm recognizes disability as a social phenomenon and not simply an individual problem. This approach promotes the creation of accessible and equitable educational environments that value differences rather than seeing them as deficiencies. Paz-Maldonado (2020) argues that inclusion must be based on respect for diversity, eliminating both physical and attitudinal barriers that limit the full participation of all students. A key element in this model is self-determination, which allows students with disabilities to be active participants in their own educational process, participating in decision-making that affects their learning and development.

Sartori de Azocar (2010) argues for the need to rethink the concept of disability, adopting a vision that recognizes its social construction. Inclusive education should not be limited to the presence of students with disabilities in the classroom, but should integrate a holistic approach that incorporates the social, cultural, and emotional dimensions of their lives. To ensure that diversity is valued and equal opportunities are promoted, it is crucial to transform teacher training and the educational culture as a whole. In this way, the inclusion paradigm seeks to transform society, creating an environment where differences are valued and equity is tangibly achievable.

### **Universal Design as an Approach to Inclusion**

Universal Design (UD) constitutes a fundamental paradigm for addressing diversity and promoting inclusion in higher education, with the aim of ensuring quality education for all (Sánchez, Díez, & Martín, 2016). Originally conceived to create products and environments that are usable without the need for specific adaptations (Sánchez, Díez, & Martín, 2016; Dalmau et al., 2015), this approach is applied to the educational field to ensure inclusion and access to the general curriculum (Sánchez, Díez, & Martín, 2016; Dalmau et al., 2015). Various denominations, such as Universal Design for Learning (UDL), Universal Instructional Design (UID), and Universal Design in Education (UDE), share the purpose of developing flexible curricula that respond to the needs of students (Sánchez, Díez, & Martín, 2016; Dalmau et al., 2015).

The implementation of UD brings benefits to both students and teachers, improving teaching and learning conditions (Sánchez, Díez, & Martín, 2016).

Successful experiences include teacher training, which promotes inclusive strategies and is positively valued by students (Sánchez, Díez, & Martín, 2016). Curricula based on UD have been shown to increase self-efficacy and positive emotions among students (Sánchez, Díez, & Martín, 2016) and, furthermore, demonstrate that learning difficulties often lie in the educational environment, not in the students themselves (Sánchez, Díez, & Martín, 2016). Likewise, participation and motivation increase with the proper use of technology under these principles (Sánchez, Díez, & Martín, 2016).

The principles of Universal Instructional Design (UID) establish that activities and materials must be accessible, equitable, flexible, simple, clear, promote a positive environment, and minimize unnecessary physical effort, ensuring adaptable spaces (Dalmau et al., 2015). Although the literature supports UD, further research is needed on its effectiveness in concrete outcomes, such as graduation rates (Sánchez, Díez, & Martín, 2016). However, it is considered a valid methodology that reduces the need for individual adaptations, decreases the associated stigma, and promotes equity (Sánchez, Díez, & Martín, 2016; Dalmau et al., 2015).

## **Inclusive Policies**

Although inclusion policies in higher education in Argentina have advanced, they face persistent challenges. Mareño Sempertegui and Katz (2011) describe how the National Constitution (1994) and the National Education Law (2006) and the Higher Education Law (1995) promote accessibility and inclusion for persons with disabilities. However, as Seda (2017) highlights, significant barriers limit effective access to higher education.

The Comprehensive Protection Law for Persons with Disabilities (1981) establishes a system aimed at ensuring medical care, social benefits, and education for this group. It is essential that universities take concrete actions to improve accessibility, such as building ramps and adapting curricula to include diverse learning methods (Seda, 2020). The creation of interuniversity commissions is a positive step forward, focusing on developing action programs and raising awareness among the university community, which are essential for promoting structural change (Observatorio Universitario de Buenos Aires, 2022).

The implementation of reflective practices in teacher training is an essential step to foster an environment that respects and values diversity, allowing all students to develop their unique abilities and potential (Mareño Sempertegui and Katz, 2011).



## Music Education and Inclusion

Inclusive music education is increasingly important in teacher training. According to Díaz Vélez (2018), it is essential that music educators implement strategies tailored to the needs of all students to ensure that none are excluded from the educational process. The study reveals that many teachers lack the necessary knowledge to implement these strategies, which represents a significant gap in their initial preparation.

The inclusion of students with special needs is also essential. According to Boltrino (2006), music acts as a valuable tool to promote inclusion in the classroom, facilitating emotional expression and peer bonding. Music education should not be limited to adjusting abilities, but should adopt a holistic approach that celebrates diversity and fosters a nurturing learning environment.

On the other hand, the training of future teachers must go beyond acquiring technical skills. Angel-Alvarado et al. (2024) argue that competencies that promote equity and respect for diversity should be integrated into music education. This perspective empowers future educators, training them as agents of change who question and transform inequalities in education.

Finally, Andino and Pedrozo de la Vega (2022) carry out a critical analysis of pedagogical practices at the National University of San Juan, highlighting that many institutions still use a deficit-centered model, which focuses on the individual limitations of students. They propose reorienting these practices toward an inclusive model, considering an accurate diagnosis of each student's needs and facilitating access and integration for students with disabilities. Music education, in this context, is a powerful vehicle for achieving meaningful inclusion in the educational environment.

## Research Problem

University music education in inclusive contexts poses epistemological and practical challenges for the Argentine education system. Although there have been legislative advances and greater social awareness, the implementation of inclusive programs faces substantial limitations related to disciplinary specificity and the scarcity of studies that articulate policies with pedagogical practices (Slee, 2018). The central question guiding this research examines how university policies and teaching practices impact the inclusion processes of students with disabilities, identifying transformative strategies for building genuinely inclusive academic environments in the music field.

## Research Objectives

The overall objective is to analyze the regulations, support programs, and accessibility proposed by university policies, as well as the teaching practices and experiences of students with disabilities that enable or hinder educational inclusion.

The specific objectives are: to examine the institutional policies and regulations of the Music Department; to describe the access, retention, and graduation trajectories of students with disabilities; to identify faculty perspectives on disability; to explore the academic experiences of students with disabilities; and to propose recommendations for strengthening educational inclusion.

### Fracture between institutional policies and disciplinary practices: The Case of a Blind Music Student

The analysis revealed a critical disconnect between general inclusion policies and their application in the music field. To illustrate this gap, we examine the experiences of a blind graduate from the Music Department at the National University of San Juan, who specialized in musical performance on the guitar. As she recounted, at the beginning of her academic journey, she faced the suggestion of seeking options in Buenos Aires due to the perceived lack of preparation among local faculty. This kind of situation, where there's an open-door policy but difficulties in its practical implementation, is the central focus of this section. Most faculty were unaware of protocols for specific adaptations in music education, demonstrating a lack of disciplinary translation of inclusive regulations. This normative-operational gap confirms findings about the disconnect between regulatory frameworks and specific practices in higher education (Soto, 2023; Slee, 2018).

Teaching concepts and pedagogical barriers: Initial Rejection and the Need for Advocacy. Many faculty members recognized training gaps in inclusive pedagogies. Approaches that perceive disability as a limitation to professional musical performance persisted, revealing resistance to implementing reasonable adjustments in methodologies and assessments. These findings are consistent with research that identifies curricular rigidity as a fundamental barrier to inclusion in arts education (Echeita, 2013; Díaz Vélez, 2018). The blind graduate's experience underscores this issue, as she initially faced discouragement and a lack of support, revealing the need for greater awareness and advocacy within the institution.

### Exclusionary infrastructure and technology: The Dependence on External Support

Critical gaps in resources for musical inclusion were identified: classrooms without sound systems for the hearing impaired, a lack of Braille sheet music, a lack of adapted notation software, and modified instruments. This reality violates the right to inclusive education and exacerbates socioeconomic inequalities, as students reported additional expenses for adapted materials (Pérez-Castro, 2019). Technological accessibility is an essential condition for contemporary musical inclusion (Gorbunova et al., 2020). The blind student's experience underscores this point, as she initially relied on external transcribers in Buenos Aires to convert scores into Braille, further evidencing the need for in-house resources and accessibility.

### Student trajectories and resilient strategies: Peer Support and the Building of Inclusive Environments

Students developed coping mechanisms based on peer support networks and individual resilience. These informal strategies reflect adaptive capacities, but also reveal an institutional gap in accessibility (Pérez-Castro, 2019), reflecting how resilience operates as a compensatory resource in the face of systemic failures (Rose et al., 2018). As the blind student explained, despite an initially isolating experience at a flute workshop, she ultimately found acceptance and support from peers, who aided her in understanding musical scores. This underscores the potential for creating inclusive environments through supportive relationships and collaborative learning.

Digital divide in music education. Underutilization of adaptive technologies with transformative potential was identified. The lack of specialized software and adaptive digital instruments particularly affects students with visual impairments, who require specific technologies for tactile music notation or audio description systems (Koh, 2019).

## Conclusions

This research reveals a persistent disconnect between inclusive discourse and concrete practices in Argentine university music education. Institutional policies are insufficiently translated into specific protocols tailored for the music discipline, resulting in an operational vacuum.

Teacher training emerges as crucial, with traditional concepts hindering the adoption of inclusive paradigms. Limited training in Universal Design for Learning (UDL) and adapted technologies restricts the ability to respond to students' diverse needs effectively. Insufficient infrastructure and resources perpetuate systemic exclusion, disproportionately affecting low-income students.

Resilience strategies adopted by students highlight the institutional failure to guarantee equitable conditions. To address this, we propose developing specific protocols, implementing mandatory teacher training in inclusive methodologies, prioritizing funding for adapted technologies, and including students in curriculum design committees.

This study acknowledges limitations in sample size and scope, focusing on a single university department. Future research should expand to multiple institutions and disciplines, exploring the long-term impact of inclusive policies on student trajectories and career paths. Further investigation into faculty perspectives and the effectiveness of UDL-based interventions is also essential.

Ultimately, achieving genuinely inclusive music education requires a comprehensive institutional commitment to eliminating barriers and valuing diversity as a core academic principle.

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# Assessment of interdisciplinary learning between design and business students through agile entrepreneurship methodologies

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## Introduction

This research is framed within an interdisciplinary learning experience involving students from the Design and Business Administration programs at the University of La Serena, Chile. The central axis of this initiative is the development of competencies related to the formulation of innovative business models. Implemented through a pedagogical approach that integrates active methodologies, collaborative projects, and territory-focused challenges, the experience seeks to strengthen the educational process from a comprehensive and meaningful perspective.

The course Business Strategies, offered during the eighth semester of the Design program, represents a key stage in the articulation of knowledge linked to management, innovation, and the planning of solutions aimed at productive and commercial environments. Its implementation is based on project-based learning, where students apply tools from the social sciences, business strategy, and design management to address real-world challenges. Through case analysis and the application of design methodologies, students are required to develop a functional prototype—either physical or digital—that responds to a specific need of a target customer segment. The process also incorporates elements such as cost structure and financial planning. The graduate profile explicitly includes entrepreneurial competencies, which is why the development of business lines and strategic proposals by students is an integral part of the course. The logical sequence of content and activities is fundamental to the advancement and consistency of the design project.

In parallel, the Entrepreneurship course, taught during the fifth semester of the Business Administration program, aims to foster an entrepreneurial mindset in

students through the exploration of innovative ideas, environmental analysis, and the creation of value propositions focused on user needs. The course promotes the application of agile methodologies such as the Business Model Canvas, empathy maps, and the development of conceptual prototypes, all with a focus on agile customer development and early-stage validation. Furthermore, the course includes direct engagement with real entrepreneurs in their early stages of development through advisory sessions conducted in collaboration with a foundation focused on supporting nascent ventures (Emprópolis), enabling practical feedback and a strong connection with the local ecosystem.

Although both courses are theoretically structured in their respective syllabi, the main teaching challenge lies in the ability to adapt and transition the instruction toward a more practical approach, particularly in relation to the development of business models. Within this context, the role of the guiding instructor becomes central—responsible for monitoring, providing feedback, and managing the creative and strategic processes undertaken by each student team in response to their specific challenges. Various active learning methodologies are employed in this process—such as analogical empathy and journey mapping—which help integrate pedagogical approaches from both design and business education, promoting a gradual alignment with the demands of professional practice and interdisciplinary collaboration.

This initiative is conceived as a concrete opportunity for interdisciplinary engagement and the co-construction of applied knowledge, articulating diverse bodies of knowledge from the humanities, design, and business administration to generate innovative, context-sensitive proposals with territorial relevance. Moreover, it aims to strengthen academic inclusion, inter-program collaboration, and meaningful learning, all of which contribute to the holistic development of students. Within this framework, time, shared experience, and the capacity for innovation are considered essential components of the educational process—further enhanced by faculty support and pedagogical planning grounded in flexibility and methodological adaptation.

The present study aims to evaluate the perceived value of interdisciplinary learning among students of Design and Business Administration Engineering at the University of La Serena, based on the joint development of innovative business models using agile methodologies and participatory tools such as Lego® Serious Play®. The specific objectives are as follows: (1) To describe the interdisciplinary experience and the dynamics of collaboration between Design and Business Administration students during the process of formulating



entrepreneurial proposals; (2) To explore students' perceptions regarding the use of agile and participatory methodologies in the ideation and creation of business models; (3) To analyze the development of value propositions through the integration of creative, strategic, and collaborative approaches.

## **Design as a Project-Based Discipline**

Project design involves a series of cognitive processes rooted in creation and ideation. These processes begin with the identification of a need or the definition of a design-related problem, progressing toward a proposed solution. Within the field of design—as well as in disciplines such as architecture and construction—various project-based methodologies have been developed to define and structure the phases of the design process.

According to Jensen (2009), design can be divided into two main approaches: executive and strategic. The executive approach focuses on transforming ideas into tangible results that serve a specific function related to fulfilling a need or desire. In contrast, the strategic approach is concerned with solving problems and with the planning and management of the resources required to conceptualize, implement, and evaluate the proposed solutions.

## **Learning in Higher Education**

Samuelowicz and Bain (2001, 2022) identified two predominant teaching approaches in higher education: one centered on the instructor's own teaching and the transmission of information, and another focused on student learning through facilitation (Biggs, 2006; Gargallo et al., 2010). In this regard, and based on findings from educational research (Samuelowicz and Bain, 2001, 2022; Gargallo et al., 2010), the approach that currently proves most effective in promoting student learning in higher education is the one centered on active student engagement. This approach is associated with deeper learning experiences and long-lasting knowledge construction (Biggs, 2006).

In the context of higher education, the Lego® Serious Play® (LSP) methodology has emerged as a pedagogical strategy designed to promote reflective thinking, creativity, and active student engagement. This methodological tool, based on the construction of three-dimensional models using Lego® bricks, enables students to articulate abstract ideas through visual metaphors, thereby facilitating deep and meaningful learning processes. LSP aligns with constructivist approaches to education, as it fosters a collaborative environment in which participants construct knowledge through experience, dialogue, and collective reflection (James & Brookfield, 2014).

Several experiences in higher education have demonstrated the effectiveness of LSP in strengthening cross-disciplinary skills such as teamwork, shared leadership, and metaphor-based understanding—key components in co-creation processes (Benesova, 2023). Its application in courses related to innovation, entrepreneurship, and design has not only enhanced student motivation but also facilitated participatory diagnostics, idea generation, and early-stage solution prototyping. Recent studies have indicated that LSP significantly increases motivation and engagement, even in advanced academic contexts (Ganiyu *et al.*, 2025). In particular, its use in postgraduate programs has shown measurable improvements in research skills, critical thinking, and strategic decision-making capabilities.

The implementation of the project provided significant evidence regarding students' motivation, participation, collaborative learning, and their overall assessment of the interdisciplinary approach. Both quantitative and qualitative data revealed a high level of acceptance of the experience, with particular emphasis on the effectiveness of active methodologies such as Lego® Serious Play® as a facilitator of the learning process.

### **Motivation and Willingness to Collaborate Across Disciplines**

One of the central indicators analyzed was the level of motivation to engage with students from other academic programs. A total of 59% of participants stated they felt motivated to collaborate, 36% selected “maybe,” and only 5% indicated they did not feel motivated.

This initial openness was further confirmed in the focus groups, where students expressed appreciation for the opportunity to interact with peers from other disciplinary backgrounds and highlighted the positive impact of exchanging diverse perspectives: “We found it interesting to work together with students from Business Administration, since they are familiar with topics we don’t usually get to practice much.” (Design student, Focus Group 1); “As designers, we were able to contribute to the importance of the value proposition within the Canvas model—things like brand identity, segmentation, and communication channels for distribution, for example.” (Design student, Focus Group 1); “At first it was difficult to organize ourselves, but after the first challenge we worked really well together on all the activities.” (Business Administration student, Focus Group 2)

### **Impact of Lego® Serious Play® as an Activation Tool**

The use of the Lego® Serious Play® (LSP) methodology during the initial stage was highly appreciated by participants. They identified it as a strategy that

facilitated symbolic communication, created a safe space for expressing ideas, and enabled a collaborative and creative understanding of real-world problems: “I had never used Legos before, but it was easy and fun to build elements that represented bad experiences I’ve had as a customer in a supermarket.” (Business Administration student, Focus Group 2); “The LEGO session was inspiring; it activated our group to begin the project... Using Lego helped us relax and feel at ease with our teammates from Business Administration, whom we didn’t know before”. (Design student, Focus Group 1)

**Figure 1.** LSP construction: “My worst experience as a customer of a company.”



Source: created by researchers 2025.-

### Assessment of Interdisciplinary Learning

Students acknowledged that the experience contributed not only to the development of technical competencies, but also to the strengthening of soft skills such as teamwork, effective communication, and empathy. The opportunity to share roles and co-construct proposals was identified as a distinctive value of the project. The following are illustrative examples of quotations: “We were able to reach agreements within the team and completed the entire Canvas model.” (Design student, Focus Group 1); “It was hard to agree on the value proposition—Design students are more creative, but we are better at handling business strategy.” (Business Administration student, Focus Group 2).

One of the survey questions asked: Were you able to reach agreements with your teammates? In response, 90.2% of students indicated yes, 9.8% responded sometimes, and 0% answered no—which reinforces the perception of effective collaborative work throughout the interdisciplinary process.

**Table 1.** Comparative Findings Table: Assessment of Interdisciplinary Learning.

| Assessed Dimension                | Quantitative Findings                                                              | Qualitative Findings (Focus Groups)                                                                                                           | General Interpretation                                                                                   |
|-----------------------------------|------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|
| Interdisciplinary Motivation      | 59% felt motivated, 36% responded "maybe," and 5% "not motivated"                  | Positive evaluation of working with different academic profiles. Quote: "We found it interesting to work with business administration peers." | High willingness to collaborate beyond one's own discipline.                                             |
| Use of LSP as Activation Tool     | High acceptance and initial enthusiasm                                             | Perceived as a playful and safe space to share ideas. Quote: "It was inspiring... it allowed us to relax and get to know each other."         | LSP acts as a catalyst for trust and creativity at the beginning of joint work.                          |
| Collaborative Work and Agreements | 90.2% reached agreements with their teams; 9.8% said they only did so occasionally | Recognition of complementarity between disciplines. Quote: "They are more creative; we handle the strategies."                                | Teamwork was strengthened through complementary roles.                                                   |
| Value Proposition in the Canvas   | 100% of teams completed the Canvas model and passed the activity                   | The Canvas was recognized as a space for interdisciplinary negotiation.                                                                       | The process enabled the integration of strategic, visual, and analytical thinking into a shared outcome. |
| Time Management and Execution     | 100% of groups completed the activity within the allotted time                     | Time was considered sufficient. Quote: "We managed to finish and apply the entire Canvas model."                                              | Good planning and methodological adaptation supported the achievement of objectives.                     |

Source: Own elaboration based on research findings.

In general terms, the interdisciplinary experience was perceived not only as an academic challenge but also as an opportunity for both personal and professional growth. All participating students were able to successfully complete the collaborative Business Model Canvas within the allotted time for the activity. The results were favorable, with 100% of the participants receiving a passing grade. The time allocated for completing the tasks was rated as appropriate and sufficient to fully carry out the exercise.

**Figure 2.** Student participation in the Canvas Model + Lego® activity.



Source: created by researchers 2025.-

## Conclusions

The results of this study demonstrate that the interdisciplinary learning experience involving Design and Business Administration students — structured around the joint development of business models and the implementation of agile methodologies such as Lego® Serious Play® — had a significant positive impact on students' motivation, engagement, and meaningful learning processes. In terms of motivation, participants exhibited a strong willingness to collaborate with peers from other disciplines, recognizing the value of addressing shared challenges through diverse and complementary perspectives. This interdisciplinary openness not only fostered active participation in project activities but also encouraged students to embrace diverse working environments — an essential competency in today's innovation-driven landscape.

From a learning perspective, the use of Lego® Serious Play® in the initial stage proved to be a critical enabler for team integration, symbolic communication, and collective creativity. The tangible representations built with LEGO bricks allowed students to express experiences, identify needs, and co-develop solutions through visual metaphors—facilitating the transition from abstract thinking to the design of feasible and contextually grounded proposals. Furthermore, interdisciplinary collaboration promoted the development of transversal competencies such as strategic thinking, teamwork, empathy, and evidence-based decision-making. The process of constructing the value proposition within the Business Model Canvas was perceived by students as a peer negotiation space, where both design-based and analytical skills from each academic field were brought into play.

From a methodological standpoint, the integration of qualitative and quantitative tools provided a broad and in-depth understanding of the educational phenomenon. The findings reflect not only high levels of

satisfaction with the experience but also its tangible impact on the participants' professional development. All students successfully completed their projects, noting that the time, structure, and collaborative environments provided were adequate to achieve the intended learning objectives.

Finally, this experience can be considered a replicable model for other educational contexts aiming to strengthen interdisciplinarity, methodological innovation, and territorial engagement. Its value lies not only in the academic outcomes achieved, but in its ability to foster conditions for collaborative, creative, and purpose-driven learning. Future research is recommended to explore the longitudinal impact of such experiences and their potential for enhancing entrepreneurial competencies in higher education.

The main limitations of this study are as follows: The sample was purposive and limited to a single university, which restricts the generalizability of the findings to other educational settings. Moreover, although the mixed-methods approach enabled a broader understanding of the phenomenon under investigation, the research design did not incorporate a longitudinal assessment. This omission limits the capacity to evaluate the potential long-term impacts of the interdisciplinary experience. Lastly, the collection of qualitative data through focus groups depended on the availability and willingness of participating students, which may have affected the depth and richness of certain responses—particularly those offering more critical or divergent viewpoints from the prevailing perspective.

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# Tutoring among higher education faculty: An integrated approach to collaborative learning

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This article arises within the framework of the Research in support of University Teaching nominated "Strengthening University Teaching through peer tutoring...", which corresponds to a research project ID of Project CEC\_PI\_2023004 with internal financing from the University of the Americas (UDLA) and whose execution was carried out between the years 2023-2024.

## Introduction

Peer tutoring (peer-assisted learning) among educators has gained recognition as an effective pedagogical method in higher education, facilitating cooperative learning for both tutors and tutees. This approach is teacher-centered, complementing the self-study methodology discussed in this study.

Peer tutoring is based on constructivist learning theories, such as those of Vygotsky (1978), who emphasizes the role of social interaction in cognitive development. Teachers work together to collectively overcome zones of proximal development. Learning is juxtaposed with teachers collaboratively working through their respective zones of proximal development (Vygotsky, 1978).

Moreover, the self-study approach, which works in tandem with peer tutoring, promotes teacher independence. It is a heuristic approach that leads educators to realize the importance of learning through reflection on their learning process, to understand the crucial elements of reflective practices, and to use techniques that provide access to challenges in their teaching (Zimmerman, 2002).

University teacher mentoring serves as a foundational model for improving academic quality, advancing teaching innovation, and refining lifelong development. In a context where educational institutions face challenges such as the ongoing need to update knowledge, the introduction of new technologies, and the adaptation to social needs, this collaborative activity is a key pillar supporting institutional renewal (García & Pérez, 2021).

The theoretical perspective of teacher mentoring aligns with the community of



practice model developed by Wenger (1990, 1991, 1999). This model posits that learning and learning to teach better occur in social settings where teachers collaborate on tasks, reflect on their practices, and support one another in solving common problems. This professional community fosters the development of a collaborative sphere based on trust, where shared experiences and knowledge lead to a collective identity: we develop as professionals through others (Wenger *et.al.*, 2011).

This is reinforced by theories of learning and action-based professional development that focus on the impact of social interaction and reflection in the development of teaching practice (Vygotsky, 1978; Darling-Hammond *et al.*, 2017). When teachers engage in mentoring activities with each other, they generate shared knowledge, pedagogical innovation, and problem-solving directly within the classroom setting.

In this way, peer tutoring among teachers can take various forms, ranging from scheduled formal meetings to virtual exchange communities. Some institutions implement structured programs in which more experienced teachers mentor colleagues who are in training or undergoing pedagogical innovation, promoting the transfer of best practices and critical reflection (López & Ramírez, 2020).

Other models are based on informal communities of practice, where teachers participate in discussion groups, collaborative workshops, or digital platforms to share resources and experiences (Wenger *et al.*, 2011). Overall, peer tutoring among teachers can take multiple formats, from structured face-to-face meetings to virtual communities for exchange and collaboration.

Some institutions implement formal programs where more experienced teachers act as mentors or tutors, guiding colleagues who are in training or engaged in pedagogical innovation. These programs promote the transfer of good practices, critical reflection, and support in specific projects (López & Ramírez, 2020). Other models are based on informal communities of practice, where teachers participate in discussion groups, collaborative workshops, seminars, or digital platforms, sharing resources, experiences, and reflections (Wenger *et al.*, 2011).

These activities not only support ongoing updates in teaching methodologies and educational technologies, but also strengthen professional identity, a sense of belonging, and a culture of continuous improvement within academic institutions (Martínez, 2022). Additionally, tutoring makes it possible to identify specific training needs and design targeted intervention strategies.

Despite everything, and as occurred in the present study, peer tutoring among teachers involved a formal and systematic collaborative relationship between peers, with scheduled and ongoing meetings. This approach incorporated a strategy to understand and deepen university teachers' experiences in relation to learning about teaching, through the use of reflective and self-reflective perspectives such as self-study (Álvarez-Gayou, 2013; Crotty, 1988; Sandin, 2003). This qualitative approach formed the core of the study, positioning teachers as both the subjects and objects of research, thereby enhancing learning processes for themselves and what is transferred to their students.

Through tutoring and the self-study methodology, teachers raise questions about their teaching practices. The issues that emerge are those that require deeper exploration and sharing with peers, allowing them through a reflective process to critically examine their habitual ways of approaching formative work. Self-study of teaching practice in higher education refers to the in-depth analysis of how educators reflect upon and evaluate their educational practice within their specific disciplines.

## Case Study

Strengthening university teaching is a pressing imperative in the context of post-pandemic higher education. In fact, in academic discourse, we frequently observe the implementation of various strategic actions aimed at academic staff, with the aim of improving the planning and delivery of their classes, in the hope of positively impacting the quality of student learning. Peer mentoring among faculty is also observed among teaching staff, as illustrated in this study. Thus, peer mentoring among all academic peers has become an effective pedagogical strategy in higher education, promoting collaborative learning that benefits both tutors and faculty.

In the context of higher education, peer mentoring among faculty emerges as a fundamental pedagogical strategy to enrich the teaching-learning process, fostering a collaborative environment between faculty and students. This methodology not only allows educators to support each other in understanding how to improve their teaching practices but also promotes professional development and empowers their role within an educational model that fosters learning and active student engagement.

As educational institutions seek new ways to enhance the quality of teaching and learning, peer tutoring both among faculty and students stands out as an effective alternative to complement traditional methods of instructional support, evaluation, and feedback.

It is within this context that the present article originates from research based on an intrinsic case study in support of university teaching, entitled “Strengthening University Teaching through Peer Tutoring”. This study is part of an internally funded research project by the Universidad de las Américas (UDLA), carried out between 2023 and 2024.

In the case of the Universidad de las Américas (UDLA), a range of initiatives have been implemented in the areas of faculty induction, support, and professional development. However, despite these efforts, many of the teachers who have received training and support are still rated by their students as underperforming. This confirms findings from various studies (Samaras, 2011; Russell et.al., 2016), which indicate that unless teachers intentionally and genuinely take ownership of their classroom practices without engaging in critical reflection on their actions and how to improve the critical aspects of their teaching they will continue to replicate habitual practices rooted in their implicit theories about how teaching should be conducted. As a result, they may reuse the same methodologies and assessment procedures for years, even though student profiles have changed over time. In other words, memorization-based, content-centered pedagogical models continue to be reproduced, instead of constructivist and socially oriented approaches as promoted by UDLA, where students are placed at the center of the teaching and learning process.

It is crucial that teachers take a central role in developing knowledge about the discipline of teaching that is, building from their own practice and engaging in critical reflection on their teaching actions. By analyzing and constructing a personal narrative, educators can define parameters to improve their practice. This process is significantly enhanced when carried out collaboratively specifically, with the support of a peer tutor (critical friend). From the perspective of professional teacher development, the self-study approach proposed in this study as the inquiry methodology professionalizes teaching practice by recognizing the teacher as a key, actor in defining and transforming their educational role (Schuck & Russell, 2016).

Reflective practice, when supported by a peer tutor and framed within the self-study approach, highlights the deliberative nature of teaching. It fosters the construction of pedagogical knowledge by bridging the gap between theory learned in training programs and mentoring, and the lived experience of teaching. When teaching experience is analyzed reflectively and critically with the support of a peer tutor, it facilitates the development of professional knowledge that integrates the teacher’s personal background and their academic and professional experience.

In this study, the implementation of the self-study methodology, accompanied by a peer tutor, made it possible to examine the very practice developed by the teachers themselves, creating a real opportunity to build knowledge from university pedagogical practice (Silva-Peña, 2007).

The study revealed itself as an intentional and systematic inquiry into one's own teaching practice, emerging from the everyday experience of teaching, with the goal of improving and transforming it. It constituted a personal investigation of one's own practice (Berry, 2016), challenging traditional paradigms by emphasizing research as a form of teaching support starting with each teacher's reflective practice. This process cannot be achieved through isolated or occasional questioning of classroom actions; it requires an ongoing process that becomes part of the teacher's habitus (Perrenoud, 2010), since there is knowledge in action that can only be revealed through experience and reflection on and within the teaching act itself (Schön, 1992).

The teachers were able to critically analyze their classroom teaching practices (Afonso, 2019), demonstrating the capacity to innovate, work democratically, and learn together with their peers (Bolívar, 2015, 2019; Contreras, 2016). Indeed, when teachers manage their pedagogical processes with the goal of achieving and ensuring high-quality learning for all students, we are looking at an educator who leads their pedagogical efforts regardless of the mode of instruction (García-Garnica, 2016), grounded in a culture of equity, inclusion, participation, and innovation that promotes continuous improvement, as Contreras (2016) affirms.

This motivated us, as researchers, to unite research and faculty development through a deeper understanding of our self. Legitimizing these inquiry processes within higher education institutions will help consolidate the creation of true reflective learning communities (Samaras, 2011).

The analysis of this data was conducted using descriptive and thematic coding with the software Atlas ti application, version 25. Within this context, analytical patterns were identified within the consolidated data. In this way, the qualitative analysis enabled a deeper understanding and insight into the experiences of the teachers who participated in the tutoring sessions. Two descriptive categories of analysis emerged, as illustrated in Table 1.

**Table 1. Descriptive Categories and Units of Meaning**

| Descriptive Categories                              | "Units of Meaning"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|-----------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Collaborative Work Among Peer Teachers              | <p>"...within the framework of the Self-study project, I was interested in participating, voluntarily agreeing to review my teaching practice in one of these courses, in parallel with writing my master's thesis, where I implemented innovations in my classes at one of the university cam"</p> <p>An essential part of the process was talking with other colleagues involved in the project. In those spaces of dialogue, deep resonances emerged: we shared fears, contradictions, but also discoveries. It was very powerful to realize that I was not alone in my concerns. The Self-study allowed me to legitimize doubt as a driving force for improvement and writing as a way of thinking."puses..."</p>                                    |
| Reflection and Self-Reflection on Teaching Practice | <p>"...I deeply value the opportunity provided by the Self-study methodology implementation project to pause, observe, and rethink my practice. Although I already had reflection habits, this process allowed me to view my teaching with greater awareness, comparing it even to a mindfulness experience: an attentive observation of what I do and what my students need."</p> <p>"...Along the way, I have always felt the need to pause and reflect on my work, but the demands of daily life often prevent it. When I was invited to participate in the Self-study project, I saw a concrete opportunity to look at myself deeply, with honesty and without fear. I took it on as a commitment to myself, rather than as an external task..."</p> |

## Conclusions

The study shows that peer mentoring in higher education is a powerful tool that, when properly implemented, can transform the educational experience, creating an enriching environment that enhances academic development. It is imperative that educational institutions continue to invest in these strategies and the resources necessary for their success, thus ensuring a brighter future for future generations.

Indeed, the results the findings of García-Garnica (2016) are confirmed regarding the existence of pedagogical leadership in university teaching classrooms, insofar as teachers are able to reflect and self-reflect on how to improve their teaching in a way that impacts the quality of student learning. Particularly through peer tutoring and collaborative work that emphasized pedagogical and formative aspects in their relationship with students, the results align with Afonso (2019), since teachers participate in tutoring activities with the purpose of sharing their challenges in search of possible solutions, understanding mistakes as learning opportunities, recognizing their students' successes, and also sharing best practices that are socialized among peers. Similarly, from the teachers' perspective, the findings of Rivera (2020) are confirmed regarding the need for teachers to work collaboratively with peers, to be listened to respectfully, to rethink their teaching practice, and to recognize their mistakes, all of which contribute to pedagogically leading their classrooms and providing enriching experiences for their professional teaching development.

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# Transforming Medical Education through Generative AI: A Comprehensive Analysis of Student Experiences and Learning Outcomes in Clinical Practice

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This chapter emerges from the MEDTECH-AI project (2023-2025) of the Universidad Católica Santa María, "Integration of generative artificial intelligence in undergraduate medical education: innovations, challenges, and pedagogical transformations."

## Introduction

The integration of artificial intelligence (AI) in medical education represents one of the most significant paradigms shifts in contemporary higher education. As healthcare systems worldwide embrace digital transformation, medical schools face the imperative to prepare future physicians who can effectively navigate an AI-augmented clinical landscape. Generative Artificial Intelligence (GAI), in particular, has emerged as a powerful educational tool capable of creating realistic, relevant, and personalized content that aligns with students' specific learning needs and preferences.

The educational potential of GAI extends beyond traditional learning modalities by offering automated assessment capabilities, formative feedback mechanisms, and the ability to generate diverse clinical scenarios that might not be readily available in conventional training settings (Chen et al., 2020; Hwang et al., 2020). Recent studies, including the Horizon Report 2019, suggest that AI has the capacity to personalize student experiences, reduce workload burdens for both students and educators, and facilitate the analysis of large and complex datasets (Zhang et al., 2023).

In the context of medical education, GAI encompasses various technological approaches, each serving distinct pedagogical purposes. Generative adversarial networks (GANs), such as Stable Diffusion, Mid Journey, and DALL-E, can generate medical images including X-rays, CT scans, or MRIs. Generative Language Models, including ChatGPT, Bing, Bard, and GPT-4, can produce medical texts such as clinical case summaries, diagnostic reports, scientific articles, and educational content. Variational Models (VAE) can

generate synthetic data including electrocardiograms, EEGs, and voice signals.

The manifold advantages of GAI in clinical practice include broadening and diversifying clinical cases, improving feedback and self-assessment mechanisms, stimulating motivation and interest, encouraging reflection and critical thinking, and facilitating knowledge transfer and application (Lee et al., 2021). However, these benefits come with inherent challenges, including the need for content verification and validation, establishing user trust and acceptance (Mousavi Baigi et al., 2023), addressing ethical implications (Zhong et al., 2023), ensuring user accountability, and providing adequate educator training and support (Charow et al., 2021).

Contemporary medical education increasingly recognizes the necessity of innovative pedagogical approaches that address the evolving healthcare landscape. The United Nations Educational, Scientific and Cultural Organization (UNESCO) publication "Reimagining Our Future Together: A New Social Contract for Education" represents the inaugural international consensus on the nexus between AI and education. This recognition underscores the urgent need to identify novel and efficacious solutions to enhance undergraduate medical students' clinical practice, ensuring these solutions are tailored to specific contextual requirements including learning, evaluation, and formative research.

## Quantitative Analysis and Student Perception Distribution

The quantitative analysis revealed predominantly positive perceptions of GAI implementation in clinical education, aligning with findings reported by Banerjee et al. (2021) in their research on AI perception in medical education. The distribution of student perceptions demonstrated a clear trend toward positive acceptance of GAI technology:

**Table 1** *Perception of the Use of SAI in Clinical Practice by Median*

| Categories             | Frequency | Proportion | p value  |
|------------------------|-----------|------------|----------|
| Negative Perception    | 8         | 0.075      | 2.79e-33 |
| Indifferent perception | 5         | 0.050      | 1.54e-38 |
| Neutral Perception     | 14        | 0.142      | 2.79e-22 |
| Optimistic Perception  | 28        | 0.275      | 7.10e-09 |
| Positive Perception    | 46        | 0.458      | 3.05e-01 |

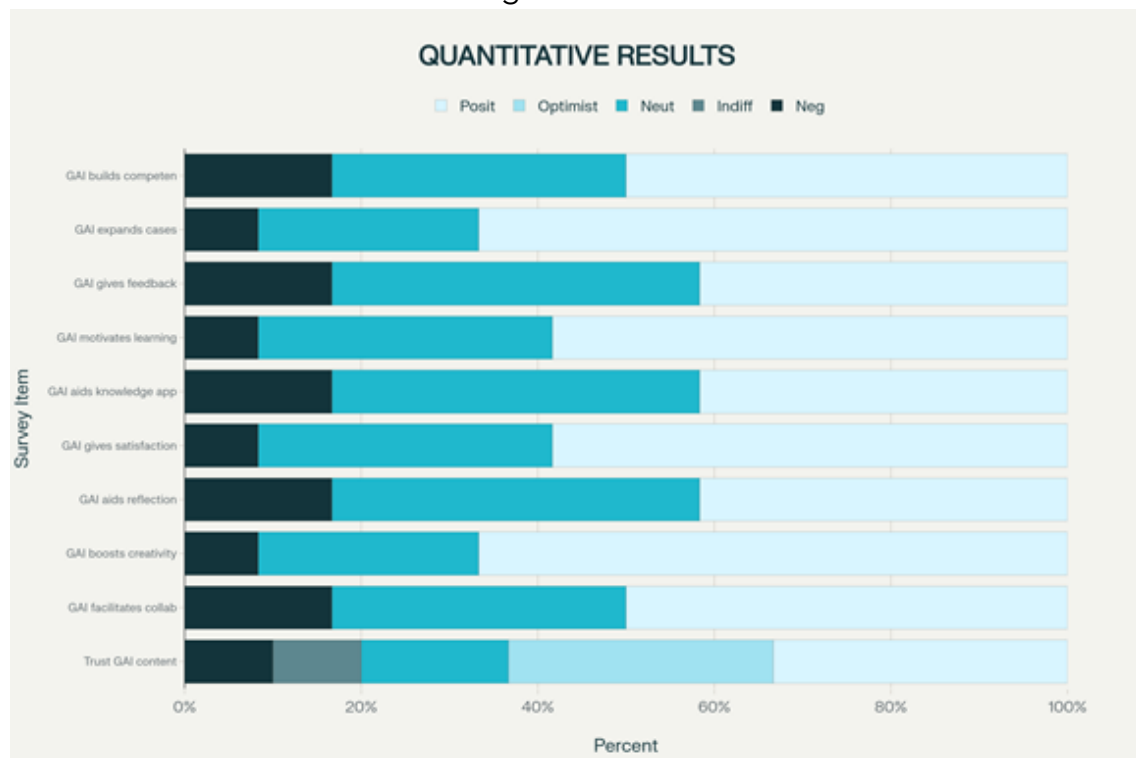
**Note.**  $\text{Chisq} = 136.667$ ,  $df = 4$ ,  $p\text{-value} = 0.000$

This distribution indicates that 73.3% of students held either positive or optimistic perceptions of GAI integration, supporting the findings of Chen et al. (2020) regarding the general acceptance of AI technologies in educational settings.

### Likert Scale Analysis: Specific Benefits and Challenges

Participant responses demonstrated significant agreement with statements valuing GAI benefits, consistent with the advantages identified by Lee et al. (2021) in their comprehensive review of AI applications in medical education. The most notable positive responses included in Figure 1

**Figure 1.** Transforming education through generative



The areas showing moderate agreement levels included immediate and personalized feedback (46%) and learning customization capability (46%), suggesting that while students recognize these benefits, there may be room for improvement in implementation strategies (Hwang et al., 2020).

Significantly, only 10% of respondents indicated disagreement with statements assessing trust in GAI-generated content and its comparability with other sources. This finding suggests high confidence levels while simultaneously indicating a critical awareness of the need for verification of information quality and veracity, consistent with concerns raised by Mousavi Baigi et al. (2023) regarding content validation in AI-assisted learning.

### Qualitative Analysis: Semantic Categories and Student Voices

The qualitative analysis identified four primary semantic categories that emerged from student interviews, providing nuanced insights into the student experience that complement the quantitative findings. This approach aligns with mixed-methods research recommendations for comprehensive understanding of educational interventions (Charow et al., 2021).

**Table 2** *Correlation between semantic categories and dimensions of the Likert scale*

| DIMENSIONS    | CATEGORIES |             |            |              | Total |
|---------------|------------|-------------|------------|--------------|-------|
|               | Assessment | Recognition | Reflection | Difficulties |       |
| Motivation    | 48         | 24          | 0          | 0            | 72    |
| Competence    | 72         | 24          | 48         | 0            | 144   |
| Comprehension | 0          | 0           | 0          | 12           | 12    |
| Confidence    | 0          | 0           | 0          | 12           | 12    |
| Total         | 120        | 48          | 48         | 24           | 240   |

**Note.** Cramer's V value = 0.619, Chi-square Test results:  $\text{Chisq} = 276.000$ ,  $df = 9$ ,  $p\text{-value} < 0.001$ .

**Recognition Category:** Students consistently identified GAI as a novel tool previously unknown to them, with representative responses indicating surprise at its capabilities. The novelty aspect aligns with the rapid evolution of AI technologies in education, as documented by Ayuso del Puerto and Gutiérrez Esteban (2022). Students described GAI as applicable to clinical practice and capable of generating content fitting their specific needs and preferences, supporting personalized learning theories advocated by Zhang et al. (2023).

**Assessment Category:** Students characterized their GAI experience as rewarding, particularly appreciating access to clinical cases they would not have otherwise encountered. This finding addresses a critical limitation in

traditional medical education where clinical case variety is often constrained by institutional resources and patient availability. The immediate and personalized feedback capability was highly valued, consistent with educational research emphasizing the importance of timely formative assessment (Lee et al., 2021).

**Reflection Category:** GAI implementation prompted students to engage in metacognitive processes, reflecting on their own practice and identifying areas for improvement. This finding supports constructivist learning theories and suggests that GAI can serve as a catalyst for self-directed learning. Students reported enhanced understanding of concepts and relationships underlying clinical practice, increased awareness of their strengths and weaknesses, and improved autonomy in decision-making and problem-solving processes.

**Difficulties Category:** Despite overall positive experiences, students encountered specific challenges that warrant attention for future implementations. Concerns about trusting GAI-generated content emerged as a primary issue, reflecting the critical thinking skills necessary for medical practice (Mousavi Baigi et al., 2023). Some students experienced resistance from faculty members who did not value or support GAI use, highlighting the importance of comprehensive institutional support and faculty development programs (Charow et al., 2021).

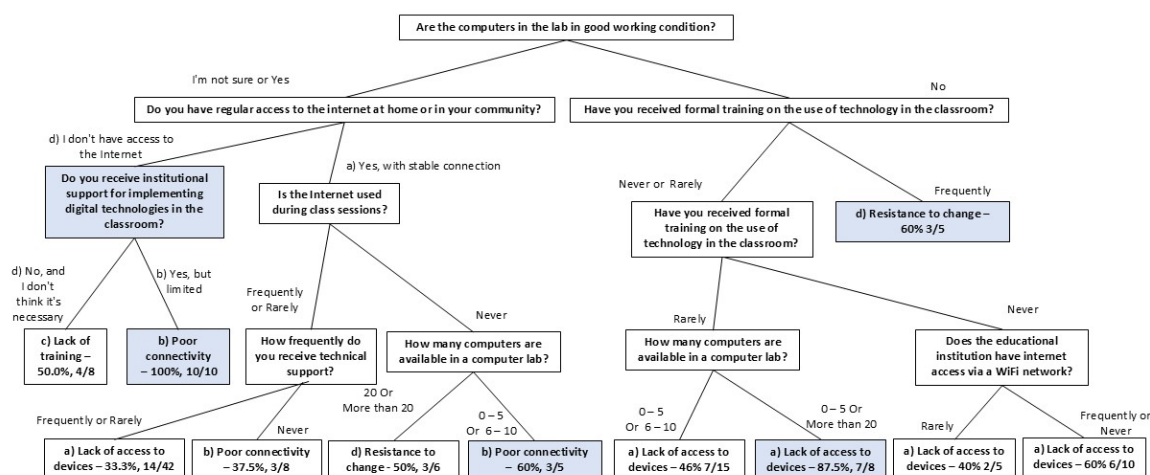
The Cramer's V measure of association (0.619) indicated a moderate to strong relationship between variables, with Chi-square test results (Chi-sq = 276.000, df = 9,  $p < 0.001$ ) confirming statistical significance. Specifically: Motivation and Competencies showed strong positive correlations with Assessment and Recognition categories, suggesting that when students recognize GAI's value and assess it positively, their motivation increases and they perceive competency improvements.

Understanding and Confidence were exclusively associated with the Difficulties category, indicating that implementation challenges primarily manifest in these domains rather than in motivation or competency areas. This pattern suggests that while GAI can effectively enhance student engagement and skill development, successful implementation requires careful attention to comprehension support and confidence-building measures.

## **Dimensional Analysis and Implementation Insights**

The qualitative analysis of GAI perception in clinical practice revealed positive overall assessments across all evaluated dimensions, with notable variations that provide implementation guidance: (see Figure 2).

**Figure 2:** Qualitative Analysis by Dimensions showing percentage distribution across competence, confidence, understanding, and motivation



- Competence: 75% favorable perception, indicating strong confidence in skill development capabilities
- Confidence: 55% favorable perception, suggesting moderate but improvable trust levels
- Understanding: 40% showing critical reflection, 40% demonstrating formal recognition of comprehension levels
- Motivation: 40% engaged in critical reflection, indicating active cognitive processing

The minimal difficulties reported (only 5% in Confidence and Understanding, none in Competence and Motivation) suggest that with proper support structures, GAI integration can be largely successful. This finding contrasts with some literature suggesting significant barriers to AI adoption in educational settings, possibly due to the structured implementation approach employed in this study.

These results align with broader studies examining AI's role in medical education while revealing unique insights specific to GAI implementation. The balance between optimism regarding skill improvement and concerns about content verification reflects the nuanced relationship between technology adoption and educational quality that has been identified in systematic reviews of AI in healthcare education.

The finding that students can maintain critical thinking while embracing AI assistance addresses concerns raised in the literature about potential over-

reliance on technology. The evidence suggests that when properly implemented with appropriate pedagogical frameworks, GAI can enhance rather than replace critical judgment skills, supporting the perspective advocated by educational technologists who emphasize complementary rather than substitutive roles for AI in education.

## Conclusions

This comprehensive investigation provides empirical evidence supporting the integration of generative artificial intelligence as an effective learning tool for undergraduate medical students' clinical practice. The findings demonstrate that GAI implementation yields positive impacts across multiple educational dimensions, including enhanced motivation, increased confidence, improved satisfaction, strengthened competencies, and expanded knowledge acquisition.

Students consistently identified GAI as a novel, applicable, useful, and transferable educational tool, expressing strong interest in continued future utilization. The technology's capacity to generate diverse clinical cases, provide immediate personalized feedback, and facilitate customized learning experiences addresses critical gaps in traditional medical education approaches. Furthermore, GAI's ability to stimulate creativity, critical thinking, and collaborative learning aligns with contemporary pedagogical best practices in medical education.

However, the study also identified significant challenges requiring careful consideration and strategic intervention. Student concerns regarding content trustworthiness highlight the necessity for robust verification mechanisms and quality assurance protocols. Faculty resistance to GAI adoption underscores the critical importance of comprehensive educator training and institutional support systems. Additionally, the identified need for enhanced technical infrastructure and user support mechanisms suggests that successful GAI implementation requires substantial institutional investment and commitment.

The correlation between motivation, competencies, and positive GAI assessment indicates that when properly implemented, GAI can serve as a powerful catalyst for enhanced learning engagement and skill development. Conversely, the association between understanding deficits, confidence issues, and implementation difficulties suggests that inadequate preparation or support can significantly undermine GAI's educational potential.

These findings align with broader literature examining AI's role in medical education, particularly regarding the balance between technological optimization and preservation of essential clinical judgment and practical skills development. The results support the implementation of GAI in medical education while emphasizing the critical importance of maintaining human oversight, ensuring content quality, and preserving opportunities for students to develop autonomous critical thinking capabilities.

Future research should focus on longitudinal studies examining GAI's long-term impact on clinical competency development, comparative analyses of different GAI tools and implementation strategies, and investigation of optimal integration approaches that maximize benefits while minimizing identified challenges. Additionally, research should explore standardization frameworks for GAI implementation in medical education to facilitate broader adoption and ensure consistent quality outcomes.

In conclusion, this study contributes valuable empirical evidence to the growing body of knowledge regarding GAI's potential in medical education, demonstrating both its significant benefits and the critical importance of thoughtful, well-supported implementation strategies. The findings suggest that when properly integrated with appropriate support systems, GAI can serve as a transformative tool for enhancing clinical education and preparing future physicians for an increasingly AI-integrated healthcare environment.

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