

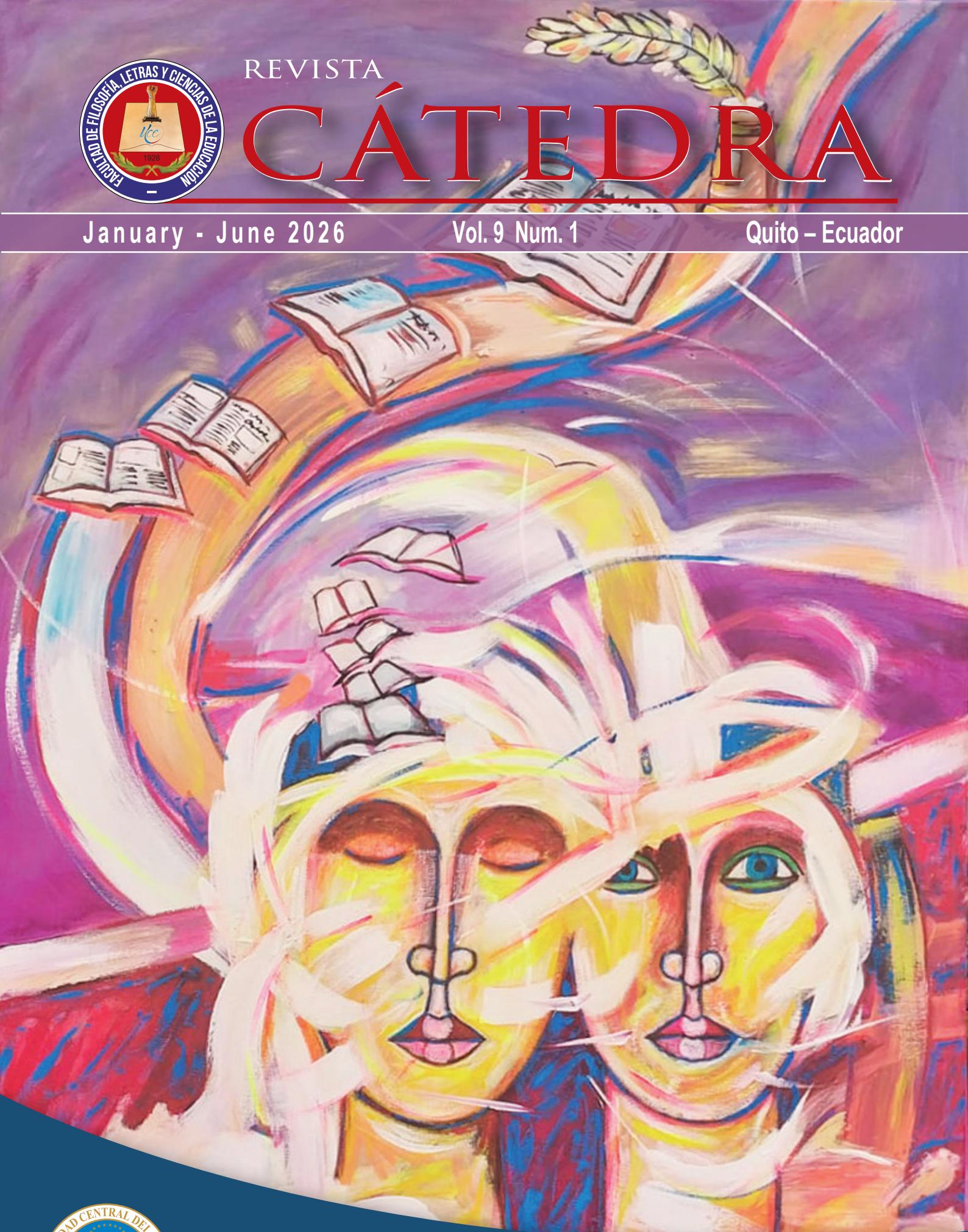


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La *Revista Cátedra*, which belongs to the Faculty of Philosophy, Letters and Education Sciences of Universidad Central del Ecuador has been a means of communication since 1992; the academic voice of the professors was expressed through the bulletins, whose relevant objective was to improve the educational quality based on their experience, wisdom and knowledge as professors forming other educators. On May 2018, Revista Cátedra reemerges as a space that creates and disseminates articles oriented to the improvement of the educational process and its linkage with society.

OBJECTIVE

To disseminate multidisciplinary scientific unpublished articles, elaborated under the parameters of the research methodology, written with academic rigor and based on the teaching practice.

TOPICS

The topics covered are the theoretical bases of the Education Sciences in its different specialties and levels of the educational system. Priority will be given to papers describing pedagogical experiences, didactics used, innovation processes, and their relationship with new educational technologies.

TARGET AUDIENCE

The Revista Cátedra is directed to all the national and international researchers interested in publishing quality works that contribute to the improvement of the educational process.

From its origins, the Revista Cátedra was published in printed format. It is currently published in electronic format, using virtual environments to align to the needs of the revista's users and editors.

MISSION

Cátedra Journal, of the Universidad Central del Ecuador, Faculty of Philosophy, Letters and Educational Sciences, publishes scientific articles on various areas of knowledge related to Educational Sciences, based on the methodology of educational research and community service.

VISION

To be promoters in the publication of high quality scientific articles that, guided by research and from different areas of knowledge linked to the Educational Sciences, become the most prestigious reference in the understanding and improvement of the educational process.

FOCUS AND SCOPE: Revista Cátedra has as its theoretical basis the Educational Sciences in its different specialties and levels of the educational system. Priority will



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be given to papers describing pedagogical experiences, didactics used, innovation processes, and their relationship with new educational technologies.

It disseminates scientific-academic articles constructed under the parameters of research methodology. It is open to national and international writers interested in contributing significantly to the solution of current educational problems.

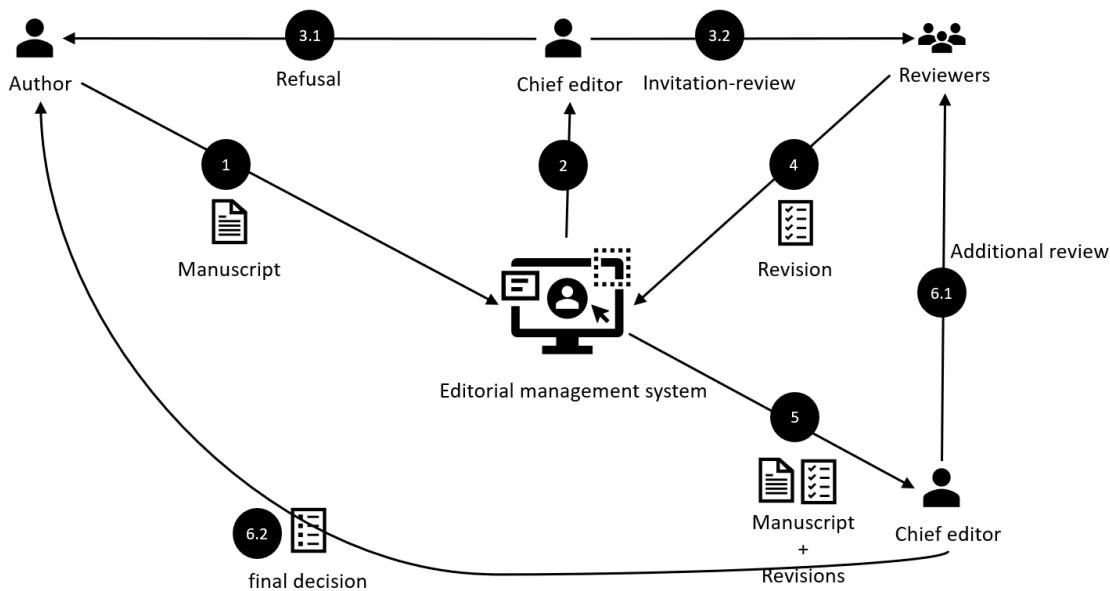
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- 3.2 Invite a set of reviewers to review the manuscript.
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EDITORIAL

It is an honor for the **Revista Cátedra** to present volume nine, number one in its electronic version. The topics covered are grounded in the theoretical foundations of Educational Sciences across its various specializations and educational levels. The journal presents some of the most relevant and noteworthy aspects of each academic work, addressing areas such as educational psychology, resources, and educational innovation.

The content presented in this new issue is characterized by its adherence to established research methodology. Furthermore, it is developed with academic rigor through blind peer review and grounded in teaching practice and theory.

This issue comprises eight accepted articles:

The first article, entitled "Comparison of two teaching methods in immunology for medical students: a quasiexperimental study with nonequivalent control group," is authored by Washington Paz-Cevallos, Marcos Jiménez-Córdova, Mary Ordóñez-Asanza, and Teresa Haro-Blacio. The main objective was to compare the effectiveness of chalk talk and slide presentation teaching methods in the short and medium term. The main results of this research show that the chalk talk group improved from a pre-intervention average score of 5.07 ± 2.76 to 12.92 ± 3.86 post-intervention and achieved a score of 8.33 ± 3.68 one week later ($p < 0.05$). The slide presentation group improved from 6.06 ± 3.29 to 8.76 ± 3.19 post-intervention, with a score of 6.93 ± 3.57 in the assessment one week later ($p < 0.05$). The authors conclude that the chalk talk method is more effective than slide presentation in the short and medium term for teaching medical students, regardless of IQ or gender.

The second article, titled "Artificial Intelligence and the Teaching Process for Economics Students," was authored by Santiago Vinuela-Vinueza and Alejandra Fonseca-Factos. The central objective of this work was to analyze how the integration of AI influences pedagogical strategies and the construction of knowledge among future professionals in the field of economics. The main findings highlight that, although students demonstrate a moderate level of ethical awareness, gaps persist in their comprehensive understanding of some theoretical constructs related to the ethical use of AI. The study concludes that it is necessary to incorporate specific content into training programs aimed at strengthening ethical awareness in the use of these technologies.

The third article, titled *Emotional Exhaustion and Teaching Performance: An Approach to Burnout Syndrome in University Professors*, was authored by Esteban Bozano-Rivadeneira, Johanna Bustamante-Torres, Brittanny Arrobo-Guayllas, and Heydi Hugo-López. The main objective of this research was to analyze the influence of burnout syndrome on the performance of university teachers. The main findings reveal significant associations between the dimensions of burnout syndrome (BS) and teaching performance, highlighting personal accomplishment as a key protective factor: moderate negative ratings with emotional exhaustion ($r=-0.317$, $p=0.001$) and depersonalization ($r=-0.353$, $p<0.001$), and



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weak positive ratings with performance ($r=0.248$, $p=0.009$). The authors conclude that BS depends on multicausal factors, with personal accomplishment as the main preventative, enhanced by vocation and experience, which improve emotional regulation, performance, and interactions with students.

The fourth article, *Incidence of GeoGebra software in the teaching-learning process on the derivative in the Second Year of Unified General Baccalaureate*, authored by José Luis Gallo-Calero, Andrés Almeida-Flores, Diego Zavala-Urquiza, and Edwin Vinicio Lozano. The main objective of this article is to demonstrate the impact of educational software on the teaching-learning process of students, since in Ecuador there is a traditional methodology that is minimally oriented towards the digital field within education. The main results show that the use of GeoGebra enhances student learning, as evidenced by higher grades among those who used the software. The study concludes that the application of this free software benefits institutions by improving learning outcomes.

The fifth article, *Use of the Educaplay Educational Platform in the Literacy Process of Primary Education Students (ISCED Level 1)*, authored by Elizabeth Pesantez-Carmona and Diana Cevallos-Benavides, addresses a literacy problem. To this end, a pedagogical intervention based on the Technological Knowledge model was designed. Pedagogical Content and Learning Framework (TPACK) focused on constructivism. The main results are that the interactive activities designed in Educaplay significantly increased aspects such as attention, motivation, and academic performance of students, especially in phonological and syllabic skills and reading comprehension. The authors conclude that the pedagogical intervention, based on the global-analytical approach and the development of linguistic awareness and reading comprehension in early stages, combined with the appropriate use of interactive activities on the Educaplay platform, promotes meaningful learning.

The sixth article, titled *Artificial Intelligence (AI) and its use in creative writing*, is authored by Manuel Villavicencio-Quinde, Alison Fajardo-Martínez, and Alejandra Suárez-Rivas. This research aims to analyze the ability of this tool to produce short fictional texts compared to the creative process of students. The main findings are that AI consistently replicates traditional writing styles at both the structural and content levels; in contrast, the stories created by students demonstrate greater richness and diversity in their construction. The authors conclude that classroom experiences, not only those related to writing, should be transformed into opportunities to learn and rekindle students' creative drive, so that the overwhelming presence of AI becomes not a threat, but an ally in the collaborative learning process.

The seventh article, titled *The quantitative and qualitative rubric in algebraic operations learning assessment in students of eighth year of general basic education*, is authored by Diego Tipán-Renjifo, Edgar Cazares-Fuentes, and Edgar Freire-LLive. This research addresses how the use of comprehensive assessment instruments improves the learning process and the accuracy of algebraic problem-solving. The main findings indicate shortcomings in the use of rubrics due to a lack of information and descriptors to guide the assessment process. The aim is to achieve a detailed understanding of learning outcomes,



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shift the focus from simply evaluating to truly valuing, and foster changes in motivation and participation. The authors conclude that assessment processes in algebraic operations are mechanical, based on solving exercises in anticipation of a good grade, neglecting the purpose of a comprehensive evaluation that involves student participation.

Finally, the eighth article *Integration of gamification into the andragogical process of the physics area for intensive evening high school students*, by Diana Pinos-Maldonado and Diana Cevallos-Benavides, is presented. This study aims to analyze the low academic performance, lack of motivation, and limited participation of adult and senior citizens with incomplete schooling in the Physics course within the intensive evening high school program. The results showed a significant improvement in motivation, conceptual understanding, active participation in the classroom, collaborative work, and the development of critical thinking. The authors conclude that contextualized and accessible gamification proved capable of transforming the teaching-learning process, fostering meaningful and resilient knowledge.

Revista Cátedra thanks all the authors and reviewers who made the publication of this issue possible. It also invites the national and international academic community to submit their research related to Educational Sciences in its various specializations and educational levels.

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Comparison of two teaching methods in immunology for medical students: a quasiexperimental study with nonequivalent control group

Comparación de dos métodos de enseñanza en inmunología para estudiantes de medicina: estudio cuasiexperimental con grupo de control no equivalente

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Abstract

The chalk talk and slide projection methods in biomedical science lectures show differences in student learning in the short and medium term, which impacts future therapeutic decision-making in favor of the patient. A 2017 study by the Faculty of Medical Sciences at the Central University of Ecuador reported that 50% of students did not fully understand the lectures. Therefore, a quasi-experimental operational study with a non-equivalent control group was conducted with first-semester medical students during the 2024-2025 academic year to compare the effectiveness of both methods in short- and medium-term learning. Participants were assigned to the interventions: chalk talk and slide projection; and received a Basic Immunology lecture using the respective methodology. Each group was evaluated before, immediately after, and one week after the lecture. The level of learning was estimated using a 20-point test specific to the course. The chalk talk group improved from a pre-intervention mean score of 5.07 ± 2.76 to a post-intervention mean score of 12.92 ± 3.86 and scored 8.33 ± 3.68 one week later ($p < 0.05$). The slide group improved from a pre-intervention mean score of 6.06 ± 3.29 to a post-intervention mean score of 8.76 ± 3.19 , with a score of 6.93 ± 3.57 one week later ($p < 0.05$). It was concluded that the chalk talk method is more effective than slide projection in the short and medium term for teaching medical students, with no influence from IQ or gender.

Keywords

Chalk talk, slides, teaching, quasi-experimental, immunology, medicine, blackboard.

Resumen

Los métodos chalk talk y proyección de diapositivas en clases magistrales de ciencias biomédicas muestran diferencias en el aprendizaje de los estudiantes a corto y mediano plazo, lo que repercute en la futura toma de decisiones terapéuticas a favor del paciente. En un estudio de la Facultad de Ciencias Médicas de la Universidad Central del Ecuador en 2017, se reportó que el 50% de estudiantes no comprendía totalmente las clases magistrales. Por ello, se realizó un estudio operativo cuasiexperimental con grupo de control no equivalente, en estudiantes de medicina de primer semestre periodo académico 2024-2024, con el objetivo de contrastar la efectividad de ambos métodos en el aprendizaje a corto y mediano plazo. Los participantes se distribuyeron a las intervenciones: chalk talk y proyección de diapositivas; y, recibieron una clase de Inmunología Básica con su respectiva metodología. Se evaluó cada grupo antes, inmediatamente después y una semana luego de la clase en cada grupo. Se estimó el nivel de aprendizaje con test propios de la cátedra sobre 20 puntos. El grupo chalk talk pasó de un promedio preintervención de 5.07 ± 2.76 a 12.92 ± 3.86 postintervención, y obtuvo 8.33 ± 3.68 una semana después ($p < 0.05$). El grupo diapositivas pasó de 6.06 ± 3.29 a 8.76 ± 3.19 postintervención, con 6.93 ± 3.57 en la evaluación una semana posterior ($p < 0.05$). Se concluyó que el método chalk talk es más efectivo que la proyección de diapositivas a corto y mediano plazo en la enseñanza a estudiantes de medicina, sin influencias por coeficiente intelectual o sexo.

Palabras clave

Chalk talk, diapositivas, enseñanza, cuasiexperimental, inmunología, medicina, pizarra.



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1. Introduction

Education is understood as an act of “instruction through teaching” (Royal Spanish Academy, 2025). It is a process that unfolds across different levels, from primary school to higher education, each with its own strategies and goals, though always involving both teachers and students (Biesta, 2020, p. 89). Beyond preparing individuals to integrate into society, education seeks to foster lasting learning, providing tools for individual and collective professional development. Flores et al. state that teachers must be constantly updating their skills; professional careers such as medicine and nursing, for example, require mastery of the physiological functioning of the human body through the basic biomedical sciences learned at the undergraduate level (Flores et al., 2021).

The central problem addressed in this study is the variability in the effectiveness of chalk talk and slide projection models in teaching basic biomedical sciences. Although both methods are widely used, some authors, such as Parashar et al. (2018), suggest that “a disadvantage of PowerPoint appears to be that the student becomes a passive observer rather than an active participant” (p. 4). However, opinions are divided. Saca and Tituña (2016) maintain that this same technique “encourages students to take initiative in their own learning” (p. 23).

Therefore, this operational study was conducted to analyze and compare the effectiveness of these two pedagogical models to determine which offers a greater advantage in the teaching and learning process of basic biomedical sciences. Specifically, it focuses on basic immunology in first-semester medical students, considering sex and IQ range as moderating variables.

Regarding the structure and content of the article, the second section delves into a literature review of the available information on teaching and learning models. The third section describes the materials, subjects, and methods used for the operational experiment. The fourth section details the results obtained from the interventions. The fifth section compares these results with those found in similar studies and presents a discussion and conclusion.

2. Literature review

2.1 The teaching and learning process

“The teaching-learning process is conceived as a deliberate communication system that involves the implementation of pedagogical strategies to foster learning” (Osorio et al., 2021, p. 2). In this context, teaching is understood as the guidance and instruction provided by a teacher through pedagogical strategies; while learning is a dynamic and continuous process through which the student receives, modifies, or strengthens knowledge, skills, and practices. This process involves both neurobiological mechanisms and contextual and emotional factors.

Authors such as Rochina et al. state that the teaching-learning process establishes a network of complex interactions that include the relationships between teacher and student, among students, between the student and knowledge, and between the student and their practical environment. These interactions reflect that learning is not limited to the simple transmission of information from teacher to student, but rather is a collective process involving multiple theoretical, practical, and relational factors. Currently, based on the teacher's role, some authors assert that these activities are carried out in groups, with an approach that integrates theory, practice, and social interaction within the classroom. They



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also state that, in general, knowledge construction is based on problem-solving, which fosters both the individual and collective development of the participants (Rochina, et al., 2020, p. 388).

The teaching-learning process naturally involves various actors and elements. Among the human factors, the teacher and the student stand out. The teacher is responsible for planning, organizing, and facilitating learning through appropriate pedagogical strategies. They must carry out the didactic act, which is "the concrete realization of the teaching process; that is, the materialization of said process in time and space" (Meneses, 2007, p. 61). Their role not only involves the transmission of knowledge but also the guidance, evaluation, and constant updating of their methodologies. For their part, students are ideally active agents in their own learning, responsible for assimilating, analyzing, and constructing their own knowledge, developing research and critical thinking skills.

Meanwhile, the non-human elements that influence this process are content, tools, and context. Content encompasses the educational objectives and the theoretical and practical knowledge imparted, as well as fundamental values and attitudes, such as effort, reflection, and decision-making. On the other hand, according to Vargas, tools include diverse teaching strategies and resources, such as reading, writing, oral expression, problem-solving, research, and collaborative work (Vargas, 2017). And the context, which is conditioned by factors such as physical space, the number of students, the availability of economic and educational resources, as well as external aspects such as stress or fatigue, can affect academic performance.

Meneses also raises other non-human elements, such as educational resources, which play a key role in teaching, as they facilitate student understanding and interest. These resources include printed texts, audiovisual materials, interactive whiteboards, and information and communication technologies. In particular, interactive whiteboards, such as the traditional blackboard and interactive materials, as well as the use of slides and audiovisual content, are widely used tools in current educational processes (Meneses, 2007, p. 32). Consequently, if the focus is on higher education, pedagogical and andragogical models play a leading role among teaching strategies; the existence of several models has "created confusion among teachers and administrators, since they all refer to education" (Correa & Pérez, 2022, p. 131). There are several pedagogical approaches that describe how the teaching-learning process is carried out. Therefore, when compiling the attitudes and practices of university classes, the authors, citing Zubiría, ultimately classify pedagogical models into three main approaches: "self-structuring, intra-structuring, and hetero-structuring" (Correa and Pérez, 2022, p. 131).

2.1.1 Self-structuring current

The self-structuring approach is based on the idea that "the student develops autonomously as the artisan of their own learning, being the core and sole agent of didactic transposition" (Not, 1992). In other words, the student transforms the technical knowledge obtained through their arduous research into assimilable or less specialized concepts, thus retaining the new knowledge and even sharing it with others, becoming the student's own educator on the subject. Dupouy argues that this approach includes theories such as social cognition, active learning, information processing theory, and constructivism. He mentions that these theories highlight the importance of the student's active and personal participation, experimentation, and lived experience for understanding knowledge. It also considers the student's individual characteristics, differentiating traits, and their particular concepts about situations, words, phrases, and facts (Dupouy, 2023).



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To achieve this, according to Vergara and Cuentas, students should be encouraged to acquire knowledge through observation, processing of new information, and application in practical situations, progressing from simple to complex concepts based on their own experience, thus making the student the architect of their own knowledge construction (Vergara and Cuentas, 2015, p. 918). However, this approach can be influenced by the institution, impacting the creation or reconstruction of knowledge. In the classroom, teachers will use methods according to the student's interests, needs, and motivation, fostering in them a desire to investigate a particular topic independently.

2.1.2 Infrastructural current

According to Dupouy, the focus of this approach is on personalized learning, adapting the educational process to the individual characteristics of students to optimize their understanding (Dupouy, 2023). According to Gómez et al., it centers on combining active roles for both students and teachers, emphasizing guided reflection and thus ensuring the participation of both parties in the process. Following this proposed norm, this approach is considered an intermediate point between the self-structuring approach described earlier and the heterostructural approach described below (Gómez et al., 2019, p. 173).

2.1.3 Heterostructural current

In this approach, the teacher plays a central role in the transmission of information, using repetitive and expository methods to ensure comprehension of the content. Furthermore, every effort is made to break down the information so that the learner can reintegrate it, thus understanding the concepts conveyed. These are heterostructuring models whose objective is the transmission of specific knowledge, values, and culturally and socially accepted norms. According to Gómez et al., this classification includes pedagogical models such as connectionism, classical behaviorism, continuity conditioning, operant conditioning, and the traditional school (Gómez et al., 2019). Correa and Pérez analyze the proposal of teacher Julián De Zubiría, whose work advocates the transmission of knowledge, values, and cultures accepted by society. Moreover, the traditional pedagogical model, which includes lectures, is a representative example of this approach (Correa & Pérez, 2022, p. 131).

In higher education, especially in basic biomedical sciences training, different pedagogical methods are used to enrich the teaching process under the hetero-structuring approach, in which the teacher serves as a presenter of information with the help of tools that guide their teaching. "A blackboard is exceptionally effective as a teaching tool in the classroom and has been frequently used in classes, while the use of transparencies with an overhead projector is also popular" (Parashar, et al., 2019, p. 4). Petimani and Adake state that Chalk Talk consists of the use of a blackboard by the professor to illustrate ideas in real time through diagrams, drawings, or keywords. The teacher uses markers or liquid chalk to illustrate the content while communicating with the students. This technique is valuable, allowing for dynamic interaction and giving students the opportunity to take notes and analyze the information as it is presented. Furthermore, the flexibility of chalk talk to adjust the explanation based on the group's response and the possibility of making gradual corrections make it particularly valuable in medical training, where a deep understanding of complex concepts is crucial (Petimani & Adake, 2015).

Slide Projection: This refers to a method that uses a video projector to display a series of slides prepared beforehand with programs such as Microsoft PowerPoint, Canva, Slidesgo, and others. While this approach can be more efficient in terms of content preparation and



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organization, it can limit the time available for detailed explanation. "The professor prepares photographic slides and distributes them to the students before class. They show the PPT slides and explain the important points during the class" (Petimani & Adake, 2015, p. 290).

2.2 Education in health areas

Medical education has not always been as it is known today; like most processes in our environment, it has undergone a series of transformations at the institutional, regional, and global levels. Just a few centuries ago, the level of technology that exists today as a support and teaching tool for those aspiring to become doctors, nurses, or artists was the stuff of science fiction. The following is an overview of the evolution of teaching practices in the medical field.

2.2.1 Historical review of medical education

With the formation of the first population groups and cultures of the ancient world, valuable documentation began of various acts that can be considered the foundations of human medicine, starting with the recording of information that for decades had only been transmitted verbally and practically from master to apprentice. "The first records of medical teaching exist in ancient Sanskrit. They provide detailed information about the training of physicians" (Fiddes, 2024). Fiddes makes a particular clarification: at that time, the main and most famous school of thought was the "Corpus Hippocraticum," considered the pinnacle of medical education. Within this corpus, the Hippocratic Oath was implemented over the years, emphasizing respect for those who were the pupil's teachers in medical training. Galen not only revolutionized the teaching of students but also generated one of the most remembered and widely used teaching practices today: bedside teaching. Thanks to this renowned philosopher, surgeon, and physician, those trained in medicine became known as physicians (Fiddes, 2024).

According to the renowned historian Pilar Cabanes, later, in the Middle Ages, medical education was managed by monasteries and certain emerging universities. In the 11th century, in Italy, the Salerno School initiated a process of formalizing medical education by incorporating ancient Greek and Arabic texts. Gradually, figures from the Islamic world, Bologna, and Paris focused on the study of specialized branches: physiology, anatomy, etc. (Cabanes, 2023). However, medical practices remained, at the very least, bloody, disturbing, and largely experimental. There was no clear boundary between the practice of healing and the art of learning; the latter likely involved actions that could contradict the former.

It wasn't until the Scientific Revolution in the 16th century that the approach to medicine changed. Renowned physicians like the Belgian Andreas Vesalius contributed fundamental knowledge to anatomy through an extensive program of dissecting human body parts, providing information that facilitated a more accurate understanding of the human body's architectural structure. "The young Vesalius delved deeper into Galen's studies and found that his anatomical descriptions did not agree" (Santillán, 2019, para. 7). During this same period, the importance of research and experimentation as a source of new information was emphasized. On the other side of the globe, in the New World, the Americas, medicine was in its infancy. The continent was in a transition from pre-Columbian practices to the new cultural impositions of the conquerors. After several years of expansion, invasion, and colonization in the territories under the rule of the Spanish Crown, the territory that is now Ecuador, then known as the Royal Audiencia of Quito, was the subject of a proposal to establish a medical school, thanks to the Dominican friars:



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The initial idea of establishing medical studies in Quito originated with the Dominican friars. Friar Ignacio de Quesada clearly recognized that university education needed less theologians, canon lawyers, rhetoricians, and Latinists, and more physicians. He engaged his community and, with their help, organized a Faculty of Medicine at the Royal University of Saint Thomas Aquinas of the Dominican Order in Quito, founded in 1688. This faculty included a three-year curriculum and two professors. By Royal Decree of April 13, 1693, the first Chair of Medicine in Quito was established there, in the Dominican convent of San Fernando (Estevez et al., 2018, p. 149).

According to Estevez's own research, throughout the history of this medical school, there have been a series of changes in the educational structure. Initially, the program was three years long. Over the years, many distinguished physicians were trained within its walls, one of the most renowned being Dr. Francisco Javier Eugenio de Santacruz y Espejo. A native of Quito, he was highly regarded for his fight against the marginalization of historically excluded social groups, his critique of the university system, and his scientific contributions to Ecuador's health regulations at that time (Estevez, 2018, p. 151).

In recent history, amidst political and ideological struggles, the Faculty of Medicine continues to train professionals in medicine and surgery. The Faculty of Medical Sciences has experienced "changes in the educational systems themselves and in social, economic, productive, ecological, political, cultural, scientific, technological, philosophical, and human structures" (Barros et al., 2018, pp. 77–78). Estevez et al. recount that the teaching of basic medical subjects such as anatomy was based on the direct observation of dissected cadavers in the anatomy theater. In these classrooms, at least one hundred students received lectures from a single professor. For clinical subjects, bedside teaching remained the foundation; moreover, the correct execution of the medical history was paramount. Amidst disputes regarding its proper preparation, an important bibliographic work was established at the Faculty: the Medical Examination, by Dr. Carlos Guarderas in 1982 (Estevez et al., 2018, p. 151).

2.2.2 Pedagogical models used in current medical teaching

Medical education is one of the settings where the pedagogical models contained within the hetero-structuring approach are commonly applied. Medical schools, such as the one mentioned earlier, use both the chalk talk model and the slide projection model for lectures. However, the effectiveness of these methods in teaching basic biomedical sciences, such as immunology, is still a subject of debate.

Saca and Tituña conducted a cross-sectional analytical epidemiological study between 2016 and 2017 at the Faculty of Medical Sciences of the Central University of Ecuador, regarding the pedagogical models used by nursing faculty. They found that 50% of faculty members who teach rotating internships consider memorization of concepts important. Meanwhile, 50% of students did not fully understand the lectures, citing some problem with content retention and comprehension (Saca & Tituña, 2017). This finding highlights the need for further investigation into the efficacy and effectiveness of different pedagogical methods in biomedical science education and their relevance to student learning.

In addition to considering the lecture-based methodologies employed, Reyes et al. analyze the students' sex and IQ range as moderating variables. According to a 2019 study by the Eloy Alfaro Lay University of Manabí, both men and women have a reflective learning style. However, individual differences may exist between the two genders, modifying their



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learning styles. It was observed that women are more active and practical in completing tasks, which may lead to higher scores on academic assessments. The study also found that women may be more skilled in perceptual speed, verbal fluency tests, manual dexterity, and mathematical calculation; while men perform better in spatial tasks, motor skills, and mathematical reasoning. However, it is worth clarifying that there are not enough studies to demonstrate that one sex has a greater learning capacity than the other (Reyes et al., 2019, pp. 48-50).

Similarly, intelligence quotient (IQ) could affect or influence the learning process. Aravena et al., in an analytical cross-sectional epidemiological study, concluded that, as an assessment of multiple domains, IQ is understood to influence the teaching-learning process depending on the approach and model used. This is why this and other studies have shown that in cases of moderate IQ deficiency, academic performance decreases, while with a normal or average IQ, there are no significant differences between individuals (Aravena et al., 2017).

3. Materials and methods

A quasi-experimental operational study with a non-equivalent control group was conducted to compare two pedagogical methods for teaching basic immunology to first-semester medical students at the Faculty of Medical Sciences of a public university in Ecuador. Four of the eight parallel sections of first-semester students were randomly selected for the study. The implications of participating in the project were explained to the students beforehand, so that they could voluntarily sign informed consent forms, along with providing basic information required for identification within the study. Participants were students over 18 years of age, enrolled in the first semester of medicine, with regular class attendance, who agreed to participate in the study and receive the educational intervention. Those who did not complete the pre-intervention and post-intervention questionnaires, did not attend the class (intervention), or had previously taken the course were excluded. Participant information was collected in person using printed forms.

In addition to the identification data according to Wang et al., the survey technique was applied to estimate IQ range using a psychometric test, Raven's Progressive Matrices Test, which measures educational intellectual reasoning ability; that is, reasoning, planning, cognitive flexibility, decision-making, abstraction, and complex problem-solving. Based on this, it estimates an individual's IQ range on a scale from Range I (Superior) to Range V (Poor) (Wang et al., 2019, p. 6441). It does not represent overall intelligence quotient and was administered using each participant's mobile device.

The sample size was estimated using a statistical calculation for two proportions based on an estimated difference in effectiveness of 0.60 versus 0.30 between the interventions. The study by Petimani was used as a reference, resulting in a minimum of 50 participants per group to ensure statistical significance (Petimani & Adake, 2015, p. 292). Based on this criterion, two of the four sections were randomly assigned to the experimental group (chalk talk class) and the remaining two to the control group (slides class).

The intervention, implemented during the 2014-2015 academic period, was delivered by the same instructor to both groups. Each session lasted 50 minutes and included an introduction to the topic, objectives, lesson development, and questions. Each group underwent three assessments: before the intervention, immediately after, and one week later, with strict monitoring to prevent cheating on the tests. Knowledge tests validated by the histoimmunology department of the same institution were used to estimate the level of



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knowledge. Each test consisted of 10 multiple-choice questions, each with 5 options, only one of which was correct. The study adopts a quantitative approach.

A traditional pedagogical model, similar to lectures, was implemented with two variations: one using chalk talk techniques and the other using slide presentations. During the chalk talk intervention, the instructor used only an enameled steel whiteboard (1.20 x 2.40 m) and dry-erase markers; no images were projected. In contrast, the control group received PowerPoint slides, limited to a maximum of seven lines of text per slide and without animations; these were projected on a 100 x 56 in image by an Epson S18+ projector. The intervention took place in a classroom with a capacity of 100 people, with tiered seating at an average distance of 5 meters from the presentation.

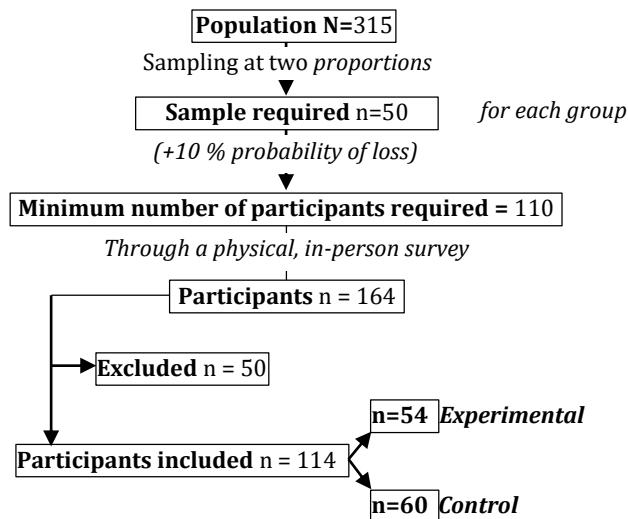


Figure 1. Sampling and allocation of study participants

The data were managed in both physical and electronic formats, collected using questionnaires printed on A5 bond paper with text in 12-point Arial font, and analyzed using Microsoft Excel and SPSS version 18.0.0. The results were anonymized with alphanumeric codes. The statistical analysis included the description of the qualitative variables sex and intellectual range (IQ) using absolute frequency, relative frequency, and the respective 95% confidence interval; Student's t-test for differences of proportions between independent groups was used to compare these data. To compare the learning level before, after, and one week after the intervention, for each study group, the scores were compared using medians, ranges, and respective 95% confidence intervals; and, for the pre-post inferential analysis in the same group, the Friedmann test was used.

For the intergroup analysis, means, standard deviations, and respective 95% confidence intervals were used. For inferential analysis, Student's t-test for the difference of means between independent groups with homogeneous variance was used. Results were compared before, after, and one week after the interventions, after the Kolmogorov-Smirnov test had been used to determine data normality. To compare the results of the two groups (experimental and control) and to verify the intervention's effect on the moderating variables of sex and IQ score, the Mann-Whitney U test was used, following the same comparison logic described above. Results were considered statistically significant as long as $p \leq 0.05$.



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The study complies with the ethical principles of the Declaration of Helsinki and the Nuremberg Code, guaranteeing the confidentiality of information and obtaining informed consent from participants. The study was conducted in accordance with current legislation and regulations.

Moderating variables	Chalk talk	Slides	p
N	54	60	
Gender			
Men	17 (31.5 %)	17 (28.3 %)	0.719
Women	37 (68.5 %)	43 (71.7 %)	0.719
IQ Range			
I-II	28 (51.9 %)	41 (68.3 %)	0.072
III-IV-V	26 (48.1 %)	19 (31.7 %)	0.072

Table 1. Comparison of sex and IQ range between chalk talk group and slides

4. Results

Of the 164 participants included in the study, 50 met one or more exclusion criteria, leaving 114 who completed all phases of the study. Of these, 54 were in the experimental group and 60 in the control group, as shown in Figure 1. These participants received the intervention in their assigned group, were assessed at three time points, and provided complete information.

The experimental group (n=54) consisted of 17 men (31.5%; 95% CI: 20.7-44.7%) and 37 women (68.5%; 95% CI: 55.3-79.3%) [p>0.05]. 28 (51.9%; 95% CI: 38.9-64.6%) were part of Intellectual Range I and II, and 26 (48.1%; 95% CI: 35.4-61.1%) were in range III, IV and V [p>0.05]. Meanwhile, the control group (n=60) consisted of 17 men (28.3%; 95% CI: 18.5-40.8%) and 43 women (71.7%; 95% CI: 59.2-81.5%) [p>0.05]; 41 (68.3%; 95% CI: 55.8%-78.7%) were in Intellectual Range I and II, and 19 (31.7%; 95% CI: 21.3%-44.2%) were in Range III, IV, and V [p>0.05]. These data are presented in Table 1.

In the experimental group (chalk talk), scores out of 20 were measured pre-intervention (O1), post-intervention (O2), and one week later (O3); all these measures are presented in Table 2. The mean O1 score was found to be 5.07 ± 2.77 (95% CI: 4.34-5.81), and the mean O2 score was 12.93 ± 3.86 (95% CI: 11.90-13.96). and the mean O3 score was 8.33 ± 3.68 , 95% CI: 7.35-9.32.

In the control group (slide presentation), scores out of 20 were measured pre-intervention O4, post-intervention O5, and one week later O6; all these measures are shown in Table 3. The mean O4 score was found to be 6.07 ± 3.29 , 95% CI: 5.23-6.90; the mean O5 score was 8.77 ± 3.19 , 95% CI: 7.96-9.57; and the mean O6 score was 6.93 ± 3.58 , 95% CI: 6.03-7.84.



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Chalk Talk	01	02	03
N	54	54	54
Average	5.07	12.93	8.33
DE	2.77	3.86	3.68
EEM	0.38	0.53	0.50
Minimum Value	0	6	2
Maximum Value	12	20	18
Lower Limit	4.34	11.90	7.35
Upper Limit	5.81	13.96	9.32

Table 2. Test results of the experimental group experimental0

Slides	04	05	06
n	60	60	60
Average	6.07	8.77	6.93
DE	3.29	3.19	3.58
EEM	0.43	0.41	0.46
Minimum Value	0	2	0
Maximum Value	12	16	16
Lower Limit	5.23	7.96	6.03
Upper Limit	6.90	9.57	7.84

Table 3. Test results of the control group

In the statistical analysis of scores between interventions, no statistically significant difference was found between the means 01 and 04 ($p>0.05$). However, a statistically significant difference was found between the means 02 and 05 ($p<0.05$); and one week later, the means between 03 and 06 remained statistically different ($p<0.05$). The aforementioned means and their 95% confidence intervals are shown in Figure 2. All these results assume that the data were not broken down by sex or age.

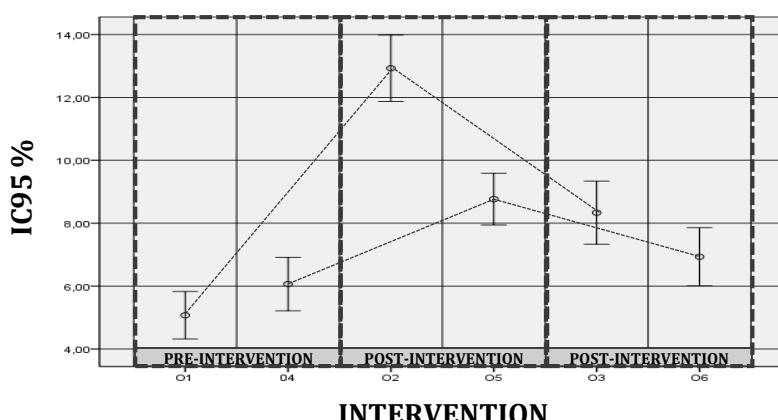


Figure 2. Averages of the six observations (01-06), with their 95% CI
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Observations 02 and 05, conducted only on men, indicate that the medians are different ($p<0.05$), as do the medians of observations 02 and 05 in women ($p<0.05$). Observations 02 and 05, conducted only on individuals with IQ Ranks I and II, indicate that the medians are statistically different ($p<0.05$). Similarly, the medians of 02 and 05, conducted only on those with IQ Ranks III, IV, and V, are also statistically different ($p<0.05$).

5. Discussion and conclusions

This study aimed to determine the effectiveness and efficiency of chalk talk and slide presentations in basic biomedical sciences. The collected data indicate a statistically significant superiority of chalk talk over standard slide presentations. These findings align with those of Asian Diphu University in 2021; as noted by Putul, medical students in the microbiology department reported a better learning experience with chalk talk (97%) compared to PowerPoint (86%) (Putul et al., 2021, p. 471). However, Lagare et al. point out data from a descriptive study conducted at Sankalchand Patel University in 2023, in which 54% of students reported a better academic experience with slide presentations compared to 46% who preferred the blackboard. It should be noted that, in this case, the presenters were not faculty members, but students during a pharmacology seminar (Lagare et al., 2023, p. 856).

On the other hand, Brown et al. state that the control material used in this study was inanimate; the differences may be partly explained by this lack of animation. This is based on the results of a study conducted by Brown in 2022 at the University of Hawaii School of Medicine, USA, which demonstrated that virtual animations in teaching medical residents were superior to chalk in learning pharmacological therapy for diabetes (Brown et al., 2022, p. 2256). It is also possible that the observed differences depend not only on the overall teaching format but also on the interactivity the methodology allows: students who actively interact with the material (discussing cases, answering questions, working in teams) retain and apply the content better than those who receive a passive lecture. In a randomized crossover trial with 146 medical students, Boedeker et al. showed that the large group session conducted as an interactive activity resulted in higher learning scores ($p = 0.010$) and a greater “sense of learning” ($p < 0.001$) compared to the passive lecture; furthermore, students with lower prior performance benefited from the interactive modality (Boedeker et al., 2024).

Another point to consider from Jabben and Ghani's perspective is the type of information to be conveyed to students; immunology and microscopic sciences are areas of study that differ from areas such as macroscopic anatomy. In these cases, the use of images via slide projection is more viable, as postulated by Jabeen from the Department of Anatomy and Orthopedics at the Faculty of Medicine of the University of Jammu, Asia (Jabeen & Ghani, 2015).

The chalk talk method shows effectiveness in the short- and medium-term teaching process for medical students; while the slide projection method shows effectiveness in the short term, but not in the medium term. In terms of efficacy, the chalk talk methodology demonstrates superiority over the slide projection methodology in both the short and medium term. The results are not influenced by the student's IQ range or gender. The academic community is recommended to consider the data presented in this study for the modification, or if necessary, ratification, of their teaching and pedagogical plans.



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Declaration of the use of artificial intelligence

The authors declare that they did not use Artificial Intelligence (AI) tools for any part of the manuscript. No part of the scientific content, results, analyses, or interpretations was generated by artificial intelligence. All material was reviewed and validated by the authors, who are responsible for its accuracy and rigor.



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Artificial Intelligence and the Teaching Process for Economics Students

*La inteligencia artificial y el proceso de enseñanza en
estudiantes de Ciencias Económicas*

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Abstract

Artificial intelligence drives knowledge, facilitates the comparison of diverse perspectives, and provides information tailored to student needs. In the teaching process, it promotes various strategies, tools, and methodologies that are revolutionizing the educational field. In this sense, within university settings, the teacher acts as a guide and facilitator, shaping a pedagogical and cognitive process. This approach is grounded in an ethical awareness that avoids excessive dependence, inequality, or misinformation. This study employed a quantitative approach with a non-experimental design. The research was cross-sectional, collecting data at a single point in time, and had an explanatory scope aimed at addressing the causes of social phenomena related to higher education and Artificial Intelligence (AI). The population consisted of 243 university students enrolled in the second and third semesters of the Statistics, Economics, and Finance programs at the Central University of Ecuador. To obtain a sample size of 149 students, simple random sampling (SRS) and proportional stratified sampling were used to ensure equitable representation according to



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academic level (68 second-semester students and 81 third-semester students). The results show that, although students demonstrate a moderate level of ethical awareness, gaps remain in their comprehensive understanding of some theoretical constructs related to the ethical use of AI. This situation highlights the need to incorporate specific content into educational programs aimed at strengthening ethical considerations in the use of these technologies.

Keywords

Artificial intelligence, educational innovation, economic sciences, ethical awareness, academic performance.

Resumen

La inteligencia artificial impulsa el conocimiento, brinda facilidad para cotejar diversas perspectivas y brindar información conforme a las necesidades del estudiante. En el proceso de enseñanza promueve varias estrategias, herramientas o metodologías que revolucionan el campo educativo. En este sentido, en los entornos universitarios el docente es un guía y moderador, a fin de construir un proceso pedagógico y cognitivo. De este modo, se parte de una conciencia ética que no incurre en dependencia excesiva, desigualdad o desinformación. Este estudio se basó en un enfoque cuantitativo, con diseño no experimental. La investigación tuvo un corte transversal, recolectó datos en un solo momento, y un alcance explicativo para responder a las causas de los fenómenos sociales sobre la educación superior y la Inteligencia Artificial (IA). La población se conformó por 243 estudiantes universitarios matriculados en el segundo y tercer semestre de las carreras de Estadística, Economía y Finanzas de la Universidad Central del Ecuador. Para obtener un tamaño de muestra de 149 estudiantes se utilizó un muestreo aleatorio simple (MAS) y un muestreo estratificado proporcional para garantizar una representación equitativa según el nivel académico (68 estudiantes de segundo semestre y 81 de tercer semestre). Los resultados evidencian que, aunque los estudiantes presentan un nivel moderado de conciencia ética, persisten vacíos en la comprensión integral de algunos constructos teóricos relacionados con el uso ético de la IA. Esta situación pone de manifiesto la necesidad de incorporar, dentro de los programas formativos, contenidos específicos orientados a fortalecer la ética en la utilización de estas tecnologías.

Palabras clave

Inteligencia artificial, innovación educativa, ciencias económicas, conciencia ética, rendimiento académico.

1. Introduction

The rapid technological evolution of recent decades has significantly transformed educational systems, generating new teaching and learning scenarios that demand the incorporation of innovative digital tools. In this context, according to Numa-Sanjuán et al. and Vera, AI has established itself as one of the emerging technologies with the greatest impact on 21st-century education, due to its capacity to process large volumes of information, personalize learning, and optimize pedagogical processes (Numa-Sanjuán et al., 2024; Vera, 2023). Its integration into higher education not only responds to a technological trend but also to the need to strengthen educational quality and prepare students to face the challenges of an increasingly digitalized academic and professional environment.



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Several studies agree that AI offers significant opportunities to innovate traditional teaching methodologies by enabling the design of more dynamic, interactive, and student-centered learning environments (Baltazar, 2023; Peñaherrera et al., 2022). These tools facilitate the adaptation of content to learning paces and styles, promoting more meaningful and effective learning processes. In particular, Jardón et al. and Ludeña-Yaguana consider that higher education has shown significant progress in the use of virtual assistants, recommendation systems, and intelligent platforms that contribute to improving academic performance and student motivation (Jardón et al., 2024; Ludeña-Yaguana et al., 2025).

In the field of Economics, the incorporation of artificial intelligence is especially relevant, given that these disciplines require the constant analysis of data, informed decision-making, and the development of critical thinking. Recent research by Espinales-Franco, and Ribas and Provazi indicates that the strategic use of AI in this field fosters the understanding of complex content, the development of analytical skills, and the improvement of students' academic performance (Espinales-Franco et al., 2024; Ribas and Provazi, 2024). Similarly, Biggs states that AI enables the implementation of more formative assessments and the continuous monitoring of learning, aligning with student-centered pedagogical approaches (1987).

However, the integration of artificial intelligence into educational processes also presents significant challenges, especially regarding teacher training, ethics, and the responsible use of technology. Vera and Piedra-Castro et al. indicate that the teacher's role is transforming, shifting from a transmitter of knowledge to a pedagogical mediator capable of guiding learning through the critical and reflective use of AI (Vera, 2023; Piedra-Castro et al., 2024). In this sense, it is essential that educators develop digital competencies that allow them to leverage the potential of these tools without affecting the development of critical thinking or students' intellectual autonomy (Vélez-Rivera et al., 2024).

From an ethical perspective, various authors, such as Ruiz-Miranda and Vélez-Rivera, warn that the indiscriminate use of artificial intelligence can generate technological dependence, biases in information, and limitations in critical analysis if clear guidelines are not established for its application in the university setting (Ruiz-Miranda, 2023; Vélez-Rivera et al., 2024). Therefore, AI should be conceived as a means of supporting the educational process and not as a substitute for pedagogical judgment, always maintaining the teacher's central role in regulating knowledge and in the student's holistic development.

Within this framework, this research aims to analyze the relationship between artificial intelligence and the teaching-learning process in Economics students, considering its technological, pedagogical, cognitive, evaluative, and ethical implications. From a comprehensive perspective, the study seeks to provide empirical evidence that allows us to understand the real impact of AI in higher education and contribute to the development of innovative teaching strategies that strengthen the quality of the educational process.

Regarding the article's structure, Section 2 presents a review of the scientific literature on artificial intelligence and its impact on the teaching and learning process for Economics students. Section 3 describes the methodology used for the research, specifying the approach, design, population, sample, and instruments employed. Section 4 presents and analyzes the results obtained concerning the impact of artificial intelligence on the technological, pedagogical, cognitive, evaluative, and ethical dimensions of the educational process. Subsequently, Section 5 discusses the results, contrasting them with previous



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studies and relevant theoretical contributions. Finally, Section 6 presents the conclusions, which are derived from the study's findings and allow for a comprehensive assessment of the contribution of artificial intelligence to the teaching of Economics.

2. Literature Review

2.1. AI in university environments and its impact on the teaching process

Artificial Intelligence (AI) is a revolutionary mechanism that marks a turning point in social spheres by providing specific assistance. In education, pedagogical paradigms are being reconstructed to achieve meaningful learning. Thus, "AI is defined as a branch of computer science that focuses on the development of intelligent agents capable of reasoning, learning, and making decisions autonomously" (Jardón et al., 2024, p. 5). Therefore, AI constitutes a process that focuses on large amounts of information, enabling problem-solving, teaching and learning, and decision-making. Its practical application lies in the didactics of teaching as a mechanism that transforms methodologies and proposes efficient tools that strengthen competencies.

At the same time, AI in university settings proposes a construction of thought that strengthens students' knowledge. It allows for machine learning, data analysis, and rapid information processing that provides feedback to the learning process. In this sense, "AI's ability to personalize learning, adapting educational content to students' individual needs, promises to significantly increase academic performance and student motivation" (Piedra-Castro et al., 2024, p. 123). Therefore, the implementation of this technology in university settings enhances knowledge and streamlines data processing through didactic and innovative explanations. However, it depends on the conditions or infrastructure of these spaces to establish a pedagogical focus that achieves teaching objectives.

Similarly, the substantial value of AI in university education lies in its ability to identify knowledge gaps, with the aim of improving academic performance. Furthermore, "AI can adapt the teaching-learning process to the individual needs and preferences of each student, offering learning resources and activities tailored to their level of knowledge, learning style, and pace of progress" (Vera, 2023, p. 20). Therefore, students benefit from an innovative methodology that meets their needs and learning styles. AI proposes student-centered activities, promoting autonomous learning. This contributes to teaching and reduces the teaching load, allowing teachers to redirect their time to lesson planning.

AI not only positively impacts student learning but also benefits teachers in administrative tasks. Educators consider this tool to be a valuable resource that contributes to didactic and pedagogical effectiveness. For this reason, "teachers highlight that AI reduces the workload in activities such as grading exams and managing attendance, allowing them to focus more on teaching" (Ludeña-Yaguana et al., 2025, p. 232). Consequently, teachers take a strategic position, becoming learning designers with technology that guarantees knowledge acquisition. This educational co-creation tool contributes to the design of teaching activities, aligns pedagogical objectives, and enables teaching with an educational purpose.

Thus, the impact of AI on the teaching process stems from an innovative transformation that provides dynamic, flexible, and personalized spaces for students. Meanwhile, "the primary advantages of implementing AI in teaching are the construction of algorithms that grade these forms, freeing up teachers more time to research, develop innovative teaching methodologies, and provide individualized attention to their students" (Peñaherrera et al., 2022, p. 407). The tool adapts content, activities, and assessments to suit the teacher's approach and ensure each student achieves the appropriate level of understanding. This



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allows teachers to generate teaching materials, analyze each student's progress, consolidate individualized learning, and develop logical reasoning and motivation.

2.2. AI tools used for the teaching process of Economic Sciences: pedagogical and cognitive process

The revolutionary shift in the use of Information and Communication Technologies (ICTs) within university settings precedes a restructuring of the pedagogical process, as it offers solutions to educational challenges in the classroom. Artificial intelligence seeks to enhance the human capabilities of teachers, in order to provide instruction that fosters critical thinking and guarantees knowledge acquisition. Thus, AI "is a science that helps to accurately diagnose each student individually in order to design a series of activities that will lead to the improvement of their main weaknesses" (Numa-Sanjuan et al., 2024, p. 51). For this reason, the student's educational development fosters a conducive environment in which skills, knowledge, and values are integrated, aiding in the practice of Economic Sciences.

AI allows for the exploration of a range of information associated with innovative methodologies or strategies that facilitate the understanding of content. Similarly, the tools used in the teaching process are replacing traditional paradigms by implementing interactive environments that promote meaningful learning. The integration of AI in Economics facilitates the understanding of topics such as data processing, finance, statistics, and calculations, among others. Therefore, intelligent tutors have the ability to collect data, investigate trends, and assess economic aspects to strengthen students' knowledge.

In this sense, personalized teaching emerges in the pedagogical field, as it is a mechanism that identifies needs and reconstructs them to provide learning solutions. In particular, "chatbots are capable of providing a personalized and flexible learning experience, which could lead to an increase in academic performance and student satisfaction" (Ruiz-Miranda, 2023, p. 158). Consequently, this tool acts as a virtual assistant that offers coherent answers, with the aim of guiding specific learning processes. Teaching is student-centered, making the student the central figure in knowledge acquisition, allowing them to authentically appropriate it in their professional development. Similarly, the most used tool by students is ChatGPT, which has become a means to search for information or organize statistical data. In the pedagogical process, it allows for independent work, analysis of statistical tables, simulations, or practical cases in finance, administration, or business. For this reason, "the application of ChatGPT is not limited to independent learning, but can also be used in the classroom to encourage student participation and improve peer interaction, as well as interaction with the teacher" (Ruiz-Miranda, 2023, p. 158). The intended use of this tool in education allows for strategic, interactive, and teacher-assistive teaching, identifying difficult-to-understand content and making it didactic for knowledge retention.

The use of AI in the cognitive process enables independent learning to organize thinking, promotes reasoning, and designs learning situations. It involves processing information through content evaluation, concentration, and knowledge comprehension. In turn, "artificial intelligence systems have the potential to increase students' cognitive abilities, stimulating the generation of alternative perspectives" (Palma-Landirez et al., 2024, p. 4023). In this sense, the cognitive paradigm combined with AI encompasses the student's information processing. Thus, their learning process is recognized and integrated with strategies that should be used to acquire knowledge meaningfully.



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Furthermore, within the cognitive process, Intelligent Tutoring Systems (ITS) stand out as an advantageous tool. Thus, "an intelligent tutor plays the role of a personalized tutor for each student, meaning it can identify their individual needs and the metacognitive processes required for their learning" (Baltazar, 2023, p. 8). Therefore, intelligent tutors offer continuous and evolving monitoring according to the learner's needs, guided problem-solving, and immediate feedback. They also strengthen attention, memory, and the development of logical-mathematical reasoning, among other skills that consolidate analytical competencies.

Next, Learning Management Systems (LMS) provide development of cognitive and metacognitive skills through interactive courses personalized to the student's needs. These platforms analyze learning styles and structure learning paths, resources, assessments, and tasks that encourage attention, memory, and comprehension. Thus, "AI-powered LMSs offer tools for tracking academic progress, allowing both students and teachers to monitor progress in real time and adjust the educational process as needed" (Rosero & Guevara, 2025, p. 6137). Therefore, these systems foster the development of critical thinking, active participation, performance monitoring, and stimulate cognitive processes (reflection, analysis, reasoning). In line with Economics, LMSs strengthen learner autonomy. For this reason, students self-regulate their learning through activities such as forums, assessments, and tasks related to accounting, economics, and administration, in order to develop their thinking through data analysis. The enhancement of logical thinking, quantitative analysis, and decision-making through these platforms catalyzes teaching and learning. In short, the system meets educational needs: on the one hand, teachers establish activities as knowledge guides; on the other hand, students seek alternatives to promote logical and methodical reasoning.

2.3. Ethical awareness in the use of AI

The usefulness of technology entails a responsibility of awareness and critical thinking to use it as a means to enhance skills. Ethical awareness in the use of AI takes into account risks such as dependency, data projection, biases, equity, and transparency in knowledge construction. Indeed, "ethics in educational AI is fundamental to protecting privacy, avoiding biases, and ensuring equity in access to and use of these technologies" (Lima et al., 2025, p. 6). Consequently, the use of AI in educational settings analyzes the benefits and risks associated with the indiscriminate use of this tool with respect to the development of analytical thinking. Likewise, ethical application integrates moral reflection when making decisions based on responsible, honest, and authentic values that support knowledge.

The combination of AI with higher education presents specific challenges stemming from the infrastructure and its ethical use. When integrating this tool into academic environments, it is essential to train educators and students to avoid disadvantages such as excessive dependency. Indeed, "it is necessary to establish clear policies and ethical regulations to guide the development, implementation, and use of AI in education, with the aim of ensuring that equity, inclusion, and the well-being of all students are promoted" (Espinales-Franco et al., 2024, p. 4734). For this reason, comprehensive and holistic training enables the proper functioning of AI in education, in order to implement it as a means of strengthening basic and transversal skills.

In this sense, AI in university settings depends on faculty regulation and the autonomy students have to understand its proper functioning. Ethical awareness responds to the need to establish values or principles for decision-making. Some of the ethical problems present are "the expansion of marginalization, inequality, inequity, injustice, and discrimination



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existing in society, through the analysis and generation of biased, opaque, or inexplicable data" (Vélez-Rivera et al., 2024, p. 4). That is, AI should be used as a learning support tool, avoiding its replacement with knowledge. The teacher, as the primary guide, contributes to establishing limits that allow for transparency, responsibility, and critical thinking, while maintaining the pedagogical focus of teaching.

The information provided by AI generates a conglomeration of perspectives that can increase misinformation in academic cases. The indiscriminate use of this tool limits the reflective and analytical development of students, leading them to complacency or conformity in completing tasks. "In many cases, students may use these tools to generate content that is not original, which raises serious doubts about the value of learning and authorship in the academic sphere" (Ribas and Provasi, (2024, p. 5). Therefore, there is no policy development that guarantees the appropriate use of AI; however, the work of teachers allows them to raise awareness and sensitivity regarding the potential of these tools in academic use. Ultimately, ongoing training not only allows for the development of teaching methodologies but also provides a conscious understanding of the conflicts that arise in the teaching process.

3. Methods and materials

This research was conducted using a quantitative approach, which allowed for the objective measurement and analysis of the relationship between the use of artificial intelligence and the learning approaches adopted by higher education students. A non-experimental design was employed, as the study variables were not deliberately manipulated but rather observed as they occur in their natural context. This approach is relevant for analyzing educational phenomena associated with pedagogical practices mediated by emerging technologies.

The study was cross-sectional, with data collection occurring at a single point in time. This provided a snapshot of the current state of students' learning processes in relation to the integration of artificial intelligence in higher education. Furthermore, the research was explanatory in scope, aiming to identify and analyze the potential causes and relationships between learning approaches and educational dynamics influenced by the use of AI tools in the university setting.

The Study Processes Questionnaire (SPC), a widely validated instrument in educational research, was used for data collection. It consists of 42 items organized around three learning approaches: surface, deep, and high-performance or achievement. Each of these approaches assesses both the motives and strategies students employ during their learning process using a Likert-type scale. The questionnaire is based on Biggs' (1987) theory of learning approaches, which posits that university learning is explained by the interaction between student motivations and the cognitive strategies they use to tackle academic tasks. In the context of this research, the SPC allowed for the analysis of how these approaches manifest themselves in an educational environment influenced by the use of artificial intelligence.

The study population consisted of 243 university students enrolled in the second and third semesters of the Statistics, Economics, and Finance programs at the Central University of Ecuador. The selection of students from these academic levels was based on two main criteria: first, this is a key formative stage in the consolidation of learning habits and approaches; and second, the curricular proximity between semesters reduced academic variability and ensured greater homogeneity in the sample. Simple random sampling was



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used to determine the sample size, supplemented by proportional stratified sampling, to ensure equitable representation of students according to their semester. The result was a sample of 149 students, distributed as 68 second-semester students and 81 third-semester students, allowing for a balanced comparative analysis between the two groups.

Data collection was carried out using the Google Forms platform, a tool that facilitated the efficient administration of the questionnaire and guaranteed the anonymity and confidentiality of the responses. Subsequently, the data obtained were processed and analyzed using IBM SPSS Statistics version 29.0, employing rigorous criteria for statistical analysis and hypothesis validation, with a significance level of 5% ($\alpha = 0.05$).

For the statistical analysis, descriptive techniques such as frequencies, means, and standard deviations were used to characterize students' learning approaches. Inferential tests were also applied to identify significant relationships and differences between the study variables, including Student's t-test, Pearson's correlation coefficient, and non-parametric tests such as Kendall's and Spearman's tau-b, selected based on the data distribution. These techniques enabled a deeper understanding of the impact of the AI-mediated educational context on teaching and learning processes in higher education.

4. Analysis and Results

Through the analysis of the tables and graphs shown below, the behavior of the study unit will be observed in order to gain a better understanding of the characteristics identified in the research.

Table 1 shows that the majority of surveyed students are from the Finance program (59.7%), followed by the Statistics program (24.2%) and the Economics program (16.1%). This distribution was relevant because the application and perception of AI can vary slightly among these disciplines within Economics. Furthermore, the sample distribution for this academic unit is concentrated in the area related to the social sciences (75.8%), while the applied statistics area represents 24.2% of the sample.

Major	Frequency	Percentage	Cumulative Percentage
Economics	24	16.1 %	16.1 %
Finance	89	59.7 %	75.8 %
Statistics	36	24.2 %	100.0 %
Total	149	100.0 %	

Cuadro 1. Distribución de los estudiantes según la carrera de estudio

According to Table 2, there is an even distribution between second- and third-semester students, with percentages of 45.6% and 54.4%, respectively. This distribution by academic level was intentional, allowing for control of variability in university experience and familiarity with the content of Economics. By concentrating the sample in these intermediate semesters, it was ensured that participants had a similar knowledge base, which is crucial for more accurately evaluating the influence of AI on their learning process, preventing differences in their level of academic progress from being a distorting factor.



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Semester	Frequency	Percentage	Cumulative Percentage
Second semester	68	45.6 %	45.6 %
Third semester	81	54.4 %	100.0 %
Total	149	100.0 %	

Table 2. Distribution of students by semester

Table 3 shows the equitable gender distribution, with 51.0% women and 49.0% men in the total sample. This distribution ensured that the study results were not biased by gender, allowing us to infer that the impact of AI on the learning process was evaluated from a balanced perspective. Furthermore, this distribution ensured the external validity of the findings, as the sample reflects gender diversity, strengthening the generalizability of the conclusions.

Semester	Frequency	Men	Women	Percentage
Second semester	68	33	35	51.0 %
Third semester	81	40	41	49.0 %
Total	149			100.0 %

Table 3. Distribution of students by sex

Analysis of Table 4 reveals that the majority of surveyed students are between 18 and 21 years old, representing 73.2%. This concentration at early stages of university life is consistent with the second- and third-semester student population, resulting in a sample composed primarily of students who are actively engaged in their studies and have grown up in an increasingly digital environment.

Age range	Frequency	Percentage	Cumulative Percentage
Between 18 y 19 Y. O	35	23.5%	23.5%
Between 20 y 21 Y.O.	74	49.7%	73.2%
Between 22 y 23 Y. O	26	17.4%	90.6%
Between 24 y 25 Y. O	7	4.7%	95.3%
Older than 25 Y. O	7	4.7%	100.0%
Total	149	100.0%	

Table 4. Distribution of students according to age range



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To evaluate how artificial intelligence impacts the assessment dimension in Economics students, with particular emphasis on ethical awareness regarding the use of these technologies in the educational field, the following hypotheses are proposed for analysis:

- Alternative hypothesis (H_i): Artificial intelligence positively influences the evaluation dimension, promoting greater ethical awareness and responsibility in its use by students.
- Null hypothesis (H₀): Artificial intelligence has little impact on ethical awareness.

The descriptive analysis of the level of ethical awareness revealed that 41.6% of the students are in the low categories (1 and 2), while 58.4% reach the medium and high categories (levels 3 to 5), as shown in Figure 1.

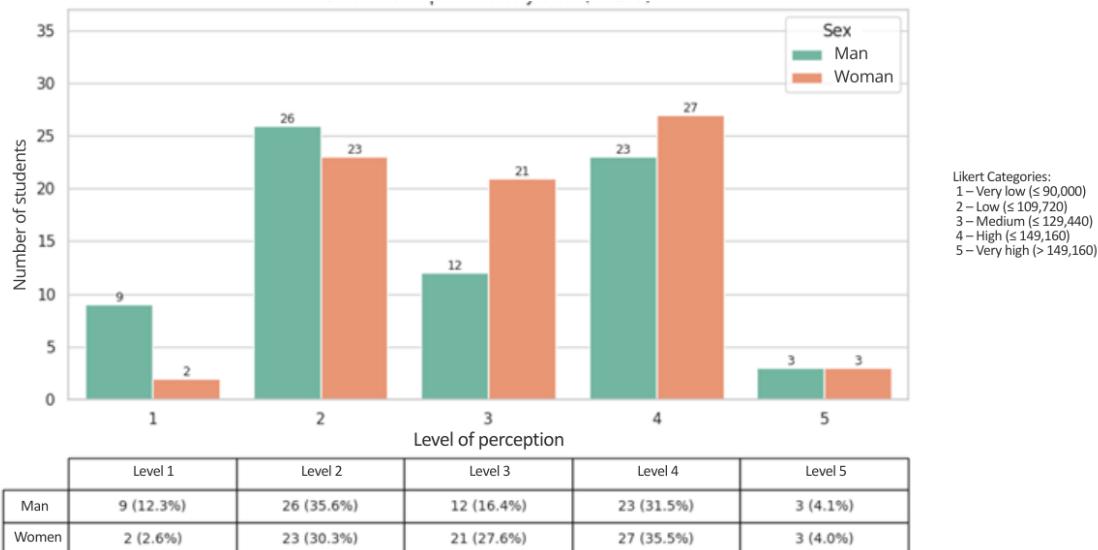


Figure 1. Level of ethical awareness about the use of AI, distribution by levels and sex (n=149)

The results of the independent samples t-test (Table 5) indicated no statistically significant differences in ethical awareness or in the AI assessment dimension among the different demographic groups analyzed (all two-tailed p-values were greater than .05, for CPE_P1 p=.207, for Age p=.234). This suggests that, although most students have moderate ethical awareness, significant gaps remain in their in-depth understanding of ethical issues, and the impact of AI on assessment is uniform across groups.

Variable	F de Levene	p de Levene	T	Gl	p (bilateral)	Difference of means	Standard error
CPE_P1	0.863	.355	1.268	147	.207	0.231	0.183
Age	1.285	.259	1.194	147	.234	0.195	0.163
Semester	0.042	.837	0.103	147	.918	0.008	0.082
TICS_P1	1,791	.183	-0.665	147	.507	-0.025	0.037
Performance	2.029	.156	-0.298	147	.766	-0.039	0.130
Motivation	0.780	.379	0.390	147	.697	0.042	0.107

Table 5. Independent samples t-test on the influence of artificial intelligence on ethical awareness and the evaluation dimension



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Note: Levene's test showed no significant differences ($p > .05$) in any case. CI = confidence interval; df = degrees of freedom.

The overall findings support the general hypothesis (H_i) that AI has a positive impact on the teaching-learning process of Economics students, with p-values < 0.001 for the main variables. For the specific hypotheses:

- Technological: It is confirmed that AI has a significant effect on students' use of technological tools, although the impact is based more on its pedagogical application than on direct access.
- Pedagogical: AI considerably enhances the educational aspect, increasing motivation and optimizing the perceived teaching process.
- Cognitive: AI has an indirect impact on the cognitive dimension, fostering motivation that affects academic performance.
- Assessment: AI promotes more individualized and continuous assessment, although its impact is equitable and does not vary according to demographic group.
- Ethical Awareness: AI promotes a moderate level of ethical awareness, although significant differences still exist in its critical understanding.

The results show that, although students demonstrate a moderate level of ethical awareness, gaps remain in their comprehensive understanding of some theoretical constructs related to the ethical use of AI. This situation highlights the need to incorporate specific content into educational programs aimed at strengthening ethical awareness in the use of these technologies.

Furthermore, the study's findings confirm the general hypothesis (H_i), which posits that AI has a positive impact on the teaching and learning process of Economics students at the Central University of Ecuador in 2024. This assertion is supported by highly significant p-values ($p < 0.001$), demonstrating that the averages obtained for the main variables significantly exceed the reference value. Consequently, the null hypothesis (H₀) is rejected, reaffirming that the impact of AI is not a random effect, but rather a real and beneficial one.

Regarding the specific hypotheses, solid evidence was obtained that allowed for their confirmation. In the technological sphere, it was found that AI is applied and understood by students, supporting the acceptance of the corresponding alternative hypothesis. In the educational aspect, the results indicate that AI significantly influences student motivation, promoting active participation in the teaching-learning process. From a cognitive perspective, it was determined that AI fosters the development of meaningful learning and stimulates critical thinking, fundamental aspects for strengthening academic skills and abilities. Regarding the evaluation process, the results show that AI facilitates task assessment and the immediate generation of error reports, enabling systematic and continuous feedback on learning.

Finally, it is important to highlight that no significant differences were identified based on the students' gender, age, or semester. This finding suggests that the influence of AI is uniform and equitable, regardless of the participants' demographic characteristics or geographic location.



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5. Discussion

The results obtained in this research show that the level of ethical awareness in the use of artificial intelligence is in the average range, a significant finding when triangulating empirical data with existing theoretical contributions. This suggests that, while students recognize the importance of responsible AI use, gaps in their training still exist, limiting a solid and critical ethical understanding. This result coincides with the findings of Gómez-Cárdenas et al., who warn of the urgent need to incorporate digital ethics as a cross-cutting theme in the university teaching and learning process (2024). Along the same lines, Espinosa-Vallejo et al. emphasize that educational transformation should not focus exclusively on technological adoption, but rather on comprehensive and holistic academic training capable of developing ethical awareness and critical thinking in students (2025).

By correlating these findings with levels of competence in artificial intelligence, the results show that greater familiarity with and academic use of AI are associated with a greater ethical awareness and responsibility in its application, reinforcing the arguments of Morocho-Pintag et al. (2025). These authors maintain that AI should not be conceived solely as an instrumental resource, but as a tool with the potential to transform learning processes, provided its integration is accompanied by clearly defined pedagogical and ethical criteria.

From the perspective of Economics, artificial intelligence has proven to be a key tool for process automation, the analysis of large volumes of data, and predictive decision-making. However, the results of this study reveal that its educational impact requires the explicit incorporation of competencies such as programming, predictive analytics, computational thinking, and algorithmic ethics. This finding aligns with the views of González-Alarcón and Melguizo (2023), who point out that the training of future professionals must respond to the new demands of the labor market without neglecting the ethical dimension. Likewise, this need is consistent with the arguments of Lamas-Lara et al., who maintain that critical and reflective thinking should be a fundamental pillar of university education (2025).

Triangulating the results with previous studies reveals that the inclusion of artificial intelligence in the educational process faces structural obstacles, such as institutional limitations, insufficient teacher training, and inadequate curricular adaptation. These findings confirm the observations of Rochina et al., who emphasize that the successful integration of emerging technologies depends not only on technological advancement but also on teacher training and curricular coherence (2024). Despite this, the study's results demonstrate that AI has high potential to increase motivation and optimize academic performance, which aligns with the findings of Sánchez-Salazar et al. (2024).

In this context, Ponce-Tituaña et al. (2025) emphasize the need to strengthen digital education from a holistic perspective, incorporating not only technical skills but also ethical foundations and an understanding of its operation. This view is triangulated with the results obtained in the study and with the proposals of Menacho-Ángeles et al., who highlight the importance of training critical, responsible, and conscious users of artificial intelligence-based technologies (2024). On the other hand, although the study did not identify statistically significant differences in the perception and use of AI according to gender or academic semester, this result should not be interpreted as evidence of equitable access to technology. As Rodríguez-Martínez et al. point out, digital divides are due to social, cultural, and structural factors (2025), which are not always directly reflected in the variables analyzed. In this regard, Armijos et al. highlight that AI has the potential to personalize



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content according to the student's learning pace and style (2025); however, the results of this study show that such personalization has not yet been fully achieved due to insufficient pedagogical integration and limited teacher training.

Finally, when correlating the empirical results with technology adoption models, it is observed that the perception of usefulness and ease of use continues to be a determining factor for the acceptance of AI in educational settings. As Pita-Briones et al. maintain, the effectiveness of artificial intelligence in education depends not only on the technology itself, but also on the institutional environment, educational policies, and teacher training (2025), elements that are consistently reflected in the study's findings. In summary, the triangulation of the results allows us to conclude that artificial intelligence constitutes a strategic resource for strengthening the teaching-learning process in Economics students, provided that its integration is carried out in a planned, ethical, and pedagogically sound manner. AI-based tools not only enhance key technological competencies for professional training, but also contribute positively to academic performance and the development of a responsible ethical awareness in the use of emerging technologies.

6. Conclusions

The triangulation of empirical results, statistical analysis, and scientific literature allows us to conclude that artificial intelligence (AI) has a positive and significant influence on the teaching and learning process of Economics students. Correlational analyses revealed a direct relationship between the level of AI competence and variables associated with academic performance, motivation, and student participation, confirming that AI, when used for pedagogical purposes, contributes to revitalizing traditional educational practices and improving the understanding of complex content specific to these disciplines.

From an educational perspective, the results show that the integration of AI fosters autonomous and personalized learning, allowing for the adaptation of content, activities, and assessment processes to students' learning paces and styles. This personalization correlates with the strengthening of key cognitive skills in Economics, such as data analysis, logical reasoning, and informed decision-making. Triangulation with previous studies confirms that these benefits are enhanced when AI is integrated in a planned manner and aligned with curricular objectives.

Regarding the ethical dimension, the statistical results showed a positive and significant correlation between the level of competence in artificial intelligence and ethical awareness in its use, allowing us to accept the proposed alternative hypothesis. However, the average level of ethical awareness achieved indicates that this aspect is not yet fully consolidated in university education. Comparing these findings with the literature reaffirms the need to incorporate digital ethics as a cross-cutting theme in the educational process, avoiding uncritical or technology-dependent practices.

Likewise, the correlation between the use of artificial intelligence and the perception of its pedagogical utility confirms that teacher mediation is a determining factor for its effectiveness. Triangulation of the results shows that AI does not replace the teacher's role, but rather redefines it, assigning them a strategic function as a guide and regulator of learning. In this sense, teacher training and instructional planning emerge as essential conditions for AI to contribute to the development of critical thinking and the active construction of knowledge. Finally, based on the correlational analysis and theoretical discussion, it is concluded that, although no significant differences were identified in the use



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and perception of AI according to sociodemographic variables, structural and institutional limitations persist that hinder its effective integration. The triangulation of the findings allows us to affirm that the positive impact of artificial intelligence in higher education depends not only on its technological availability, but also on an educational ecosystem that integrates curriculum, ethics, teacher training, and institutional policies. Consequently, artificial intelligence is consolidated as a strategic resource for higher education in Economics, provided that its implementation is carried out in a critical, ethical, and pedagogically sound manner.

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Declaration of the use of artificial intelligence

The authors declare that they did not use Artificial Intelligence (AI) tools for any part of the manuscript. All material was reviewed and validated by the authors, who are responsible for its accuracy and rigor.



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Emotional Exhaustion and Teaching Performance: An Approach to Burnout Syndrome in University Professors

Desgaste emocional y desempeño docente: una aproximación al síndrome de Burnout en profesores universitarios

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Abstract

This study analyzes the influence of burnout syndrome on the performance of university teachers, based on data collected at the Faculty of Philosophy, Letters, and Education Sciences of the Central University of Ecuador. The central problem addressed by the manuscript is the lack of attention given to the emotional health of education professionals, who constitute one of the populations most exposed to work-related stress. In response to this problem, the authors propose an approach to assess the impact of factors such as emotional exhaustion, personal fulfillment, and depersonalization on faculty performance. It contextualizes the current state of studies associated with the topic through a brief overview of the state of the art and the conceptualization of the variables studied. This is a quantitative, cross-sectional study based on descriptive and correlational methods, as well as data provided by a sample of professors. Data collection involved interviewing teachers using the Maslach Burnout Inventory and the Competency-Based Teacher Evaluation Questionnaire (EDBC). Relevant findings include the weak relationship between the study variables, the importance of considering sociodemographic qualities such as the gender and age of participants when identifying possible causes of burnout, and the implication of professional experience in the development of strategies for preventing and coping with work-related stress.

Keywords

Educational quality, teaching profession, work-related stress, teaching practice, burnout.

Resumen

Este estudio analiza la influencia del síndrome de burnout en el desempeño de los docentes universitarios, a partir de datos recopilados en la Facultad de Filosofía, Letras y Ciencias de la Educación de la Universidad Central del Ecuador. El problema central que aborda el manuscrito es la escasa atención brindada a la salud emocional de los profesionales de la educación, quienes constituyen una de las poblaciones más expuestas al estrés laboral. En respuesta a esta problemática, los autores proponen una aproximación para evaluar el impacto de factores como el cansancio emocional, la realización personal y la despersonalización en el desempeño del cuerpo docente. Contextualiza el estado actual de los estudios asociados con la temática, mediante una breve exposición del estado del arte y la conceptualización de las variables estudiadas. Es una investigación con enfoque cuantitativo de temporalidad transversal, respaldada en métodos descriptivos y correlacionales, al igual que en los datos proporcionados por una muestra de catedráticos. El levantamiento de los datos consideró la técnica de la entrevista a docentes con la aplicación del Maslach Burnout Inventory y el Cuestionario para evaluar docentes basado en competencias (EDBC). Como hallazgos relevantes están la escasa relación entre las variables de estudio, la importancia de la consideración de cualidades sociodemográficas como el género y la edad de los participantes al momento de identificar las posibles causas del Burnout, así como, la implicación de la experiencia del profesional en el desarrollo de estrategias para la prevención y el afrontamiento del estrés laboral.



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Palabras clave

Calidad de la educación, docencia, estrés laboral, práctica pedagógica, síndrome del quemado.

1. Introduction

Globalization and relentless capitalization, accompanied by stereotypes and social mandates, have shaped scenarios in which productivity is conceived as an inherent quality of a responsible individual committed to improving their environment. According to Salvagioni et al. (2017)

The combination of stressors has triggered conditions that affect the daily lives of millions of people around the world; this has increased the risk of emotional and sleep disorders, as well as psychosomatic problems, including cardiovascular disease, diabetes, musculoskeletal pain, and strokes (p. 5).

Burnout syndrome (hereafter referred to as BS) is a significant biopsychosocial problem, as it is associated with both the physical and emotional well-being of human beings and their ability to respond to work and social demands. Furthermore, authors such as Rincón point out that this condition was recognized in 2019 by the World Health Organization (WHO), being included in the International Classification of Diseases (ICD), and has gone from being conceived as a state of vital exhaustion to being considered a disease resulting from chronic stress caused by work overload (Rincón, 2025, p. 19).

However, when transferring this condition to the educational sphere, it has been identified that teachers are one of the populations most at risk of developing symptoms associated with BS. In this vein, Manzano-Díaz (2020) states that "when working conditions are poor, given that they often do not provide the necessary safety and protection for employees, they become a threat to health, causing occupational diseases" (p. 500). The teaching profession is also subject to constant change, as frequent reforms in the education system tend to increase both the demands and quality standards in this area of knowledge.

According to Díez-Romero (2023), "among the group of workers who are at particular risk of burnout are those who work in social care, health care, or teaching" (p. 192). Similarly, authors such as Sorce and De Lucca (2020, p. 7) point out that, due to the high probability of forming bonds with the people in their care, education professionals are exposed to greater emotional exhaustion, influenced by both contextual factors and work demands. What has been mentioned up to this point is important in understanding the meaning of this research, since in addition to these factors, university teachers not only guarantee a quality educational process, but also, in their role as trainers of professionals, perform other substantive functions that support their vocation of service, such as research, links with society, and academic management.

In this regard, studies such as that by Kwiek (2016) warn that only 10% of university faculty in Europe are responsible for 50% of scientific production, reflecting a marked structural inequality in higher education systems (p. 395). This concentration of knowledge generates latent tension between teaching and research, as less productive academics tend to focus their efforts on teaching. Thus, there is a clear conflict between traditional educational functions and contemporary demands aimed at generating new knowledge.



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For authors such as Briceño-Núñez (2024), the SB approach in higher education poses challenges that go beyond andragagogical praxis, as it involves the consideration of epistemological, ontological, and axiological dimensions (p. 4). As this is an academic population with representative training in their respective areas of knowledge, the probability of divergences regarding epistemological conceptions of teaching increases. This heterogeneity can be both a protective factor and a risk factor with respect to a comprehensive approach to the academic function.

The ontological dimension focuses on the teacher's being and not simply on their doing (Villegas-Torres and Lengeling, 2021, p. 231), which addresses the teacher's sense of self-perception as a human being in service to society. In this sense, it is interesting to encourage approaches to professionals who have managed to remain active for prolonged periods, considering that the teaching vocation has three stages in its development: "entering the teaching profession, choosing to be a teacher, and the educational vocation" (Cardosa-Batres, 2024, p. 35). Along the same lines, teaching is configured as a reflective practice where the teacher continuously questions their role, values, and beliefs. In other words, it is not simply reduced to a technical training function, but also implies a form of existence linked to broader personal and social meanings. The tension between the roles of researcher and teacher is a substantive ontological aspect, as it compromises the way teachers recognize themselves within the educational institution. Along these lines, authors such as Yağan et al. (2022) highlight that the academic system itself forces faculty members to face a conflict of institutional roles assumed in their hiring, which guide research toward productivity, prestige, and metrics established by the scientific community (pp. 3-10).

In addressing the axiological dimension, Briceño-Núñez (2024) emphasizes the values that guide the actions, decisions, and relationships of teachers, influencing both their well-being and their professional performance, as well as their decision-making and interaction with the different actors in the academic context (p. 4). The aforementioned dimensions correspond to the cornerstone of teaching performance in higher education institutions, as they shape their level of commitment to the training of future professionals, as well as their self-care actions for the maintenance and improvement of educational quality. The study by Onofre-Pérez (2021) mentions that intrinsic work values, such as personal development and meaningful work, correlate positively with work commitment and negatively with SB (pp. 30-31). Therefore, this finding emphasizes the importance of integrating personal work values with institutional culture to improve individual and collective performance.

The current state of research on SB in teaching staff performance provides a solid basis for generating new studies on this topic. However, as it is a multi-causal phenomenon, one of the main challenges of burnout research is to define its causes and consequences. "Predicting performance is a complex task and requires analysis of its nomological network for understanding, since psychological variables are difficult to analyze in isolation" (Choy-Vessoni and Prieto-Molinari, 2023, para. 11). Furthermore, the diversity of each participant's realities and perceptions implies limitations in these studies, as they could lead to biased results regarding the degree to which burnout affects teaching.

In general terms, this article aimed to contribute to the field of educational research related to quality assurance and the care of teaching staff in higher education. It began with the application of a survey of sociodemographic characteristics and the Spanish version of the Maslach Burnout Inventory for Human Services (Maslach burnout inventory human services survey), with the aim of characterizing the participating population. At the same time, the sample of teachers assessed their performance using the "Competency-based



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Teacher Evaluation Questionnaire (EDBC)" (Torres-Roldán et al., 2024), which allowed for a subsequent comparison between the two variables.

In light of the above, the aim of this study was to evaluate the impact of factors such as emotional exhaustion, personal fulfillment, and depersonalization on the performance of a sample of teachers from the Faculty of Philosophy, Letters, and Education Sciences at the Central University of Ecuador during the 2024-2025 academic year. The recognition of the scarcity of this type of study in the field of education, especially in the case of teachers involved in the training of other professionals in this field, was the main motivation for the development of this article. Thus, the question was raised: How do the dimensions of burnout affect the performance of the teaching staff of the Faculty of Philosophy, Letters, and Educational Sciences of the Central University of Ecuador in the 2024-2025 academic period?

This formulation was based on the recognition of university teachers as integral subjects who, despite having a remarkable career and extensive experience in their work, do not abandon their human condition. The assessment of teachers, as well as the prevention of health problems, is a relevant responsibility of the ideological, political, and economic spheres of any sociocultural context.

This manuscript was structured with the aim of starting with a brief overview of the state of the art and a theoretical-conceptual approach to the variables analyzed, in order to subsequently provide methodological specifications for the interactive phase. Once these components have been clarified, the most relevant results are presented based on the objectives of the study, moving on to a discussion of the findings and corresponding conclusions.

2. State of the Art

This section reviews research related to the topic; the studies considered were published within the last five years. Priority was given to identifying systematic reviews that provide a general overview of advances in the study of SB in teaching performance in recent years.

Tabares-Díaz et al. (2020) conducted a systematic review of 53 scientific articles, emphasizing studies on SB in teachers in Latin America. The objective that guided the study was to identify scientific production related to the topic, generated in the period between 2008 and 2018. One of the main findings was the recognition of a higher prevalence of research of this nature in health care populations, compared to the analysis of professionals in the field of education. It was concluded that most studies that sought to associate SB with sociodemographic, occupational, and psychological variables were able to establish relationships in the form of risk and protective factors.

Rojas-Solís et al. (2021) conducted a review of research carried out between 1994 and 2019. The objective of the study was to explore SB in the context of Latin American teachers. Based on the PRISMA model, they identified 25 research articles from nine high-impact electronic databases. Among the main results, it was evident that research on BS in teacher performance has mainly focused on the analysis of prevalence and the recognition of etiological factors, in contrast to the means of prevention and treatment. The conclusions highlighted the need to consider the gender variable, situational analysis, and the specific needs of participants in this type of study.

González-Valero et al. (2021) conducted a review of research related to the topic. The objective was to provide an overview of the main variables associated with SB and resilience



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in the field of teaching. The methodology used was similar to that of Rojas-Solís et al. (2021), who identified a sample of 25 scientific articles published between 2016 and 2019. The results showed that since 2019 there has been an upward trend in interest in researching psychosocial variables linked to BS. Similarly, it was stated that a large part of the studies analyzed showed that the dimensions of BS are highly related to the mood, sense of fulfillment, and work and interpersonal performance of university teachers. It was concluded that all levels of education show a significant number of professionals suffering from BS, which could have an impact on both the mental health of these individuals and the teaching-learning processes.

3. Conceptual approach to burnout

For authors such as Caballero-Domínguez et al. (2010), burnout syndrome is a term coined in the healthcare and organizational context to refer to people who showed signs of professional and emotional exhaustion (p. 132). For their part, Saborío-Morales and Hidalgo-Murillo (2015) mention that the first approaches to this condition date back to the 1970s, when psychiatrist Herbert Freudenberger first used the concept of burnout to describe the decline in the physical and psychological health of care staff at an addiction clinic in New York, USA (p. 2). Thus, they were able to identify effects from the first year of service, evidenced by changes in attitudes toward work and a continuous reduction in the effectiveness of the activities performed by these professionals throughout the workday.

In 1976, American psychologist Christina Maslach revisited the term burnout to refer to a three-dimensional syndrome characterized by emotional exhaustion, depersonalization, and low personal accomplishment, mainly associated with professions involving direct contact with human beings (Maslach and Jackson, 1981, p. 106).

Over the years, the definition of burnout syndrome has been supplemented by contributions from various authors. Figure 1 below summarizes the evolution of the concept of burnout syndrome over the last few decades.

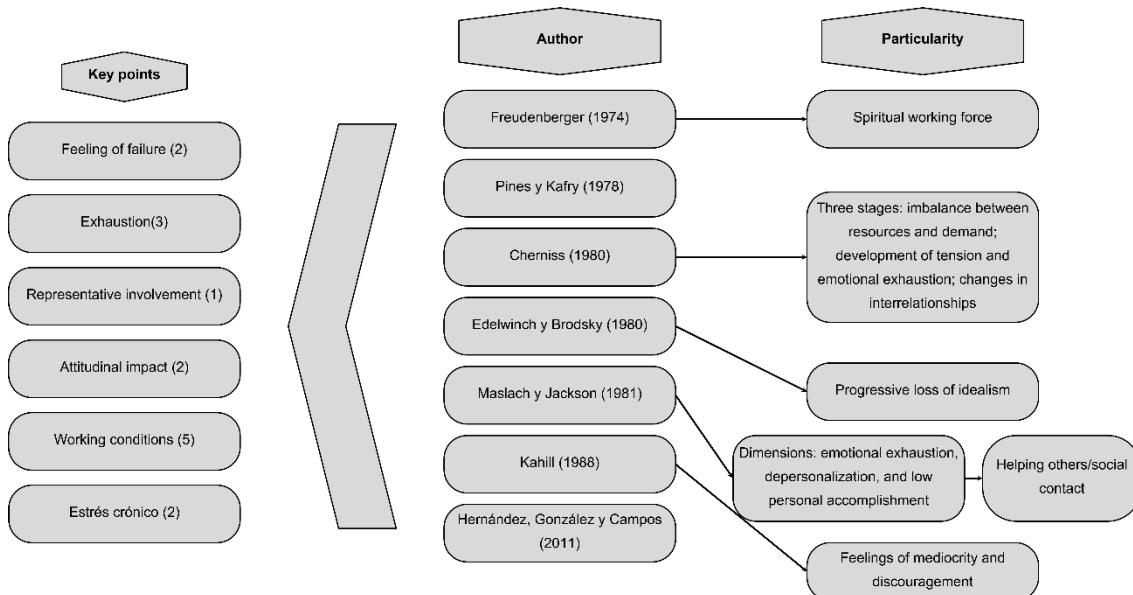


Figure 1. Conceptual evolution of SB. Adapted from: Estrada-López et al. (2018).



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Figure 1 shows that, from the perspective of Estrada-López et al. (2018), authors such as Freudenberg (1974) and Hernández, González, and Campos (2011) focused their work on recognizing burnout syndrome (BS), referring to a feeling of failure in individuals with this condition; while Pines and Kafry (1978), Maslach and Jackson (1981), and Kahill (1988) delved mainly into the study of factors associated with the syndrome, such as exhaustion from the work environment, weariness in dealing with people, changes in the attitude of the affected worker, and chronic stress.

Similarly, among the particularities and representative contributions to the concept of BS, three stages in the development of the syndrome have been identified: 1) the imbalance between resources and demands; 2) the development of a feeling of exhaustion, accompanied by an increase in stressors; and 3) behavioral changes in interpersonal relationships. In addition, it is worth highlighting the dimensions proposed by Maslach and Jackson (1981), which have been the basis for the development of numerous subsequent studies, thanks to the creation of the Maslach Burnout Inventory for human services.

3.1 Teaching Performance in Higher Education

The task of educating requires vocation and key skills for proper execution; however, the performance of university teachers demands greater rigor, as it incorporates personal, disciplinary, and pedagogical elements (Salazar, 2006, p. 31). The characterization of the professor is based on the recognition of the multidimensionality that defines the profile of the academic professional, given that, as a subject linked to the higher education sphere, they must perform training tasks of research, coordination, and tutoring that go beyond exclusively pedagogical aspects. University teachers represent strength and expertise in a specific area of knowledge; however, according to the United Nations, their participation in educational work requires that, in addition to being specialists in their area of knowledge, they possess skills in the field of pedagogical knowledge, such as knowledge of learning methods and understanding of assessment processes (UNESCO, 1998, p. 3).

The conceptual approach to university teaching performance becomes more complex when recognizing this multidimensionality in practice, and even personal and emotional aspects that may affect performance throughout the educational process have been taken into consideration. The practice of teaching is inseparable from the establishment of relationships with students. Therefore, elements such as the treatment of students, attitude in learning spaces, and proximity to future professionals are important components in the evaluation of professional performance.

4. Methodology

This research focused on recognizing the degree of association between the dimensions of burnout syndrome as an independent variable and teaching performance as a dependent variable, as well as the influence that exists between them, making it specifically a correlational study. The article was written from a quantitative, non-experimental, cross-sectional, and correlational approach. This approach was chosen because priority was given to obtaining and interpreting numerical data in an uncontrolled environment, with the aim of providing objective answers to the research questions (Creswell, 2014). It was cross-sectional because the data collection was carried out on a single occasion, and correlational because of the degree of association between the two variables.



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4.1 Participants

The study involved a sample of teachers from the Faculty of Philosophy, Letters, and Education Sciences at the Central University of Ecuador during the 2024-2025 academic year. The sampling process was non-probabilistic and intentional, given that individuals were selected based on the following criteria: a) working in the Faculty of Philosophy at the UCE; b) having an employment relationship with the university for more than one year; c) having a third-level degree in the field of education as their basic training.

Thus, a sample of 109 university teachers was considered for participation. This group corresponded to 39% of the total number of teachers working in the aforementioned faculty (279 professionals) at the time of data collection.

Características	N	%
Gender		
Male	67	62
Female	41	38
Other	0	0
Age		
Under 40	15	13.8
40 to 49	43	39.4
50 to 59	39	35.8
60 or older	12	11.0
Employment Status		
Full-time	87	79.8
Part-time	13	11.9
Part-time	9	8.3
Job Length		
1-10 years	35	32.1
11-20 years	49	45
21-30 years	22	20.1
Over 30 years	3	2.8

Table 1. Sociodemographic characteristics of the teaching sample.

It should be noted that the participation of all individuals involved in this study was completely voluntary, with informed consent and consent. Likewise, confidentiality and anonymity were respected at all times.

4.2 Instruments

The instruments used to conduct the research were the Maslach Burnout Inventory (Spanish version) and the Competency-Based Teacher Evaluation Questionnaire (EDBC) (Torres et al., 2024). Both instruments have been recognized for their wide application in various studies as tools for measuring the variables: SB and teacher performance.



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The MBI (Maslach and Jackson, 1981) considers the dimensions of emotional exhaustion, depersonalization, and personal fulfillment. This inventory has high internal consistency and reliability, close to $\alpha = 0.90$ (Oyola-García et al., 2023). Its application has been one of the most recognized for research projects on SB (Rojas-Solís et al., 2021). The ranges for the rating by aspect evaluated are shown in Table 4.

Evaluated aspect	Low	Medium	High
Emotional exhaustion	0-18	19-26	27-54
Depersonalization	0-5	6-9	10-30
Personal fulfillment	0-33	34-39	40-56

Cuadro 2. Rangos para la calificación del MBI. Fuente: Briceño-Núñez (2024).

The “Competency-based teacher evaluation questionnaire (EDBC)” was created by Torres et al. (2024). The instrument has 22 items, designed with the intention of measuring the performance of teaching staff in higher education through the following competencies: Knowledge, Skills, Attitudes, and Values. A pilot test was conducted to establish the reliability of the instrument, obtaining a Cronbach's alpha value corresponding to the excellent range ($\alpha = 0.924$).

4.3 Data analysis

The first phase of the study consisted of administering the instruments to the teaching sample of the Faculty of Philosophy, Letters and Educational Sciences of the Central University of Ecuador, active during the 2024-2025 academic year. The data were subsequently processed using the SPSS v26.0 statistical package and Microsoft Excel. The descriptive analysis included graphs created based on the measures of central tendency and the values obtained. A correlational analysis was also performed by comparing the scores resulting from the application of both instruments.

5. Results

5.1 Fase 1: Measurement of burnout levels among teaching staff at the Faculty of Philosophy, Literature, and Education Sciences

The first element analyzed was the prevalence of SB among the teaching staff. It should be noted that the sample consisted primarily of full-time professors with approximately 11 to 20 years of service in higher education, with a mean (μ) age of 49 years and a standard deviation of $\sigma = 9$.

Figure 2 presents the data obtained according to each dimension of the MBI, referring to the high, medium, and low levels offered by the instrument.



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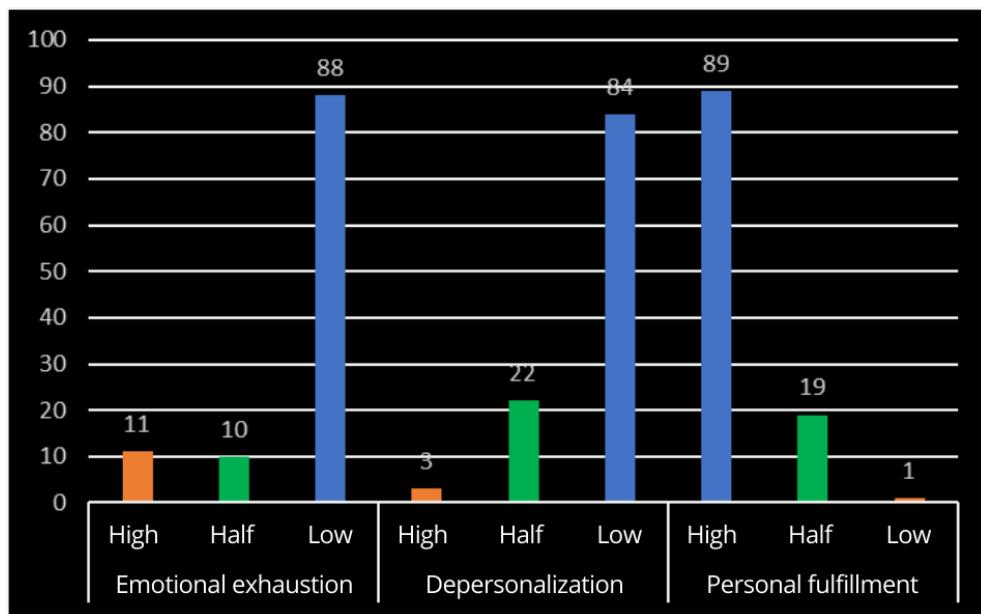


Figure 2. Distribution of the teaching sample according to the dimensions of burnout.

5.1.1 Emotional exhaustion

- 88 teachers showed scores between 0 and 18 (low): Indicates that burnout or emotional overload generally does not occur due to stress levels experienced during the academic day.
- 10 teachers showed scores between 19 and 26 (medium): These teachers report feeling some level of emotional exhaustion, which could increase and rise to a high level of fatigue in this dimension.
- 11 teachers showed scores between 27 and 54 (high): Typical of individuals who constantly experience exhaustion due to work demands.

5.1.2 Depersonalization

- 84 teachers scored between 0 and 5 (low): Refers to teachers who can easily establish positive relationships with students.
- 22 teachers scored between 6 and 9 (medium): Indicates a certain emotional distance and loss of interest in interacting with others.
- 3 teachers reported a score between 10 and 30 (high): These teachers consider themselves to have a poor ability to connect emotionally with their students. This could be interpreted as a cynical and dehumanizing attitude toward others.

5.1.3 Personal fulfillment

- One teacher reported a score between 0 and 33 (low): This teacher claims to be dissatisfied with their job and lacks a sense of accomplishment.
- 19 teachers demonstrated scores between 34 and 39 (medium): Typical of teachers with a relatively moderate sense of satisfaction with their job performance and achievements.
- 89 teachers obtained scores between 40 and 56 (high): Indicates that these participants feel satisfied with their work and their academic achievements.

When comparing the results with the sociodemographic qualities presented previously, it is possible to affirm that from a sample of teachers with an average age of 49 years, mostly



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composed of male teachers with approximate seniority of 11 to 20 years, no participants with SB indicators were evident.

5.2 Fase 2: Análisis Correlacional entre las dimensiones del SB y el índice de desempeño docente

The results of the first phase allowed for a distribution of SB dimensions, which facilitated correlational analysis using the Pearson coefficient (r). The results presented below correspond to a comparison between the SB dimensions and the total score obtained in the questionnaire regarding teacher performance.

		Emotional exhaustion	Personal achievement	Despersonalization	Teaching performance
Emotional exhaustion	Correlación Pearson	.317**	.248**	-.110	
	Sig. (bilateral)	.001	.009	.254	
	N	109	109	109	109
Personal achievement	Correlación Pearson	-.317**	1	-.353**	.248**
	Sig. (bilateral)	.001		.000	.009
	N	109	109	109	109
Despersonalization	Correlación Pearson	.248**	-.353**	1	-.072
	Sig. (bilateral)	.009	.000		.459
	N	109	109	109	109
Teaching performance	Correlación Pearson	-.110	.248**	-.072	1
	Sig. (bilateral)	.254	.009	.459	
	N	109	109	109	109

**. The correlation is significant at the level 0.01 (bilateral).

Table 3. Correlation between SB dimensions and teacher performance index.

Regarding the relationships between the dimensions of burnout syndrome, the results showed significant correlations between them, consistent with what has been reported in the literature. A moderate negative correlation was found between emotional exhaustion and personal accomplishment ($r = -.317$, $p = .001$), indicating that as teachers perceive greater emotional exhaustion, their sense of achievement and personal efficacy tends to decrease. Likewise, the relationship between emotional exhaustion and depersonalization was positive and weak ($r = .248$, $p = .009$), suggesting that higher levels of emotional exhaustion are associated with more distant or cynical attitudes toward students and teaching. Finally, the relationship between personal accomplishment and depersonalization



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was negative and moderate ($r = -.353$, $p < .001$), reflecting that a lower perception of personal success is accompanied by greater depersonalization in professional practice.

On the other hand, when analyzing the relationship between the dimensions of burnout syndrome and teacher performance, the findings revealed that only one of the dimensions showed a significant correlation. Personal accomplishment was positively and weakly associated with performance ($r = .248$, $p = .009$), suggesting that teachers who feel more professionally fulfilled tend to report better performance in their academic duties. In contrast, the correlations between emotional exhaustion and performance ($r = -.110$, $p = .254$), as well as between depersonalization and performance ($r = -.072$, $p = .459$), were negative but not significant, indicating that these dimensions of burnout did not show a statistically relevant influence on perceived performance in the participating sample.

6. Discussion of results

The state of the art presented at the beginning of this article raises the importance of expanding the depth of studies related to burnout syndrome (BS) in teacher performance. Clearly, there is a significant number of analyses that focus specifically on descriptive approaches (Rojas-Solís et al., 2021), neglecting contextualization that facilitates a broader understanding of the conditions under which the findings were obtained.

In this study, significant associations were identified between the dimensions of BS and teacher performance, particularly in the dimension of personal accomplishment, which was shown to be a relevant factor in the prevention of this syndrome. Using the Pearson coefficient, the following were found: 1) a moderate negative correlation between emotional exhaustion and personal accomplishment ($r = -.317$, $p = .001$); 2) a moderate negative correlation between personal accomplishment and depersonalization ($r = -.353$, $p < .001$); and 3) a weak positive correlation between personal accomplishment and teaching performance ($r = .248$, $p = .009$). These results suggest that a greater sense of personal accomplishment could contribute to mitigating symptoms such as emotional exhaustion and depersonalization, while also promoting better professional performance.

When comparing these findings with the systematic review by González-Valero et al. (2021), who stated that "[...] personal accomplishment is related to emotional repair with a large effect ($r = 0.501$)" (p. 282), consistency is observed regarding the positive role of this dimension in teacher well-being. A notable aspect of this study is the typology of the participating teachers, given that all had basic training in education, which could have favorably influenced their ability to manage work demands and maintain a sense of personal accomplishment. In line with Hernández-Ortega (2023), who notes that several university professors "have found themselves under constant work pressure, which has forced them to adapt environmentally and professionally" (pp. 112-113), the findings of this study suggest that such adaptation appears to be effective in the analyzed sample, with no evidence of severe impact on performance. In fact, the majority of professors presented low levels of emotional exhaustion and depersonalization, along with high or medium levels of personal accomplishment. This is consistent with Garcés-Delgado et al. (2023), who argue that, despite moderate levels of stress, there are no indicators that indicate that professors suffer from chronic stress, suggesting that the symptoms of BS in university contexts are situational and not necessarily clinical.

Finally, factors such as age and professional experience appear to play an important role in the quality of teaching performance. Bolívar and Mula-Falcón (2022) highlight that teachers are more likely to develop stress in their early years of practice, when they are still adapting,



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since "the fear of failure leads individuals to voluntarily exploit themselves to the point of exhaustion" (p. 123). This approach is consistent with what was observed in the present sample, characterized by an average age of 49 years and extensive professional experience, which could explain the greater emotional resilience and sense of personal achievement reported. As Mendes and Miguel (2024) affirm, experienced workers are more successful in regulating their emotions in demanding situations, which facilitates a more defined sense of personal accomplishment, positively impacting performance and relationships with students.

As a result, it is understood that a sense of personal accomplishment could be considered a protective factor for teachers against emotional burnout and depersonalization. For their part, the professional career and experience were also perceived as elements that could make a difference in the etiology of SB in this population, something that undoubtedly deserves to be investigated in greater detail in subsequent studies, especially with samples of novice teachers or those from other training areas.

7. Conclusions

In the analyzed sample, the influence of burnout syndrome (BS) on university professor performance depended on a combination of personal, emotional, social, and occupational factors that enabled or prevented the onset of warning signs. In this regard, no participant showed chronic stress; however, some professors reported experiencing emotional exhaustion and depersonalization. It is worth noting that sociodemographic characteristics provided key information in understanding why there was no significant relationship between the study variables, given that factors such as age, vocation, and years of service proved relevant for managing the demands associated with teaching.

Among the most relevant dimensions of burnout syndrome in relation to professor performance, a sense of personal accomplishment was identified as especially important as a factor in preventing emotional exhaustion and depersonalization in the analyzed population. This finding is significant considering that the entire sample consisted of teachers with a background in education, which suggests that many of them may feel fulfilled by working in university teaching.

Teacher performance is undoubtedly a multi-causal phenomenon that combines a variety of resources and skills developed throughout one's professional career. Factors such as teachers' age and years of experience play a fundamental role in consolidating optimal performance and in students' positive perceptions of their work. Both the present study and the aforementioned contributions show that, over time, teachers tend to adjust their priorities, increasingly focusing on aspects that promote educational quality and empathic and assertive interactions with students. This shift in perspective enriches the learning experience and strengthens the relationships between teachers and their context. Likewise, as they gain more experience, teachers refine their strategies for managing stress and improve their emotional regulation skills, which contributes to the development of protective factors against burnout and other conditions related to work-related stress.

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Declaration of authorship-CRediT

ESTEBAN BOZANO-RIVADENEIRA: Conceptualization, methodology, software, validation, formal analysis, research, resources, data curation, writing – original draft, writing – revision and editing, visualization.

JOHANNA BUSTAMANTE-TORRES: Supervision, methodology, writing – revision and editing, validation.

BRITTANNY ARROBO-GUAYLLAS: Resources, data curation.

HEYDI HUGO-LÓPEZ: Resources, data curation.

Declaration of the use of artificial intelligence

The authors declare that they used the ChatGPT tool – GPT-4 model (OpenAI), June 2025 version – solely for linguistic review and improvement of the wording of certain sections of the manuscript. All scientific content was prepared, reviewed, and validated by the authors, who assume full responsibility for the accuracy, integrity, and academic rigor of the work.



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Incidence of GeoGebra software in the
teaching-learning process on the derivative in
the Second Year of Unified General
Baccalaureate

*Incidencia del software GeoGebra en el proceso de
enseñanza-aprendizaje de la derivada en el segundo año
de Bachillerato General Unificado*

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Abstract

This article presents a study on the use of the free software GeoGebra in the teaching and learning process of mathematics, focusing on differentiation, with the aim of demonstrating its impact on second-year students of the Unified General Baccalaureate at the "Juan Wisneth" municipal school. This is particularly relevant given that in Ecuador, the educational methodology is traditional and minimally oriented towards the digital realm. The students were divided into two groups: the first group was introduced to the program using a didactic guide, while the second group continued with the established academic curriculum provided by the institution. The research is quasi-experimental with a quantitative approach. Data was collected using three instruments: a diagnostic assessment (before the intervention), a formative assessment (during the intervention), and a summative assessment (at the end). Furthermore, this research is part of a socio-educational project with a descriptive level of detail. This finding demonstrates that the use of GeoGebra enhances student learning, as evidenced by higher scores among those who used the software. Consequently, the impact of the digital age on mathematics, particularly in the study of derivatives, encourages institutions to use free software for improved learning.

Keywords

Mathematics, derivatives, software, GeoGebra, academic performance.

Resumen

Este artículo presenta el estudio sobre el uso del software libre denominado GeoGebra, en el proceso de enseñanza-aprendizaje de la Matemática, centralizada en el campo de la derivación, con la finalidad de evidenciar la incidencia de la misma en los estudiantes del segundo año de Bachillerato General Unificado del colegio municipal "Juan Wisneth", puesto que, en Ecuador existe una metodología tradicional y mínimamente orientada al ámbito digital dentro de la educación. Para esto, el estudiantado fue dividido en dos grupos: el primero fue incluido al programa mediante una guía didáctica, mientras que el segundo continuó con el pénsum académico establecido y otorgado por la institución. La investigación es de tipo cuasiexperimental con enfoque cuantitativo. De igual manera, para la recolección de datos se emplearon tres instrumentos: evaluación diagnóstica (antes de la intervención), evaluación formativa (durante); y, evaluación sumativa (final). Asimismo, la modalidad de investigación forma parte de un proyecto socioeducativo con un nivel de profundidad descriptiva. Este hallazgo evidencia que la utilización de GeoGebra favorece en la enseñanza-aprendizaje de los estudiantes al mostrar calificaciones más altas en aquellos que utilizaron el software. Por consecuente, la implicación de la era digital en la Matemática, específicamente al tratar el tema de la derivada, favorece a las instituciones el uso de software libres para un mejor aprendizaje.

Palabras clave

Matemática, derivadas, software, GeoGebra, rendimiento académico.



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1. Introduction

In order to provide better education in both public and private schools, this article presents and explains the impact of GeoGebra software as a technological, technical, and strategic tool for teachers to generate effective, agile, and engaging learning experiences for students, achieving favorable results in their understanding of various mathematical topics. This research stems from postgraduate studies. To this end, a guide on the derivative was developed, reviewed, and validated using the online GeoGebra software, known to the students participating in this research as the "Didactic Guide to the Derivative." Additionally, diagnostic, formative, and summative assessment tools were used to quantitatively determine the acceptance or rejection of this educational resource.

In this context, teachers play a fundamental role in ensuring quality education through the continuous updating of their knowledge and the strengthening of their digital skills. Mastery of Information and Communication Technologies (ICTs) thus becomes an essential condition for designing relevant and innovative learning experiences. This reflects the characteristics of new generations of students, who develop their cognitive and social skills in digital environments, demonstrating a high level of familiarity with the use of technological tools for knowledge construction.

In this way, society can demand that teachers, students, and citizens in general have the capacity to solve problems and face new challenges, offering timely solutions that contribute to its development. In this sense, within the academic sphere:

New educational needs arise from the transformations taking place in society; and it is here that the great challenges of the 21st century become apparent. These impending changes are related to education, particularly to the different teaching methods employed by teachers and the learning situations that arise in the learning environment. (Olivo and Corrales, 2020, pp. 8-9).

Thus, the multiple needs faced by students, teachers, and the education system in general become evident. One of these is the digital age, where the teacher must be a guide and the student the primary builder of knowledge. However, the development of subjects through a blackboard, a textbook, or a notebook is still prevalent, and there is no focus on innovating new teaching strategies that are geared toward a more active and participatory methodology.

This study was conducted at the Wisneth Municipal School, in the second year of the Unified General Baccalaureate (BGU), with the aim of demonstrating the impact of the GeoGebra program in the following contexts

1.1 Needs of contemporary education

ICTs have become essential tools for supporting teaching and learning processes. Therefore, when Holguín et al. (2002) analyze Roig and Santiago, they conclude that "the presence of ICTs in education is definitive, and thus it is necessary to change methodological practices, as well as to open up to different virtual environments where learning can take place" (p. 63). This change implies significant opportunities and challenges in the development of new teaching and learning skills for teachers and students both inside and outside the classroom.

However, the implementation of digital competence in education depends heavily on the resources available to the educational institution and how teachers use these resources. In the words of Revelo et al (2019), "the development of digital competence allows the teacher and student to build a bridge between intuitive ideas and formal mathematical concepts,



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providing an appropriate learning environment that involves knowledge, pedagogical strategies and technology" (p. 161).

1.2 Needs for teacher training in Mathematics

Teaching mathematics has become the biggest challenge for some teachers, such as Álvarez et al., who state that, according to the Ministry of Education's 2016 guidelines, this teaching revolves around students being able to reason, think, relate, and apply mathematical knowledge and premises to everyday life situations (Álvarez et al., 2020, p. 213). In other words, learning mathematics becomes difficult due to the complexity, precision, and abstraction of the content covered in class.

Similarly, according to Ayil, the creation of innovative virtual environments has become necessary in current technological development so that students can actively participate in their learning (Ayil, 2018, p. 36). Therefore, innovation in mathematics teaching must be dynamic, ensuring that students have a more active role, where the resources used capture their attention, motivating them and generating interest in acquiring knowledge and mastering skills, thus transforming a large part of traditional teaching spaces.

1.3 Needs for the teaching of Mathematics

The difficulties involved in understanding concepts, analyzing, and solving mathematical problems on a blackboard or in a notebook are numerous. Since it is difficult to grasp and, above all, to master certain skills, the subject becomes tedious and boring. Holguín et al. (2020) mention that "mathematics is considered one of the most complex subjects in the academic curriculum, which is reflected in high failure rates. For this reason, new strategies are being used to improve the teaching and learning method" (p. 72). One of the difficulties in the teaching and learning process of defining and developing calculus, specifically the topic of the derivative, is that there is no single way to represent it, as there are many methods, such as graphical, algebraic, or numerical.

Based on the above, the aim of improving the teaching and learning processes of mathematics, specifically in the area of the derivative, is framed within the implementation of GeoGebra software as a teaching resource. To achieve this, a dynamic approach and strategies were developed to capture students' attention, employing the words of Blázquez et al., who state that motivation plays a significant role in prospective memory—the ability to remember what needs to be done at the precise moment (Blázquez et al., 2008). Consequently, if teachers aspire to achieve good results in the teaching and learning process of derivatives, they must first awaken students' curiosity, interest, and motivation through various didactic or technological resources, depending on their needs.

Finally, this application aims to contribute to overcoming the difficulties present in the teaching and learning process, considering that the software is a beneficial tool for teachers, students, and the entire educational community. Beyond achieving the understanding and acquisition of a mathematical concept essential for students at higher levels of education, the goal is to foster their interest and motivation, making the most of tools with which they feel comfortable and which are new to them. This allows for more in-depth teaching, optimizing time and enabling students to develop useful cognitive skills in both the school and social environment.

2. Methodology

This research is based on the following methods, methodology, techniques, and instruments:



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2.1 Research Approach

The research employed a quantitative approach. Hernández et al. state that the “quantitative approach uses data collection to test hypotheses based on numerical measurement and statistical analysis, in order to establish patterns of behavior and test theories” (2014, p. 5). In other words, it represents a set of processes organized sequentially to verify certain assumptions, starting with a defined idea, progressing through additional processes, and culminating in the presentation of the results report.

2.2 Level of research

The research focused on a descriptive level. On the one hand, Guevara et al. state that “descriptive research is carried out when the aim is to describe a reality in all its main components” (2020, p. 165). Thus, a detailed view of the influence of the GeoGebra program on students is obtained.

On the other hand, Hernández and Mendoza maintain that the main function of the study is to specify the characteristics, properties, and profiles of communities, groups, objects, or any phenomenon (Hernández and Mendoza, 2018, p. 108). This scope allows for the collection and measurement of data on the variables initially identified, with the possibility of predicting an event in a rudimentary way, provided that the theoretical foundations and background information are well established.

2.3 Type of research

The design of a research study is based on the steps, procedures, and strategies that must be followed to address the research according to the model adopted for controlling variables. Three types were used: documentary, field, and experimental, focusing on a quasi-experimental design.

On the one hand, documentary research, according to Muñoz (2015), is that which deals with “the collection of information and the analysis of the results found; these investigations are generally theoretical, abstract, and not very susceptible to verification” (p. 256). On the other hand, Hernández et al. state that field research consists of studies carried out in a realistic situation, in which the researcher manipulates one or more independent variables under carefully controlled conditions (Hernández et al., 2014, p. 150). Thus, this type of research allows for the recording and control of data with the support of evaluations or other data collection instruments, in order to facilitate information management.

The research is experimental according to Arias et al. (2021), “is a process whose main characteristic is to quantitatively verify the causality of one variable on another; this implies the manipulation or control of the independent variable.” For this, an action plan is needed, which can be established in stages” (p. 72). In this sense, the work carried out is of a quasi-experimental type, one that manages the experimental and control groups. This design is used when it is not possible to use subjects randomly, so they are already pre-selected.

2.4 Population and sample

According to Mejía, the population is the totality of elements or individuals that comprise the study, delimited by the researcher according to the parameters established in the study (Mejía, 2015, p. 95). Therefore, the research involved a population of 61 second-year students in the Unified General Baccalaureate program at the “Juan Wisneth” municipal school. These students were divided into two sections: the experimental group of 30 students, belonging to the first section, to whom the proposed didactic guide was applied, and the second, control group of 31 students who were not subjected to the same guide.



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The population coincides with the sample, since it is a specific educational institution where the hypothesis is to be tested or rejected. For the aforementioned reasons, a non-probabilistic convenience sampling method was used. Regarding the first point, Arias et al. state that sampling is used when the population is very small or less than 100 individuals, and the population is chosen directly based on shared characteristics or a biased judgment on the part of the researcher (Arias et al., 2021, p. 115). As for the second point, convenience sampling, according to Parra et al. (2017), "consists of selecting elements that are convenient for the research, for the sample; this convenience arises because it is easier for the researcher to examine the subjects" (p. 10).

2.5 Research Technique

The technique used in this research is the objective test. Thus, "all activities carried out during the teaching and learning process provide information that allows for evaluation; however, sometimes it is necessary to apply tests in order to evaluate specific elements and content" (Garcés & Garcés, 2015, as cited in Arias et al., 2021, p. 83). Therefore, the chosen technique allows us to measure the level of learning achieved by a student in a given content area or topic to determine whether the teaching guide benefits or hinders student academic performance.

2.6 Instrument and validity

The questionnaire was used as the instrument. Hernández and Mendoza define a questionnaire as a data collection instrument used in scientific research, consisting of questions administered to a sample or population (Hernández & Mendoza, 2018, p. 250). In this application, three questionnaires were administered for diagnostic, formative, and summative assessment. Each questionnaire consisted of 10 questions with structured items.

Regarding validity, according to Hernández et al., validity is the "degree to which an instrument truly measures the variable it seeks to measure. It is achieved when it is demonstrated that the instrument reflects the abstract concept through its empirical indicators" (2014). Thus, the instrument has the support and guarantee of being well-designed and intended to have sound content, criteria, and construct. Based on the above, the assessment instruments were reviewed and approved by three experts in the field.

2.7 Reliability

According to Hernández et al., reliability is the "degree to which an instrument produces consistent and coherent results in the sample or cases" (2014). In simpler terms, reliability aims to ensure consistency in the instruments' methodology and the population to which they are applied, resulting in similar data or results. All students taking the assessments should be on equal footing. To determine the reliability of the three assessments, pilot tests were administered to 15 randomly selected third-year high school students. It is recommended that pilot testing be conducted with a class of the same or higher grade level, and that students have recently covered the topic of derivatives. Once the assessments were administered, data tabulation and the calculation of Cronbach's alpha for each instrument began. The following reliability results were obtained:



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Scale	Levels
Less than 0.200	Very low reliability
De 0.210 a 0.400	Low reliability
De 0.410 a 0.600	Regular reliability
De 0.610 a 0.800	Acceptable reliability
De 0.810 a 1.000	High reliability

Table 1. Cronbach's Alpha

Assessment instruments	Reliability coefficient	Levels
Diagnostic	0.891	Confiabilidad elevada
Training	0.954	Confiabilidad elevada
Summative	0.905	Confiabilidad elevada

Table 2. Results obtained from Cronbach's Alpha in the assessment instruments

Once the results of Cronbach's alpha were observed using the Kuder-Richardson method, it was concluded that the three instruments have high reliability, according to the scale proposed by Hernández and Mendoza, and can be applied to the students of the experimental and control groups of the institution.

3. Results

Within the statistical analysis of the instruments applied to the students, the results were tabulated and organized; the descriptive measures were analyzed in terms of frequency distribution, percentages, arithmetic means, mean, mode, standard deviation and advanced.

3.1 Diagnostic assessment

Within this category, the type and level of students' knowledge were established before the research process began. As Vera (2020) states, diagnostic tests "are carried out at the beginning or end of the course to compare students' knowledge, that is, to understand the before and after of the teaching-learning process" (p. 4). In other words, quantitative grades were not issued, since this type of assessment serves to analyze students' responses and their level of understanding and knowledge of the topic. Similarly, the following nomenclature was used for the statistical analysis:

- σ : Standard deviation
- \bar{x} : Arithmetic mean.
- n : Total number of data points
- Σf : Sum of the frequencies.
- $\Sigma fixi$: Sum of the product of the scores and the frequency.

The diagnostic instrument consisted of ten multiple-choice questions. The test was based on prior knowledge from lower grades and the current grade. The test was administered in person using a printed copy. The second-year students of the Unified General Baccalaureate were divided into two groups. The first group, consisting of 30 students (experimental group), will be referred to as the group that used the instructional guide; the second group, consisting of 31 students (control group), did not use the GeoGebra program.

Below are the tables for both the experimental and control groups, showing scores, absolute frequencies, and other data that allow for interpretation and provide insight into the academic level at which the students in the experimental and control groups began the test.



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Ratings	Absolute frequency	Product	χ^2	$\sum fxi^2$
1	0	0	1	0
2	1	2	4	4
3	3	9	9	27
4	7	28	16	112
5	6	30	25	150
6	4	24	36	144
7	2	14	49	98
8	5	40	64	320
9	2	18	81	162
10	0	0	100	0
Total	30	165		1017

Table 3. Record of the diagnostic evaluation of the experimental group

Ratings	Absolute frequency	Product	χ^2	$\sum fxi^2$
1	0	0	1	0
2	0	0	4	0
3	4	12	9	36
4	5	20	16	80
5	8	40	25	200
6	3	18	36	108
7	6	42	49	294
8	3	24	64	192
9	2	18	81	162
10	0	0	100	0
Total	31	174		1017

Table 4. Record of the diagnostic evaluation of the control group

As shown in Table 3, a total of 30 students participated in the experimental group and were evaluated on a scale of 1 to 10 points. No student obtained the maximum score; however, 9 students scored higher than 7, meaning that 30% of the students achieved the learning objectives. This implies that 70% did not. These results were expected, given that this was a diagnostic assessment and no intervention had yet been implemented with the group.

In Table 4, 31 students participated and were evaluated on a scale of 1 to 10 points. No student obtained the maximum score; however, 35.48% of them scored 7 or higher. Therefore, it is understood that 64.52% did not achieve the learning objectives. These results are not very high; however, it should be noted that, as this is a diagnostic assessment, few students are engaged.

3.1.1 Calculation of the arithmetic mean

Formula used in calculating the arithmetic mean of the experimental group with its respective replacement:

$$\bar{x}_e = \frac{\sum x_e}{n_e} = \frac{165}{30} = 5.50$$



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$$\bar{x}_e = 5.50$$

Equation 1

Formula used in calculating the arithmetic mean of the control group with its respective substitution:

$$\bar{x}_c = \frac{\sum x_c}{n_c} = \frac{174}{31} = 5.61$$

$$\bar{x}_c = 5.61$$

Ecuación 2

3.1.2 Calculation of the standard deviation

Formula used in the calculation of the standard deviation of the experimental group with its respective replacement:

$$\sigma_e = \sqrt{\frac{\sum f x_i^2}{n_e} - \bar{x}_e^2}$$

$$\sigma_e = \sqrt{\frac{1017}{30} - 5.50^2}$$

$$\sigma_e = \sqrt{3,65}$$

$$\sigma_e = 1.91$$

Equation 3

Formula used in calculating the standard deviation of the control group with its respective substitution:

$$\sigma_c = \sqrt{\frac{\sum f x_i^2}{n_c} - \bar{x}_c^2}$$

$$\sigma_c = \sqrt{\frac{1072}{31} - 5.61^2}$$

$$\sigma_c = \sqrt{3,108}$$

$$\sigma_c = 1.76$$

Equation 4

As shown in Figure 1, the control group obtained an average score of 5.61 out of 10, while the experimental group obtained 5.50. These results are within the normal range, as they were obtained at the beginning of the study before the intervention. Furthermore, the standard deviation of the control group reflects that the scores are less dispersed compared to those of the experimental group.



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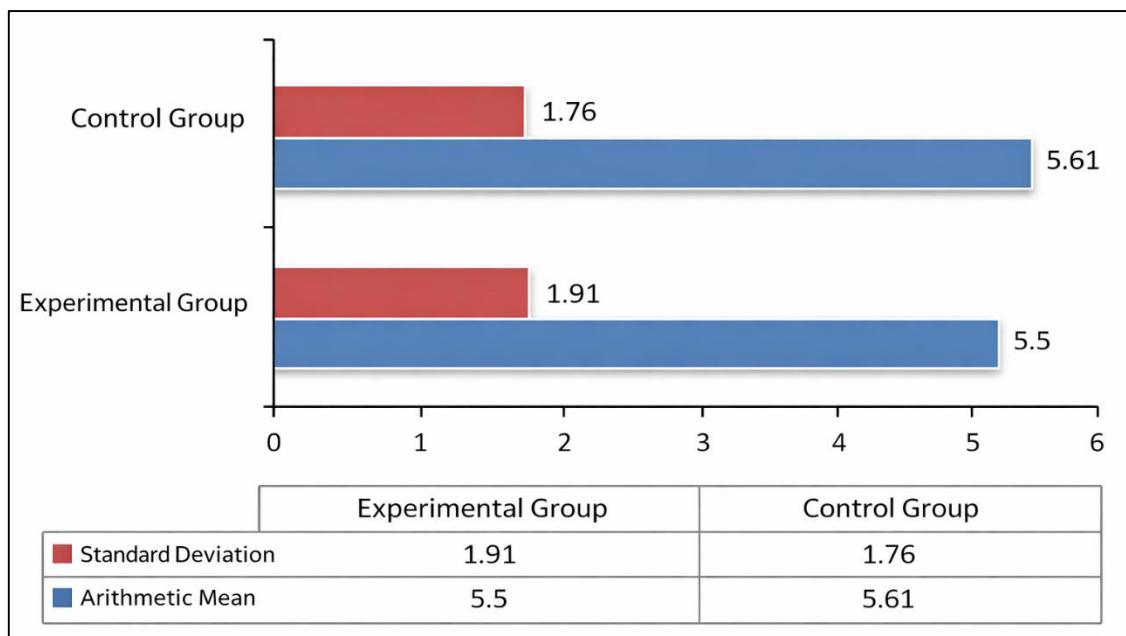


Figure 1. Statistical data analysis of the diagnostic evaluation.

It can be said that both the experimental and control groups are in a very similar situation, tending to be below average and mostly failing to achieve the required learning outcomes.

3.2 Formative assessment

Formative assessment, according to Mellado et al., is defined as “the subjective, individual, and personal search for the evolution that each subject has experienced thanks to the educational intervention” (2021, p. 174). It contributes to knowledge formation and the improvement of learning processes. Therefore, the test was developed with a structured format and ten multiple-choice questions, each worth one point for a correct answer. The topics covered included the definition of the derivative, derivatives of common functions, and trigonometric derivatives. However, the instrument was administered virtually on the CEVIM platform, Moodle, which is used by the municipal schools.

The data obtained from both the experimental and control groups are recorded in the following tables, which include scores, absolute frequencies, and other data necessary to interpret the data and understand the progress made by the groups during the intervention of the teaching guide on derivatives using GeoGebra.

Ratings	Absolute frequency	Product	χ^2	fixi^2
1	0	0	1	0
2	0	0	4	0
3	0	0	9	0
4	0	0	16	0
5	2	10	25	50
6	3	18	36	108
7	6	42	49	294
8	6	48	64	384
9	7	63	81	567
10	6	60	100	600
Total	30	241		2003



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Table 5. Formative assessment record of the experimental group

Ratings	Absolute frequency	Product	xi^2	$fixi^2$
1	0	0	1	0
2	0	0	4	0
3	2	6	9	18
4	2	8	16	32
5	3	15	25	75
6	3	18	36	108
7	4	28	49	196
8	7	56	64	448
9	6	54	81	486
10	4	40	100	400
Total	31	225		1763

Table 6. Record of the formative assessment of the control group

On the one hand, Table 5 revealed encouraging data, as 25 students scored 7 or higher, with only 5 students neither achieving nor mastering the learning objectives. Furthermore, 20% of students obtained the maximum score of 10 points, and the most frequent score was 9, with 7 students achieving 9 points. Therefore, it is evident that the experimental group has made significant progress since the implementation of the teaching guide.

On the other hand, Table 6 shows that 21 students scored 7 or higher, while 10 students have not yet achieved the learning objectives, with scores of 3 and 4. The most frequent score was 8, achieved by 7 students. It should be mentioned that in the control group, 12.90% achieved the maximum score of 10. This demonstrates a very noticeable improvement compared to the diagnostic evaluation.

3.2.1 Calculation of the arithmetic mean

Formula used in calculating the arithmetic mean of the experimental group with its respective replacement:

$$\bar{x}_e = \frac{\sum x_e}{n_e} = \frac{241}{30} = 8.03$$

Equation 5

Formula used in calculating the arithmetic mean of the control group with its respective substitution:

$$\bar{x}_c = \frac{\sum x_c}{n_c} = \frac{225}{31} = 7.26$$

Equation 6

3.2.2 Calculation of the standard deviation

Formula used in the calculation of the standard deviation of the experimental group with its respective replacement:

$$\sigma_e = \sqrt{\frac{\sum f x_i^2}{n_e} - \bar{x}_e^2}$$



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$$\sigma_e = \sqrt{\frac{2003}{30} - 8.03^2}$$

$$\sigma_e = \sqrt{2.28}$$

$$\sigma_e = 1.49$$

Equation 7

Formula used in calculating the standard deviation of the control group with its respective substitution:

$$\sigma_c = \sqrt{\frac{\sum f x_i^2}{n_c} - \bar{x}_c^2}$$

$$\sigma_c = \sqrt{\frac{1763}{31} - 7.26^2}$$

$$\sigma_c = \sqrt{4.16}$$

$$\sigma_c = 2.05$$

Equation 8

Analysis of the formative assessment data shows that the experimental group has an average score of 8.03, while the control group has an average score of 7.26, both scores being out of 10 points. In this respect, both groups achieved the learning objectives; however, the standard deviation of the experimental group is 1.49, which is lower than that of the control group, which stands at 2.05.

3.3 Summative assessment

This assessment, Mellado et al. (2021) define it as “the objective search for results through the gathering of evidence with a fundamentally accrediting and operational function of positive and negative reinforcement” (p. 173), taking into account that these tests must be standardized, universal, and procedural. The instrument consisted of 10 structured questions, and the topics were presented cumulatively. Among the topics reviewed were: derivatives of common functions, trigonometric functions, derivatives using the chain rule, and derivatives of the addition, subtraction, multiplication, and quotient of functions. It was administered virtually for the reason mentioned above.

Ratingss	Absolute frequency	Product	xi^2	$fixi^2$
1	0	0	1	0
2	0	0	4	0
3	0	0	9	0
4	1	4	16	16
5	3	15	25	75
6	6	36	36	216
7	5	35	49	245
8	5	40	64	320
9	4	36	81	324
10	6	60	100	600



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Total	30	226	1796
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Table 7. Record of the summative evaluation of the experimental group

Ratings	Absolute frequency	Product	Σx^2	$\Sigma f x_i^2$
1	0	0	1	0
2	0	0	4	0
3	8	24	9	72
4	5	20	16	80
5	6	30	25	150
6	3	18	36	108
7	2	14	49	98
8	7	56	64	448
9	0	0	81	0
10	0	0	100	0
Total	31	162		956

Table 8. Record of the summative assessment of the control group

Table 7 shows the grades obtained by the students in the experimental group, in which 66.67% scored 7 or higher, with a total of 20 students achieving the learning objectives. Thus, 33.33% of students scored between 4 and 6 out of 10. It is noteworthy that the highest grade, 10, was the most frequent, and the median grade was 7 out of 10. Although the average score in the summative assessment was lower than that in the formative assessment, a high percentage of students still achieved the learning objectives.

Table 8 shows that within the control group, only 29% of students achieved the learning objectives; consequently, 71% of students had grades below 7. Furthermore, the most frequent grade was 3 out of 10, with a total of 8 students achieving this score, and the average grade was 5 out of 10.

3.3.1 Calculation of the arithmetic mean

Formula used in calculating the arithmetic mean of the experimental group with its respective replacement:

$$\bar{x}_e = \frac{\Sigma x_e}{n_e} = \frac{226}{30} = 7.53$$

Equation 9

Formula used in calculating the arithmetic mean of the control group with its respective substitution:

$$\bar{x}_c = \frac{\Sigma x_c}{n_c} = \frac{162}{31} = 5.23$$

Equation 10

3.3.2 Calculation of the standard deviation

Formula used in the calculation of the standard deviation of the experimental group with its respective replacement:

$$\sigma_e = \sqrt{\frac{\Sigma f x_i^2}{n_e} - \bar{x}_e^2}$$



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$$\sigma_e = \sqrt{\frac{1796}{30} - 7.53^2}$$

$$\sigma_e = \sqrt{3.16}$$

$$\sigma_e = 1.77$$

Equation 11

Formula used in calculating the standard deviation of the control group with its respective substitution:

$$\sigma_c = \sqrt{\frac{\sum f x_i^2}{n_c} - \bar{x}_c^2}$$

$$\sigma_c = \sqrt{\frac{956}{31} - 5.23^2}$$

$$\sigma_c = \sqrt{3.48}$$

$$\sigma_c = 1.88$$

Equation 12

The results show a significant difference in the average score between the two groups. The experimental group had an average of 7.53, while the control group had an average of 5.23. Therefore, the first group achieved the intended learning outcomes, while the second group did not, as their score was below 7.

4. Analysis and discussion

In this section, the results collected in the study were analyzed and discussed. The similarities and differences found between the experimental and control groups regarding the teaching and learning of GeoGebra software were examined. Likewise, and due to the circumstances of the country where this research was conducted, it was also discussed whether or not the virtual environment affected the quality of instruction when subjected to formative and summative assessments.

On the one hand, to test the hypothesis regarding the impact of GeoGebra software use (Hi) and its lack thereof (Ho), it is necessary to extract the data from both assessments, including both the arithmetic mean and the standard deviation for both groups. The following mathematical language was used for this purpose:

$$H_i: \bar{x}_e \neq \bar{x}_c: \text{con } A_1: \bar{x}_e > \bar{x}_c \text{ o } A_2: \bar{x}_e < \bar{x}_c$$

Equation 13

$$H_o: \bar{x}_e = \bar{x}_c$$

Equation 14



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Nº	Evaluations	Arithmetic mean	Standard deviation
1	Formativa	8.03	1.74
2	Sumativa	7.53	1.77
Overall average		7.78	1.755

Table 9. Statistical record of evaluations of the experimental group

Nº	Evaluations	Arithmetic mean	Standard deviation
1	Formativa	7.26	2.05
2	Sumativa	5.23	1.88
Overall average		6.245	1.965

Table 10. Statistical record of control group evaluations

Table 9 shows an average score of 7.78 for both tests, which is higher than 7. It can be noted that the students achieved the learning objectives with an average standard deviation of 1.77, demonstrating that the scores are not highly dispersed.

Meanwhile, Table 10 shows an average score of 6.245 for the two assessments, indicating that the control group did not achieve the learning objectives, as their score was lower than 7 out of 10. Furthermore, they had a standard deviation of 1.965.

To determine critical values and rejection regions, it is taken into account that in the calculation of the parametric Z test, the null hypothesis is rejected if:

$$Z_c < -Z_T$$

$$Z_c < -1.96$$

Equation 15

Or also

$$Z_c > Z_T$$

$$Z_c > 1.96$$

Equation 16

Where Z_T is the theoretical value of Z for a significance level of 5%, $\alpha=0.05$; that is, the research will have 95% reliability; otherwise, the research hypothesis is accepted with one of the two alternatives. The corresponding mathematical language with its replacement is:

$$\bar{x}_e = 7.78; \bar{x}_c = 6.245; \sigma_e = 1.75; \sigma_c = 1.965; n_e = 30; n_c = 31$$

Equation 17

Once the theoretical bases have been detailed, the calculated parameterized Z test is found:

$$Z = \frac{\bar{x}_e - \bar{x}_c}{\sqrt{\frac{\sigma_e^2}{n_e} + \frac{\sigma_c^2}{n_c}}}$$

$$Z_c = \frac{7.78 - 6.245}{\sqrt{\frac{1.75^2}{30} + \frac{1.965^2}{31}}}$$



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$$Z_c = \frac{1,535}{\sqrt{0.2266}}$$

$$Z_c = 3.22$$

Equation 18

Comparing the calculated Z value and the theoretical Z value, we understand that the former is greater than the latter. That is to say:

$$Z_c > Z_T$$

$$3.22 > 1.96$$

Equation 19

Where $Z_c=3.22$ is outside the acceptance region of the null hypothesis, which leads us to reject the null hypothesis $H_0: (x_e) = (x_c)$ and accept the research hypothesis $H_1: (x_e) \neq (x_c)$ with the alternative $A_1: (x_e) > (x_c)$. That is, in non-mathematical terms, the use of GeoGebra software impacts the teaching-learning process of the Derivative in the second year of the Unified General Baccalaureate at the "Juan Wisneth" municipal school.

On the other hand, since the tests were administered virtually, it is evident that the experimental group, being in contact with the teaching guide, was not affected by the online evaluation. However, the control group did not improve its results. This premise demonstrates that teachers and students, when using GeoGebra software with the accompanying online learning guide, develop a greater capacity to solve problems involving derivatives and tackle new challenges. This is achieved not only through the GeoGebra software itself, but also through engagement with the accompanying learning materials, which help address social problems that may exist both nationally and internationally.

5. Conclusions

The use and application of the derivatives teaching guide using GeoGebra software strengthened the understanding of formal mathematical concepts focused on derivatives. Students who participated in the program achieved greater independent and collaborative learning than those who did not. This resulted in the first group being more organized, participative, and critical in their learning process.

The students in the experimental group showed considerable academic improvement compared to the students who did not participate. This means the first group has greater knowledge, which they can then apply in conversations with their classmates, in individual tests on the same topic, and in everyday life. Promoting the use of the derivatives teaching guide improves the teaching and learning process, meets the needs of contemporary education by digitally integrating the educational environment with the free software. Furthermore, it influences teacher training, as teachers transform the traditional learning environment for students who learn primarily visually and interactively. Similarly, it fulfills the need for teaching mathematics by offering different forms of representation, allowing students to improve their ability to analyze and solve mathematical problems through both in-person and digital learning experiences.

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Edwin Vinicio Lozano: related concepts, methodology, validation, research, organization and integration of collected data, conclusions, supervision, first draft, revision, and editing.

Declaration of the use of artificial intelligence

The authors declare that they did not use Artificial Intelligence (AI) tools for any part of the manuscript. No part of the scientific content, results, analyses, or interpretations was generated by artificial intelligence. All material was reviewed and validated by the authors, who are responsible for its accuracy and rigor.



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Use of the Educaplay Educational Platform in the Literacy Process of Primary Education Students (ISCED Level 1)

*Uso de la plataforma educativa Educaplay en el proceso
de lectoescritura en estudiantes de educación primaria
(nivel ISCED 1)*

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Abstract

This research was conducted in a public school located in the urban center of Cuenca, Ecuador, with primary school students (ISCED Level 1) who are experiencing difficulties in developing literacy skills. To address this problem, a pedagogical intervention was designed based on the Technological Pedagogical Content Knowledge (TPACK) model and the theoretical foundations of constructivism and constructionism, integrating the use of the Educaplay educational platform as a technological resource for developing interactive activities. The research adopts a mixed-methods approach and is structured using



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Sequential Transformative Design (DITRAS). Data collection included observations of classroom sessions with and without the use of technology, a survey administered to primary school teachers at the institution, and interviews with experts in the field of Language and Literature. The results show that the interactive activities designed in Educaplay significantly increased aspects such as attention, motivation, and academic performance of the students, especially with regard to phonological and syllabic skills and reading comprehension. In conclusion, the pedagogical intervention, based on the global-analytical approach and the development of linguistic awareness and reading comprehension in the early stages, combined with the appropriate use of interactive activities on the Educaplay platform, fosters meaningful, motivating, and autonomous learning in the initial phases of the reading process.

Keywords

Linguistic awareness, Educaplay, literacy, global-analytical method.

Resumen

La presente investigación se llevó a cabo en una unidad educativa fiscal ubicada en el centro urbano de la ciudad de Cuenca-Ecuador, con estudiantes de Educación Primaria (Nivel ISCED 1), quienes presentan dificultades en el desarrollo de habilidades de lectoescritura. Con el propósito de atender esta problemática, se diseñó una intervención pedagógica sustentada en el modelo Conocimiento Tecnológico Pedagógico del Contenido (TPACK) y en fundamentos teóricos del constructivismo y el constructivismo, integrando el uso de la plataforma educativa Educaplay como recurso tecnológico para el desarrollo de actividades interactivas. La investigación adopta un enfoque mixto y se estructura mediante el Diseño Transformativo Secuencial (DITRAS). Para su desarrollo, se realizaron observaciones de sesiones de clase con y sin el uso de tecnología, una encuesta dirigida a docentes de primaria de la institución, y entrevistas a expertos en el área de Lengua y Literatura. Los resultados evidencian que las actividades interactivas diseñadas en Educaplay incrementaron significativamente aspectos como la atención, la motivación y el desempeño académico de los estudiantes, especialmente, en lo que respecta a habilidades fonológicas, silábicas y a la comprensión lectora. En conclusión, la intervención pedagógica, sustentada en el enfoque global-analítico y en el desarrollo de las conciencias lingüísticas y la comprensión lectora en etapas iniciales, combinada con el uso adecuado de actividades interactivas en la plataforma Educaplay, favorece un aprendizaje significativo, motivador y autónomo en las primeras fases del proceso lector.

Palabras clave

Conciencias lingüísticas, Educaplay, lectoescritura, método global-analítico.

1. Introduction

Today, education is a fundamental pillar that guarantees students' rights to receive a quality education tailored to their needs. The United Nations Educational, Scientific and Cultural Organization (2023) emphasizes its position on technology in education:

Learning to live both with and without digital technology; taking what is necessary from an abundance of information, but ignoring what is not; letting technology help, but never supplant, the human connection on which teaching and learning are based... We must focus on learning



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outcomes, not on the digital contribution. To contribute to improving learning, digital technology should not replace face-to-face interaction with teachers, but rather complement it (p. 24).

Therefore, quality education must be grounded in the principles of social equity and the pressing need to ensure truly inclusive educational processes. In some educational contexts, inclusion is considered a way of managing the needs exclusively of students with disabilities. However, in the international context, this concept involves a much broader vision related to "a reform that supports and addresses the diversity of all learners" (United Nations Educational, Scientific and Cultural Organization, 2009, p. 6). This means that educational processes must consider disabilities and, in addition, the different learning difficulties and styles of students.

SDG 4 calls for "ensuring inclusive and equitable quality education" (UN, 2015, p. 16), which requires strengthening literacy instruction from the earliest stages. International assessments demonstrate this urgency; for example, The PIACC program showed that Mexico is at level 2 in reading proficiency, while Ecuador has 38% of its students at level 1 (National Institute for Educational Evaluation, 2019, pp. 23–54); similarly, PISA-D reported that "51% of 15-year-olds have low reading performance" (National Institute for Educational Evaluation, 2018, p. 41), and the ERCE revealed that "44% of 3rd-grade students and 68.8% of 6th-grade students are at the minimum proficiency level" (UNESCO, 2022, p. 12).

At the national level, the Ser Estudiante test revealed that 58% of elementary school students do not reach the minimum level in Language and Literature and that 68% present "6 or more spelling errors in their compositions" (National Institute for Educational Evaluation, 2025, pp. 25–35). Finally, Ecuadorian legislation on education guarantees inclusive education and establishes that:

All students must be assessed, if necessary, to determine their educational needs and the characteristics of the education they require. The education system will promote the early detection and intervention of special learning difficulties and learning-related factors that put these children and young people at risk, and will take measures to promote their recovery and prevent them from falling behind or being excluded from school (Ministry of Education, 2012, p. 7).

This inclusive approach highlights the commitment to protecting students' rights and addressing their needs promptly. In this context, analyzing and understanding the ambitious demands of the outside world is fundamental to providing quality education and implementing education laws at the smallest levels.

This study was conducted in a public school located in the urban area of Cuenca, in the province of Azuay, where it was identified that primary school students (ISCED Level 1), afternoon session, exhibit significant difficulties in developing literacy skills. According to the results of the diagnostic test administered at the beginning of the school year, a group of students was identified who present more severe problems with the development of these skills and who, although they do not have a prior psychoeducational diagnosis, show signs related to learning difficulties. Learning difficulties are defined as "various problems that share the undeniable fact of difficulty in learning optimally, that is, effectively, within the established timeframe, and without extraordinary human and material resources" (Romero-Pérez & Lavigne-Cerván, 2005, p. 9).



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On the other hand, the adverse circumstances facing the Ecuadorian education system, such as the reduction of class hours in the afternoon session, established in the guidelines to guarantee educational continuity during the national energy crisis (Ministry of Education, 2024), are factors that hinder the normal development of planned activities in educational institutions and exacerbate the situation for this group of students. In this context, it is necessary to implement a pedagogical strategy to compensate for lost time and ensure that students can reinforce their learning at home.

Given the problem described, the following research question is posed: How can the development of literacy skills be strengthened in primary school students (ISCED Level 1)? This research seeks to analyze the pedagogical strategies that can be implemented inside and outside the classroom to strengthen the literacy skills of this group of students. In this sense, it is considered necessary to select the most appropriate methods for teaching literacy. Based on the research question, the general objective is to strengthen the literacy skills of primary school students (ISCED Level 1) through interactive activities on the Educaplay educational platform. To this end, the following specific objectives are established: to identify the main difficulties in the literacy process of this group of students; to design an educational intervention proposal that adapts to the TPAK model and includes interactive activities from the Educaplay platform for literacy development; and to assess student progress throughout the process. This study summarizes the most relevant elements and considerations developed in the thesis work of Pesántez-Carmona and Cevallos-Benavides (2025), which focused on the use of the Educaplay platform as an educational resource to strengthen the literacy process in primary school students (ISCED Level 1). Regarding the organization of the article, section 2 presents the concepts and theoretical foundations related to the research; section 3 presents a review of studies and experiences on the use of digital resources in literacy; section 4 describes the methodology employed; section 5 shows the results obtained during the implementation of Educaplay; and finally, section 6 presents the conclusions of the study.

2. Literature review

2.1 Language teaching methodology and national curriculum for the development of literacy

The Ecuadorian curriculum posits that learning to read and write is a multifaceted process, encompassing four main areas that must be addressed simultaneously. These areas are: the language system, written production, text comprehension, and written culture. This holistic view recognizes that the development of reading and writing is not limited to technical aspects but also includes social and cognitive practices. In this context, the language system consists of learning the alphabetic code, developing linguistic awareness, and mastering spelling (Ministry of Education, 2016, p. 76).

2.2 Initial teaching of the alphabetic code and linguistic awareness

Learning the alphabetic code is fundamental to literacy processes, allowing students to understand the relationship between sounds and graphemes. However, in traditional schools, teaching the alphabetic code is often confused with teaching literacy, since knowing how to read and write is much more than learning a code and correctly forming letters. This is why the Language and Literature curriculum "suggests a path for teaching the phoneme-grapheme relationship (alphabetic code), whose objective is to overcome the associative methods of rote memorization" (Ministry of Education, 2016, p. 80). This phonological path



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includes three stages. The first consists of developing linguistic awareness, the second, the phoneme-grapheme relationship, and the third, conventional orthographic writing.

This curricular proposal is not entirely feasible, since it suggests that the teacher should not intervene in syllable formation and that this process should develop intuitively in the student. This idea is far removed from what is intended and what actually happens in the classroom. Students in the early stages of literacy already struggle with identifying and memorizing the similar sounds of some letters of the alphabet. If the teacher doesn't intervene to explain that these letters, when combined with vowels or other consonants, form syllables, and that these in turn generate other sounds, reading will be much more complex and the learning process much slower. It is not surprising, then, that in assessments administered by the National Institute for Educational Evaluation to fourth-grade students, 66.8% have difficulties with spelling, particularly with the use of accent marks: "Level 0.- The text presents six or more spelling errors (use of accent marks on acute, grave, and proparoxytone words; use of capital letters)." (National Institute for Educational Evaluation, 2025, p. 33). These results confirm that syllabic awareness has not been addressed at previous levels. At this point, it is crucial to consider that linguistic awareness, including syllabic awareness, must be developed simultaneously.

2.2.1 Linguistic awareness

As previously stated, an essential element for learning to read and write is the development of linguistic awareness, which manifests itself in the understanding of various levels of language: lexical, semantic, syntactic, and phonological. The development of linguistic awareness not only allows for the identification and manipulation of language units but is also fundamental for accessing the writing system in a comprehensive and functional way. In this regard, the Ministry of Education of Ecuador recognizes that its development is fundamental for literacy learning and explains the following:

The development of linguistic awareness encompasses the development of lexical awareness (word morphology and the word as the smallest unit of speech), semantic awareness (the meaning of words, phrases, sentences, and longer texts), syntactic awareness (the relationship between words within a sentence), and phonological awareness (sounds). The latter is primarily addressed in relation to phoneme-grapheme correspondence (Ministry of Education, 2016, p. 79)

The development of each of the linguistic awareness levels mentioned in the curriculum plays a crucial role in literacy learning and must be addressed simultaneously. These levels of awareness are interconnected, enabling children to understand, construct, and produce language meaningfully. Therefore, from a pedagogical perspective, teachers must be able to design integrated, engaging, and contextualized activities that foster metalinguistic reflection from the earliest years of schooling.

2.3 The teacher's role as a mediator of language learning

The constructivist educational approach considers that all students, as native speakers, arrive at school with cognitive, affective, and motor skills. That is, they possess prior knowledge upon which new learning is built. In this sense, "the role of the school is precisely to mediate the learning that students do not acquire on their own" (Ministry of Education, 2016, p. 83). Thus, the teacher's role serves as scaffolding for students to connect their prior knowledge with new experiences.



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The curriculum guidelines establish that "at the Elementary Basic Education level, the teacher has the responsibility to teach reading and writing" (Ministry of Education, 2016, p. 76), using the phonological approach detailed above. Consequently, the Language and Literature curriculum addresses specific skills that integrate the use of Information and Communication Technologies (ICTs) to improve oral communication, reading, and writing abilities. In this sense, the teacher's role consists of adopting "a fundamental role as mediator, facilitator, and creator of the necessary conditions for learning to occur" (Aboal et al., 2015, p. 233). In other words, the teacher must not only have sufficient mastery of the content the students are learning but must also be able to diversify the use of teaching resources to address different learning styles.

2.4 Methodological approaches to literacy

There are various teaching methods for the literacy process. Traditionally, three main approaches are distinguished: synthetic, global or analytical, and mixed. Below is a comparative table summarizing the main characteristics of each method, its subtypes, and the sources that support them.

Method	Models/subtypes	Description	Source
Synthetic	Alphabetic, Syllabic, Phonic/phonemic	It progresses from the smallest units (letters or syllables) to more complex units (words and phrases).	Lucas- Griñán (2014); Puñales- Ávila et al. (2017); Tangarife- Chalarca et al. (2016)
Alphabetic			Puñales-Ávila et al. (2017)
Syllabic		It consists of memorizing the alphabet and combining them to form syllables and words.	Lucas- Griñán (2014); Puñales- Ávila et al. (2017)
Phonic/Phonemic		Progressive instruction of vowels and letters, followed by combining them to form syllables and then words;	Lucas- Griñán (2014); Puñales- Ávila et al. (2017)
Analytic-Global		It is based on teaching letter sounds and direct, inverse, and complex syllables;	Lucas- Griñán (2014); Tangarife- Chalarca et al. (2016); Puñales- Ávila et al. (2017)



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Mixed or Eclectic	It begins with recognizing complex units (words or phrases) and progresses to analyzing their constituent elements;	Lucas- Griñán (2014); Tangarife-Chalarca et al. (2016); Puñales-Ávila et al. (2017)
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Table 1. Methods for teaching literacy

2. 5 The global method as an integrative approach to the proposal

Currently, contributions from constructivist learning theories have superseded the debate on methods for teaching the alphabetic code. Indeed, teachers must focus on understanding how students learn and utilize the resources of different methods, prioritizing meaning and functionality. Thus, authors like Aboal et al. (2015) point out that teachers should, "on the one hand, motivate children to read and write through real-life experiences, making them feel the need to communicate. On the other hand, create functional situations in which children see that written language is useful" (p. 252). However, it is crucial to consider that "in each eye fixation, the reader perceives a set of graphic elements as a whole" (Higueras-Gámez, 2017, p. 8). The author notes that, in this process, the brain interprets the information from each glance and reads it. It has been shown that during reading, fixations occupy most of the time. In this sense, it follows that fewer fixations lead to greater speed and fluency in reading.

From this analytical perspective, a global analytical approach is adopted for the introduction of the alphabetic code. This approach consists of analyzing and breaking down sentences or words into the smallest unit of written language. This is done while also considering the development of linguistic awareness, as stated by the Ministry of Education (2016): "to enable students to construct the conventional orthography of the language, based on phonological and semantic reflection" (p. 82). It is important to consider that, in this process, students may face various difficulties, such as confusion with phonemes, difficulty segmenting words into syllables, and complications structuring sentences. Therefore, it is necessary to address these difficulties through the development of linguistic awareness.

2.6 Learning theories that underpin the use of ICTs

The integration of ICT in the pedagogical field must be based on learning theories to give meaning to its use in educational contexts. Among the most relevant approaches are Piaget's constructivism, Vygotsky's socio-constructivism, and Papert's constructionism. According to Ackermann (2000):

Papert's constructionism, in contrast, focuses more on the art of learning, or 'learning to learn', and on the significance of making things in learning. Papert is interested in how learners engage in a conversation with [their own or other people's] artifacts, and how these conversations boost self-directed learning, and ultimately facilitate the construction of new knowledge. Papert's constructionism, in contrast, focuses more on the art of learning, or "learning to learn," and on the importance of creating



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things during the learning process. Papert is interested in how students engage in conversations with artifacts—their own or others’—and how these conversations enhance self-directed learning and ultimately facilitate the construction of new knowledge.] (p.1).

Despite its orientation toward technology-mediated learning, constructionism retains its constructivist foundations by placing the student at the center of cognitive and social development. Both Piaget and Vygotsky emphasize that activity is the driving force of mental development, albeit with different nuances: “Piaget focuses on the relationship with the material world, while Vygotsky prioritizes interpersonal interaction through reason, affectivity, and instincts” (Aparicio-Gómez & Ostos-Ortiz, 2018, p. 116). Within this framework, constructivist and socio-constructivist approaches conceive of learning as a continuous process influenced by experiences, stimuli, and social interaction. Therefore, the traditional concept of reading readiness is being questioned, since “the concept of reading readiness, so fashionable in the past, has been criticized, even leading to the coining of the derogatory term ‘reading readiness theorists’” (Aboal et al., 2015, p. 250).

The introduction of technology in educational settings aligns with the principles of constructivism, by encouraging the creation of tangible products that strengthen reflection and collaboration. Papert and Harel (1991) explain that:

Constructionism—the word spelled with an n as opposed to the word spelled with a v—has the same connotation as constructivism: learning as the creation of knowledge structures, independent of the circumstances of learning. He then adds the idea that this occurs particularly opportunely in a context where the learner is consciously engaged in constructing a public entity, be it a sandcastle on the beach or a theory of the universe (p. 2).

In this way, technology not only supports the acquisition of content but also fosters meaningful learning based on knowledge construction, interaction with society, and self-regulation. Therefore, incorporating technology into the classroom involves adapting spaces where students actively participate, enabling them to create, explore, and transform their environment, thus consolidating learning with personal and social significance.

2.7 TPACK Model

The TPACK model, developed by Mishra and Koehler in 2006, aims to guide teachers in the effective integration of technology into educational processes. In other words, for a teacher to use technological tools meaningfully, they must master curricular content, teaching methodologies, and technological knowledge. Salas-Rueda corroborates this, stating that technological, pedagogical, and disciplinary knowledge foster the creation of innovative and creative spaces for learning and teaching (Salas-Rueda, 2019, p. 3).

2.8. Educaplay in the literacy process

The Educaplay digital platform is a highly versatile educational tool that allows users to create their own pedagogical content by designing interactive activities. No advanced programming knowledge is required, so teachers can easily and quickly create their own activities and share them via web links, blogs, or educational platforms (Páez-Quinde et al., 2022, p. 37). With the recent development and integration of Artificial Intelligence, this platform has experienced significant improvements through a virtual assistant and prompts, making it possible to design activities in less time. However, it is important to note



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that this capability comes at a cost, as do services such as student registration and activity reporting.

3. Methods and materials

The research was conducted using a mixed-methods approach based on Sequential Transformative Design (DITRAS), which allowed for the integration of quantitative and qualitative techniques to understand in detail the difficulties experienced by primary school students (ISCED Level 1) in learning to read and write. The study was carried out in a public school located in the city of Cuenca, Azuay province, specifically during the afternoon session, where a group of students with significant difficulties in developing the alphabetic code, linguistic awareness, and reading comprehension was identified.

The sample was selected non-probabilistically, taking into account the nature of the problem. Twenty-four students from the level, twenty-two primary school teachers, and two language and literature experts participated, the latter providing specialized criteria to strengthen the interpretation of the findings.

Different techniques were combined in the data collection. Two observation checklists were used: one to record student performance during a class without technology and another to evaluate the effect of interactive activities developed in Educaplay. A Likert-type survey was also administered to teachers to identify their perceptions related to literacy instruction and the integration of technological resources. Additionally, semi-structured interviews were conducted with two specialists, who provided insights into the reading and writing process, the methodological approach, and recurring difficulties at this level. Results from the second and third trimester institutional assessments were also collected, aligned with categories such as phonological, lexical, and semantic awareness, as well as reading comprehension.

Data analysis was performed using differentiated procedures according to the nature of the data. Quantitative information was processed using SPSS, which allowed for the generation of descriptive statistics and the determination of the reliability of the instruments used. For this purpose, Cronbach's alpha coefficient was used, with values ranging from 0.792 to 0.992, indicating high internal consistency. Regarding the qualitative data, interview and observation transcripts were organized and coded using MAXQDA, following the corresponding coding processes. This allowed for the construction of interpretive matrices by category and the establishment of relationships between the findings.

Finally, the results underwent methodological triangulation, integrating information from surveys, observations, interviews, and academic assessments. Based on these inputs, the theoretical framework and discussion were developed, comparing the findings with previous studies related to the use of ICT, literacy instruction, and the application of the whole-word approach. This process allowed for the generation of well-founded conclusions that guide the proposal for academic strengthening through interactive resources.

4. Results

4.1 Observation sheet without the use of technology

This analysis stems from the observation of a literacy class session with primary school students (ISCED Level 1). Among the most relevant aspects noted in the observation sheet, without the use of Educaplay, was low student attention and participation. Only 16.67% showed consistent attention to the teacher's instructions and directions. The overall level



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of interest was limited, with only 20.8% of students maintaining interest throughout the activity. Enthusiasm for the class was also scarce, with only 20% of students participating during the reading and writing activity. Therefore, the lack of interactivity and student motivation resulted in limited voluntary participation. These results align with Salas-Rueda's (2019) findings, who argues that when technology is not meaningfully integrated, it limits students' intrinsic motivation and active engagement.

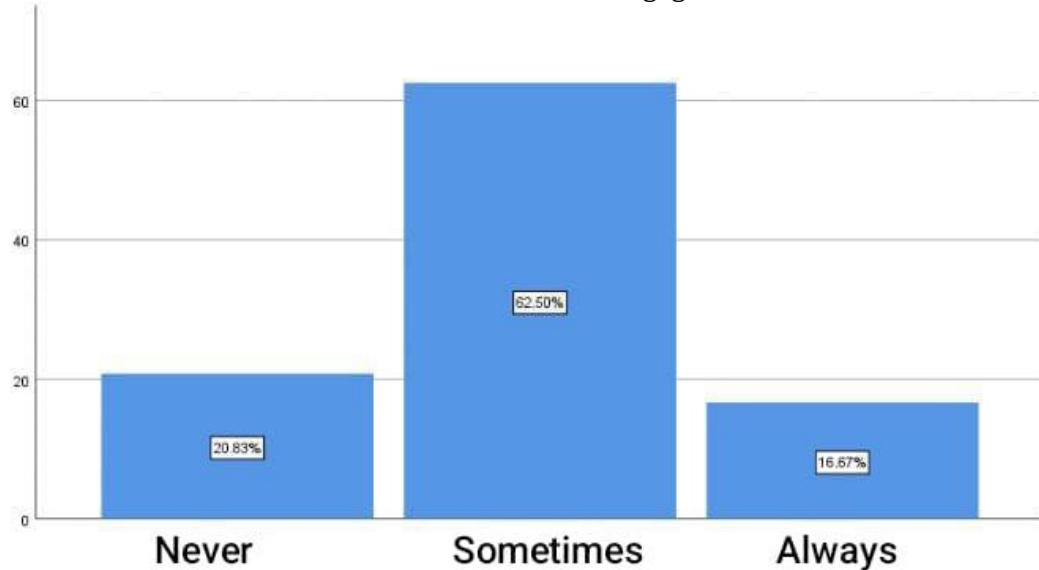


Figure 1. Percentage of student attention in a class session without using Educaplay

4.2 Second Quarter Summative Assessment

To characterize the level of development of students' literacy skills, the second-term summative assessment is used as a reference. This assessment allows for the evaluation of the basic skills that enable the development of literacy at the level of linguistic awareness, as well as initial reading comprehension. A frequency table corresponding to each category is presented below.

Variable	Meets	Percentage	Does not meet	Percentage
Phonological comprehension	19	79.2	5	20.8
Lexical comprehension	1	4.2	23	95.8
Syllabic comprehension	12	50	12	50
Morphological comprehension. Creation of new words by adding a suffix	17	70.8	7	29.2
Syntactic comprehension	15	62.5	9	37.5



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Semantic comprehension.	16	66.7	8	33.3
Words that belong to the same category				
Reading comprehension	5	20.8	19	79.2
Total number of students evaluated	24	100	24	100

Table 2. Results of the second quarter summative assessment

Thus, a high percentage of students demonstrate moderate proficiency in phonology (79.2%) and morphology (70.8%), while syllabic and semantic skills show a balanced level of 50% and 66.7%, respectively. However, lexical and reading comprehension skills are alarmingly weak, as indicated in the table, with 4.2% and 20%, respectively, exhibiting a significant level of difficulty. These data align with the "Being a Student" report (National Institute for Educational Evaluation, 2005), which indicates that 68% of students make more than six spelling errors and have serious difficulties structuring sentences and understanding written texts. Therefore, these results allow us to identify the students' strengths and main weaknesses, facilitating the design of a relevant pedagogical intervention that encompasses all literacy skills, as each one has potential for improvement.

4.3 Teacher survey

The survey results show that the greatest difficulty in literacy processes lies in phonological and syntactic skills. In this regard, structuring coherent sentences presents a significant challenge for students, reinforcing the assessment results. On the other hand, although respondents reported less difficulty with lexical and semantic skills, these remained present in a considerable number of responses. Regarding writing whole words and reading comprehension, professionals believe that students face moderate barriers, suggesting a need to strengthen their decoding and reading comprehension skills.

Regarding the use of technology in literacy learning processes, the results indicate that most teachers surveyed use interactive platforms such as Educaplay, Wordwall, Liveworksheets, Genially, and Kahoot for this purpose. They frequently use these platforms at the beginning of a class, during content development, or as reinforcement activities for homework.

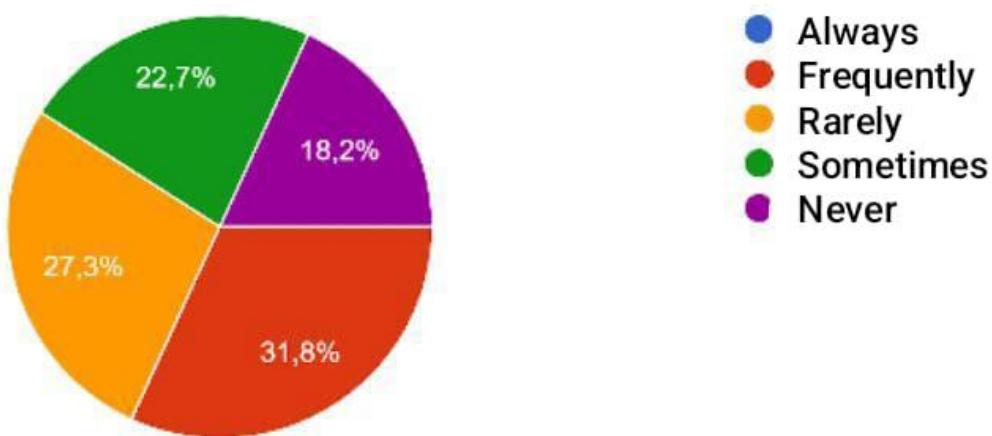


Figure 2. Frequency with which teachers use Educaplay for teaching literacy



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When asked about the frequency of use of the Educaplay platform, it became clear that, although the employability rate varies considerably, participants are familiar with it, indicating a positive level of technological familiarity. Furthermore, they agreed that incorporating these tools fosters student motivation and participation through timely feedback. This idea is supported by the findings of Páez-Quinde et al. (2022), who argue that Educaplay promotes meaningful student participation by allowing them to interact with graded activities without requiring high levels of digital literacy.

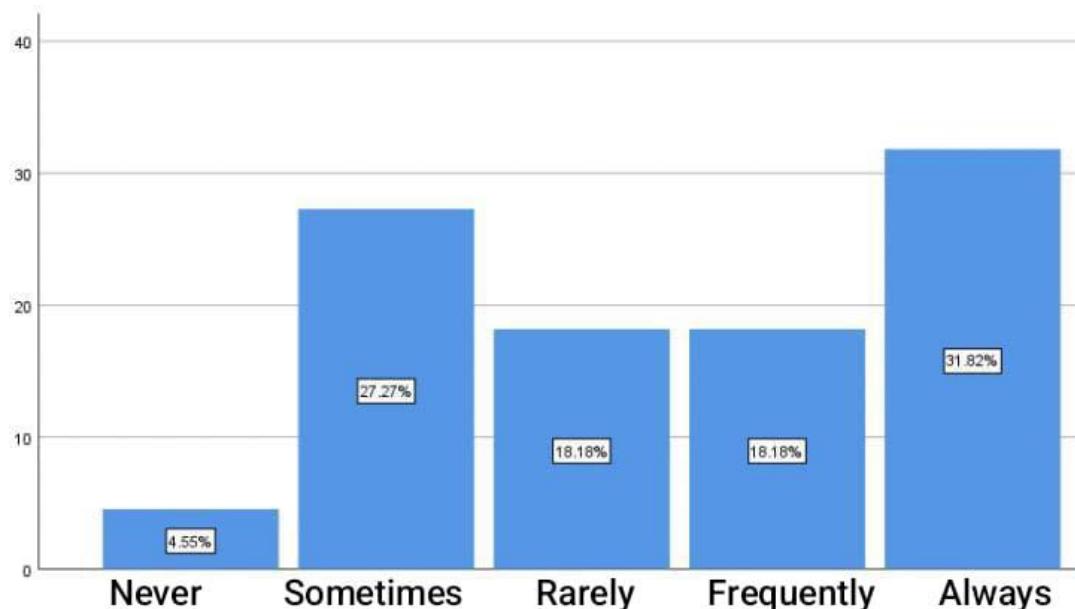


Figure 3. Percentage of application of the global method in the teaching of literacy

The indicators suggest that, of the literacy methods consulted—including whole-word, alphabetic, syllabic, phonetic, and mixed—the whole-word method stands out with the highest percentage of use, at 31.8%, in situations where it is "always" used. On the other hand, the syllabic method is used frequently, at over 54.5%. Meanwhile, the phonetic method represents a percentage of 40.9%. Therefore, these results demonstrate a consensus regarding the frequent use of mixed methods, especially the whole-word method. This relates to the findings of Lucas-Griñán (2014), who points out that eclectic methods allow for responding to different learning styles.

4.4 Interview with experts in the area of Language and Literature

In the qualitative analysis of the interviews, a systematic coding process was carried out using the MAXQDA program. This software allowed for the organization and classification of the responses to the nine questions asked of each interviewee. It is important to note that this program "allows for the calculation of code application through a clear use of coding frequency while also allowing the visualization of the codes in the document" (Casasempere, 2024, p. 2). From the systematic coding, recurring patterns and words were identified among the interviewees, which facilitated the clear and concise structuring of the main analysis results. The main findings are presented below:



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Criteria based on objectives	Expert 1	Coding	Expert 2	Coding	Analisis
Difficulties in reading and writing	Focus on intrinsic student factors and pedagogical deficiencies.	A.1. Lack of motivation towards reading and writing, A.2. Absence of relevant and contextualized processes, A.3. Lack of connection with the learning environment, A.4. Loss of interest in reading due to previous negative experiences, A.5. Mismatch between curriculum and teaching practice.	Focus on cognitive, developmental, and sociocultural barriers.	B.1. Limitations of adult-centrism in education, B.2. Critique of traditional methodologies, B.3. Errors in oral language,	Both experts agree that literacy difficulties stem from internal factors within the student, as well as from the teaching environment.
Intervention proposal	Communicative approach supported by the use of technology, gamification, and an eclectic method of literacy instruction. Emphasis on pedagogical and curricular mastery, incorporating the positive aspects of	Reflective use of technology and relevant, contextualized hybrid methodologies for developing linguistic awareness.	B.4. Communicative approach, B.5. Gamification, B.4. Accessibility, B.5. Educational relevance, B.6. Feedback, B.7. Emotional self-regulation, B.8. Methodological	B.4. Communicative approach, B.5. Gamification, B.4. Accessibility, B.5. Educational relevance, B.6. Feedback, B.7. Emotional self-regulation, B.8. Methodological	



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traditional methodologies.	syncretism, B.9. Linguistic awareness, B.10. Whole language approach, B.10. Reading for life, B.11. Logical thinking, B.12. Respecting the child's pace and world.
Assessment of student progress	<p>Student progress is determined by the ability to self-regulate their learning, motivated by achievement s and feedback.</p> <p>A.6. Incorporation of educational technologies, A.7. Readings based on student interests, A.8. Gamification, A.9. Games with pedagogical purpose, A.10. Eclectic method, A.11. Appreciation of traditional methods, A.12. Communicative approach, A.13. Curriculum mastery.</p>

Table 3. Coding and interpretation of interviews

Experts explain literacy difficulties from a holistic perspective that integrates internal student factors, environmental conditions, and limitations in teaching practice. This aligns



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with Aboal et al. (2015), who emphasize the need to create meaningful experiences tailored to children's interests. The development of linguistic awareness within the communicative approach is also highlighted, promoting the use of relevant technology and eclectic methods to address diversity. According to Higueras-Gámez (2007) and the Ecuadorian curriculum (Ministry of Education, 2016), progress assessment should focus on autonomy, self-correction, and guided self-evaluation. They add that asynchronous learning enhances the meaningful construction of knowledge.

4.5 Intervention process

Based on the positive results and the great reception the Educaplay platform received during in-person classes, a pedagogical intervention process is being implemented to strengthen the literacy skills of this group of students. This intervention includes the design of interactive activities on the Educapplay platform, which focus on developing linguistic awareness and reading comprehension. It is important to note that the activities proposed on the platform are sent as academic reinforcement assignments. Therefore, students must complete them at home.

To implement this proposal, students receive a detailed explanation of the steps to access the platform. A video tutorial is also created and shared in the WhatsApp group so parents can support them in this process. To track student participation, an academic plan is purchased for the Educapplay platform. This plan allows for the enrollment of an unlimited number of participants and generates an invitation code that students can use to access and complete the activities. Their participation is automatically recorded, including the number of plays, time spent, and their lowest and highest scores.

USUARIOS	JUGADAS	PRIMERO	MEDIA	MEJOR	Acciones
Invitado 15	25	70	93	100	
Invitado 13	4	70	80	100	
Invitado 4	5	100	98	100	
100.000	2	100	95	100	
Invitado 17	3	90	93	100	
Invitado 14	2	100	90	100	
Invitado 7	3	90	90	100	
"UPC-BYQ-KTR"	3	90	93	100	
Invitado 1	4	80	90	100	
Invitado 10	2	90	95	100	
Invitado 23	1	100	100	100	
Invitado 19	1	80	80	80	
Invitado 3	4	80	78	90	

Figure 4. Report on student interactivity on the Educapplay platform

The platform's report suggests that students tend to repeat the same number of attempts until they achieve the highest score. As they repeat the activity, the time they spend completing it decreases. These results provide insight into the impact of immediate feedback and the importance of repetition in the learning process.



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4.6 Main findings from the Observation sheet using Educaplay

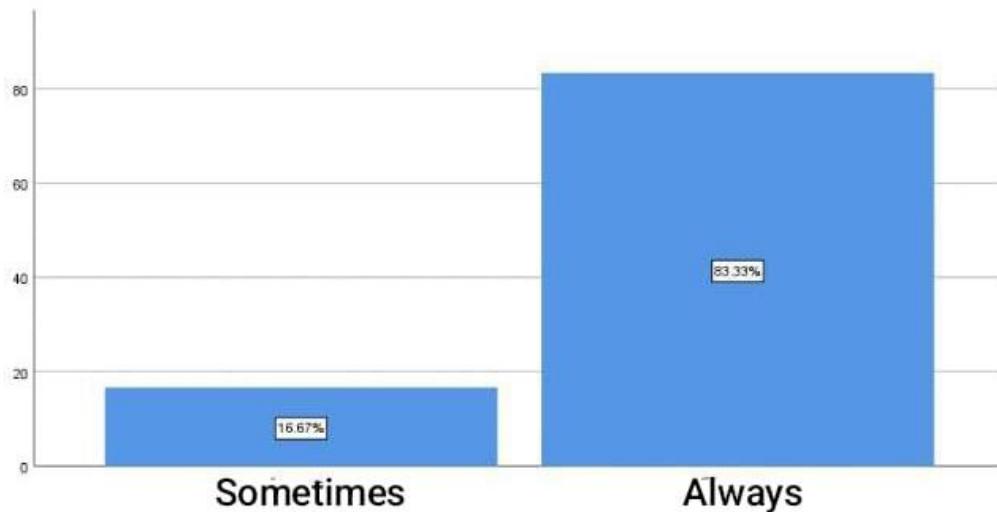


Figure 5. Percentage of student attention using Educaplay

As shown in the graph, the literacy class session, conducted with the same group of students and incorporating interactive activities from the Educaplay platform to develop language awareness, yielded significant positive results. 83% of the students maintained consistent attention, and 62.5% remained interested throughout the activity. Similarly, the results indicate a high level of enthusiasm and excitement among the students when interacting with the Educaplay educational platform.



Figure 6 Students interacting with the Educaplay platform

As can be seen in the image, student participation is active, their attention focused on identifying the correct answer to obtain the highest score. Therefore, as they develop the proposed activities, they not only strengthen their literacy skills but also become familiar with the use of technology for educational purposes. This significant change can be explained by Papert's constructivist theory, which posits that learning is enhanced when students interact with tangible digital objects (Papert, 1991). Consequently, this strategy fosters self-regulation and motivation through immediate feedback, factors also highlighted by the experts interviewed.

For the third-quarter summative assessment, which was administered after the implementation of the pedagogical approach, the categories of analysis used in the second-quarter assessment were maintained, specifically linguistic awareness (lexical, syllabic,



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phonological, and syntactic) as well as reading comprehension in its initial stages. It is important to clarify that this is not an identical test to the one administered in the second term, nor is it a post-test. Rather, it is a different assessment specifically designed to evaluate the student's progress after the intervention. To this end, the specific content of the instrument was modified. For example, new words were included for segmentation, different sentences were used to assess syntactic awareness, and a different reading comprehension exercise was used, with equivalent levels of complexity. The following table details the results obtained in this assessment:

Variable	Meets	Percentage	Does not meet	Percentage
Phonological comprehension	21	87.5	3	12.5
Lexical comprehension	8	33.33	16	66.7
Syllabic comprehension	18	75	6	25
Morphological comprehension. Creation of new words by adding a suffix	19	79.2	5	20.8
Syntactic comprehension	20	83.3	4	16.7
Semantic comprehension. Words that belong to the same category	16	66.7	8	33.3
Reading comprehension	20	83.3	4	16.7
Total number of students evaluated	24	100	24	100

Table 4. Third Quarter Assessment Results

The following cumulative bar chart shows the results obtained in the second and third trimester assessments, allowing for a visual and comparative analysis of the variations in the development of reading and writing skills among this group of students. The chart's structure represents the combined performance levels in each of the assessed categories (linguistic awareness and reading comprehension), both before and after the medium-term pedagogical intervention using the Educaplay platform. The chart allows observation of the distribution of achievement levels by skill and a comparison of progress between the two trimesters. This visualization is useful for demonstrating the improvements achieved after the intervention, as it shows the increase in students who performed satisfactorily and the decrease in those with significant difficulties.



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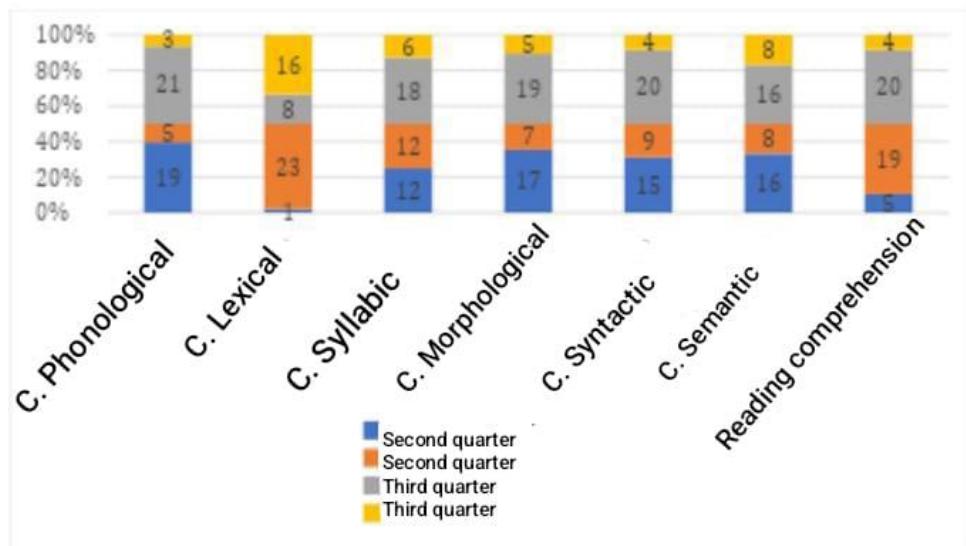


Figure 7. Percentage of results from the second and third quarter assessments

5. Discussion of the results

The results obtained from methodological triangulation allow us to understand the complexity of the significant difficulties faced by primary school students (ISCED Level 1) in the literacy learning process. This finding coincides with the report from the National Institute for Educational Evaluation (2025), which clearly shows that a significant percentage of students fail to consolidate basic reading comprehension skills in their initial stages. According to Romero-Pérez and Lavigne-Cerván, this problem can be associated with interrelated factors such as poverty, malnutrition, and especially with decontextualized pedagogical practices that limit students' meaningful learning (Romero-Pérez & Lavigne-Cerván, 2005). Therefore, these results validate the need for a specific intervention to address this problem.

Regarding the perceptions of the surveyed teachers, the quantitative results demonstrate a significant familiarity with the use of interactive tools in their teaching practice and a frequent use of eclectic methods, with the whole-word approach being one of the most frequently used. This teaching practice aligns with the proposal of Lucas-Griñán (2014), who points out that combined literacy methods better address the diversity of learning paces and styles. Furthermore, it was evident that the use of platforms such as Educaplay, Geneally, and Wordwall was positively valued by teachers as complementary educational resources. However, as Salas-Rueda (2019) states in the TPACK model, technological knowledge alone does not guarantee effective integration unless it is properly articulated with pedagogical and disciplinary knowledge. Nevertheless, despite the recognition of the benefits and pedagogical value offered by interactive tools, challenges remain in teacher training regarding the design and reflective application of educational platforms.

The qualitative analysis of interviews with specialists in the field of Language and Literature delves into the possible causes of the observed difficulties. The experts agree that the student's cognitive and developmental factors influence this process and that this phenomenon is exacerbated by decontextualized pedagogical practices disconnected from the child's interests. These observations align with the arguments of Aboal et al., who maintain that the development of literacy skills in the initial stages should be based on



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meaningful experiences relevant to the child's world (Aboal et al., 2015). Similarly, the need to implement methodologies based on a communicative, gamified approach with a pedagogical focus on the meaning of language is highlighted. As Salas-Rueda indicates in 2019, when well-designed, these methodologies promote motivation, engagement, and emotional self-regulation.

Observations during classroom sessions with and without the use of Educaplay reveal a significant change in student participation. In the first class session, students showed little attention and participation, while in the technology-mediated class, 83% of students maintained sustained attention and demonstrated enthusiasm while participating in the activities. This finding supports Papert's assertion (in Ackermann) that learning is enhanced when students construct knowledge through motivating, manipulable, and meaningful means. It also reaffirms what experts have stated regarding the improvement of academic performance, self-regulation, and educational autonomy through motivation and immediate feedback.

Finally, the data obtained from the third-quarter summative assessment demonstrate a significant improvement in reading and writing skills. Following the integration of interactive activities into the Educaplay platform, the percentage of students who demonstrated significant progress in phonological awareness increased from 79.2% to 87.5%, while the percentage for reading comprehension rose from 20.8% to 83.3%. This result validates the findings of authors such as Salas-Rueda (2019) and Páez-Quinde et al. (2022), who agree that the planned implementation of platforms like Educaplay within a holistic-analytical approach can enhance the development of linguistic skills, provided it is appropriately contextualized to the student's environment and needs.

6. Conclusions

The research met its objectives. First, it identified that primary school students (ISCED Level 1) exhibit significant difficulties in developing literacy skills, particularly in lexical awareness, syllable segmentation, and reading comprehension. These findings were initially identified through the second-term summative assessment and subsequently corroborated by the perceptions of the surveyed teachers, who confirmed similar deficiencies in literacy, highlighting lexical awareness, syllable segmentation, and reading comprehension as the most critical aspects. Despite methodological efforts, they indicated that structural deficiencies persist at these levels, validating the need for a specific intervention to address this problem.

Second, the pedagogical intervention, designed using the TPACK model and implemented through interactive activities on the Educaplay platform, demonstrated a positive impact on the literacy learning process of primary school students (ISCED Level 1). The proposal integrated the components of content, focusing on linguistic awareness and reading comprehension; pedagogy, through playful strategies that fostered curiosity, motivation, and active participation; and technology, with interactive activities that offered immediate feedback and enabled independent practice of the exercises. The playful design encouraged curiosity and a desire for improvement through voluntary repetition of the exercises. This independent repetition facilitated memorization, the recognition of linguistic patterns, and the consolidation of basic written language concepts. Consequently, it enhanced the progressive development of linguistic awareness, which facilitates reading fluency and comprehension.



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Thirdly, the instant feedback offered by Educaplay was a key factor in learning, allowing students to correct their errors immediately and better understand the concepts, thus reinforcing their literacy development and acquisition. On the other hand, the third-quarter summative assessment, administered at the end of the intervention, showed significant improvements in all evaluated dimensions, both in terms of academic performance and attitudes toward learning. These results confirm the positive impact of the intervention and reaffirm the value of technology as an effective resource for developing literacy skills in early childhood education students.

Finally, the use of interactive activities designed on the Educaplay platform proved to be an effective resource for strengthening literacy skills in elementary school students (ISCED Level 1). The intervention promoted a significant increase in motivation and in the acquisition of the alphabetic code and the development of linguistic awareness, as well as text comprehension in its initial stages. Through the repetition of exercises and immediate feedback, improvements were generated in both academic performance and students' attitudes toward learning to read and write.

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Declaration of authorship-CRediT

ELIZABETH PESANTEZ-CARMONA: Conceptualization, methodology, formal analysis, research, data analysis, writing.

DIANA CEVALLOS-BENAVIDES: Conceptualization, methodology, formal analysis, research, data analysis, writing, supervision, final review.

Declaration of the use of artificial intelligence

The authors declare that they used the ChatGPT tool (OpenAI) partially during the manuscript preparation stage, specifically to assist with the syntactic restructuring of some paragraphs, as well as to generate alternative versions of titles and subtitles, which were subsequently reviewed and adjusted manually. Artificial intelligence was not used for writing the methodological design, data analysis, interpretation of results, or academic discussion. All content was reviewed and validated by the authors, who are responsible for the accuracy, coherence, and scientific rigor of the final text.



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Artificial Intelligence (AI) and its use in creative writing

La Inteligencia Artificial (IA) y su uso en la escritura creativa

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Abstract

The use of ChatGPT without guidance or support raises concerns among teachers, parents, and educational administrators. This action research project analyzed and compared the style of twenty-four micro-stories generated by AI with twenty-four texts written by university students. Initially, each student asked the ChatGPT application to generate a story



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about the character "ant." Subsequently, a learning sequence was designed, implemented, and analyzed to guide them in writing the same text. In-depth interviews were also conducted with the students to understand their experience before, during, and after this classroom activity. The results showed that AI consistently replicates traditional writing styles in terms of structure and content, limiting the communicative skills and creative abilities of the tool's users, as it prevents them from exploring other forms of text construction or development that transcend the individual writer. Conversely, the stories created by the students demonstrate greater richness and diversity in the construction of characters, plots, and endings, reflecting the volitional and identity-based characteristics of each author. Consequently, classroom experiences, not only those involving writing, should be transformed into opportunities to learn and rekindle students' creative drive, so that the overwhelming presence of AI becomes not a threat, but an ally in the collaborative learning process.

Keywords

ChatGPT, creation, education, writing, Artificial Intelligence

Resumen

El uso del ChatGPT sin acompañamiento ni asesoría provoca preocupaciones en docentes, padres de familia y gestores educativos. Esta experiencia de investigación-acción analizó y comparó el estilo de veinticuatro microcuentos generados por la IA, con veinticuatro textos escritos por estudiantes universitarios. En primera instancia, cada alumno solicitó a la aplicación ChatGPT generar un relato alrededor del personaje "hormiga". Posteriormente, se diseñó, implementó y analizó una secuencia didáctica para escribir el mismo texto. De igual manera, se utilizó una entrevista en profundidad a los estudiantes para conocer cuál fue su experiencia antes, durante y después de esta experiencia áulica. Se evidenció que la IA replica estilos de escritura tradicionales a nivel estructural y de contenido de manera constante, que limita las competencias comunicativas y las facultades creativas de los usuarios de la herramienta, pues les impide explorar otras formas de construcción o elaboración textual en el que trascienda el sujeto escritor. Por el contrario, los relatos creados por los alumnos muestran una mayor riqueza y diversidad en la construcción de personajes, historias y desenlaces, reflejando los caracteres volitivos e identitarios de cada autor. En consecuencia, las experiencias áulicas, no solo de escritura, deben transformarse en oportunidades para aprender y recuperar el impulso creativo de los estudiantes, de manera que la presencia arrolladora de la IA no se transforme en una amenaza, sino en una aliada en el proceso de interaprendizaje.

Palabras clave

ChatGPT, creación, educación, escritura, Inteligencia Artificial.

1. Introduction

Since its origins, humankind has designed tools and devices to solve problems in its environment and satisfy basic survival needs. In prehistory, for example, the axe, the spear, and the bow and arrow were invented. Later came the wheel, the chariot, the steam engine, the printing press, and the automobile. Currently, telecommunications and cybernetics are at the epicenter of global change, which, along with the economy, shapes the destinies of human beings in their family, academic, and professional lives.



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Indeed, today we interact with a wide variety of technologies that supposedly aim to optimize how we perform our daily activities. This is the case with Artificial Intelligence (AI), which arises from the model of artificial neurons mimicking human cognitive abilities, and has extended into the workplace.

In medicine, for example, it uses tools for managing information and medical procedures. In engineering, AI has facilitated the design and simulation of systems that contribute to work optimization through data analysis. In the field of education, "intelligent tutoring systems, administrative tasks, and educational materials" (Bolaño-García & Duarte-Acosta, 2024), among others, have been implemented. However, their use in activities where human faculties prevail has sparked numerous controversies, transforming them into a kind of "ghost with which human beings must coexist" (Flusser, 2023, p. 16) going forward.

This study focused on the creative dimension of writing, particularly the production of a micro-story whose central theme revolves around a character (an ant). Second-year students of the Language and Literature Pedagogy program at the University of Cuenca participated in this experience during the March-August 2024 semester, based on the following question: Can ChatGPT produce creative texts similar to those of human beings? Or, better yet, how can the creative dimension of language, inherent to human beings, be influenced by ChatGPT? Is creativity suppressed or enhanced by the use of ChatGPT? Our objective was to analyze this tool's capacity to produce short fictional texts in comparison to students' creative process after a didactic sequence, from a stylistic perspective.

Therefore, an initial problem is defining what creativity is, as it responds to various contexts and does not allow us to grasp its essence. For example, the Dictionary of the Spanish Language (DLE, 2024) includes two fundamental definitions: "1) f. Faculty of creating. Syn.: inventiveness, imagination, ingenuity, inspiration, brain; 2) f. Capacity for creation. Synonyms: inventiveness, imagination, ingenuity, inspiration, wit" (definitions 1 and 2).

In the first sense, the entry refers to a faculty, which the DLE (Dictionary of the Royal Spanish Academy) itself associates with "intellect, perspicacity, reasoning, ingenuity, originality, imagination, fantasy" (definition 1). That is, creativity is a quality, a faculty of human beings. Chacón, for his part, mentions that within creativity, human processes and capacities converge to generate ideas based on three dimensions: creative process, resulting product, and combination of factors (Chacón, 2005). The first involves the stages that an idea must go through to acquire form, structure, and organization. The second is the resulting product, that is, the materialization of the idea, which must be recognized as original, innovative, and functional by the public.

Finally, the combination of the two previous dimensions, along with external factors such as the cognition of the creative subject, the context, the conditions in which an idea is produced, the reasons for producing said idea, and its functionality when solving a problem. a problem or the criteria for determining it. Once the process is complete, it can be determined whether the creativity has been successful, or whether it constitutes an exercise in imitation rather than invention.

On the other hand, the criteria for evaluating a product as creative can also vary according to a trend, movement, or even school of thought. Penagos and Aluni propose four characteristics of creativity: fluency, flexibility, elaboration, and originality (Penagos and Aluni, 2000). Rodríguez (1997) defines them as follows:

Fluency is the ability to generate a large number of ideas on a specific topic; flexibility relates to the diversity and versatility of ideas from



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various approaches; elaboration refers to the effectiveness of ideas in practice; and finally, originality is the distinction of the idea, process, and product as unique. (p. 11)

Goñi uses these definitions to refer to the creative subject, stating that this individual must generate ideas quickly (fluency), create solutions to problems from a new perspective (flexibility), and produce innovative and distinct ideas (originality). A creative subject is someone who constructs and evolves into a new being, master of their individual and collective memories and contexts; desires, expectations, tensions, dreams, and catharsis. In other words, creativity shapes identities (Goñi, 2000, p. 43).

However, it must be stated that creativity is not limited to artistic pursuits such as painting, music, or film, but rather flows through everyday life, from the very processes of communication at home, university, or work. Every day we need to communicate with others, whether orally or in writing, and as senders, we must be able to express the message clearly and precisely, maintaining a functional structure. Likewise, the receiver must be able to deconstruct the content for comprehension, grasping and translating the communicative intentions, discarding what is superfluous and accidental. This process demonstrates that creativity is a fundamental part of the construction of thought that leads to successful communication. Specifically, and focusing on the educational sphere, Tomalá de la Cruz et al. (2023) agree with García-Peña et al. (2020) that personal and institutional efforts should revolve around teaching reading and writing, and calculation.

Of course, written communication entails additional effort compared to oral communication, as it is more elaborate and artificial; it requires certain protocols, genres, or formats according to the recipients and is generally learned in formal educational settings. One of the tools currently used in teaching related to writing is the ChatGPT application, which uses machine learning techniques to meet the demands of its users.

Language is constantly trained so that its responses are, apparently, coherent and natural. In this sense, prompts (requests, instructions, inquiries) must contain the maximum amount of information possible to achieve a satisfactory result that meets the user's requirements; that is, the communicative tool (words) must be used so that the machine understands what is required. In other words, what would happen if a user did not know how to communicate effectively with another person or, in this case, with ChatGPT to request information? Communication would simply break down. The person must necessarily know, understand, and skillfully and competently use words. These are the right words to accurately express what one wants, feels, and thinks, thus successfully completing the communication circuit.

Next, the classroom experience will be described in each of its stages (data collection, discussion, and analysis), highlighting some aspects considered outstanding, especially during the process of conceiving, writing, and revising the narratives. This part, undoubtedly, constitutes one of the aspects that teachers currently neglect: the student's sensitivity and creativity. Finally, some conclusions regarding this teaching experience are noted, to encourage a rediscovery of the creative powers of both teachers and their students, often silenced by the momentary allure of technology and consumerism.

2. Methodology

This work was conceived from a qualitative approach, specifically as an action research experience. The study focused on the writing of a microfiction piece, whose central theme revolved around a character (an ant). Initially, students were asked to request the



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microfiction from ChatGPT; subsequently, after a four-session in-person learning sequence, the students wrote their own microfiction, based on their classroom experience. Both texts (ChatGPT and student) were analyzed from the perspective of style, primarily structure and content.

This study involved twenty-four second-year students enrolled in the Writing course of the Language and Literature Pedagogy program at the University of Cuenca, Ecuador, during the March-August 2024 semester. This group was selected because the author teaches the course, allowing for a more relaxed and supportive environment for the students throughout the pre-writing, writing, and post-writing phases of the texts. This approach minimized interference caused by the pressure to complete the curriculum or the frequent loss of classes, issues common in many institutions.

Furthermore, and importantly, these students are training to be language and communication teachers at the secondary level of formal education. Their curriculum focuses on teaching reading and writing, as well as understanding and using different academic and fictional genres within family, academic, and professional contexts. For this reason, the contributions of two theorists (Bazerman, 1988 and Russell, 1997) have been incorporated. These theorists, drawing on the "Writing to Learn" and "Writing Across the Curriculum" movements, argue that writing should be approached with the needs of future professionals in mind. In this case, the future professionals are pre-service teachers of reading and writing.

Finally, the importance of this study for the academic community in general was explained to the students, and they were invited to actively participate in each of the activities. Confidentiality and anonymity in the presentation of data were guaranteed, as stated in the consent form approved by the Ethics Committee of the University of Cuenca.

2.1 What did we do, and how?

In the first few classes, we read some texts about the arrival of Artificial Intelligence in classrooms, highlighting some implications in the domestic, academic, and professional spheres. It was precisely in this section that the presence of ChatGPT and its use in our writing course were introduced, encouraging students to participate in a classroom experience focused on writing a micro-story using AI, and following a specific learning sequence.

Once several agreements were reached with the group, the learning sequence was prepared in its different phases: Planning, Action, Observation, and Reflection (Fiore and Leymonié, 2014), lasting eight 60-minute periods. The course has four hours of instruction per week. In the first session of the learning sequence (two hours), the teacher presented the topic (writing a micro-story about an ant character) that would be covered over the next two weeks.

The students were asked to download the ChatGPT (Ask AI) application to their mobile phones. Subsequently, students were asked to enter the following instruction into the application: "Write a micro-story whose main character is an ant." They then began entering their responses (the micro-stories) into the app on their mobile phones, and were asked to share their texts with the group by reading them aloud. Simultaneously, they were asked to send these materials to the teacher via the group's WhatsApp.



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In the following two-hour session, the story “Butterflies,” by Oswaldo Encalada (2002), was presented. Students were asked to read it silently, noting any terms that required further explanation. Once this activity was completed, several students were asked to read the micro-story aloud. The teacher then conducted a similar activity, analyzing some of the story's structural and stylistic characteristics (beginning, development, end, plot, climax, setting, characters, among others). This activity was essential, as it is necessary for students to “read with a writer's eye” (Trujillo, 2017, p. 25) and learn to differentiate and characterize the various stylistic elements of the text.

At the end of the session, students were given the microfiction “Fireflies” by the same author and asked to complete the previous activity at home and prepare a presentation analyzing the story, using the model provided by the teacher. This activity was completed during the third two-hour session, which included feedback from both students and the teacher.

In the fourth session, students were given the following assignment: “Write a microfiction piece whose main character is an ant.” During the two-hour session, students wrote their texts under the teacher's guidance, focusing on the theme and stylistic characteristics of the story. Students were asked to let their texts sit for a week and submit the final version afterward.

Using a corpus of forty-eight texts (twenty-four generated by ChatGPT (Ask AI) and twenty-four created through the didactic sequence), the materials were first analyzed according to the essential characteristics of the short story, without adhering exclusively to any particular movement or theory, as this genre enjoys flexibility in form and content. A table was created that included the two texts belonging to each student: the first generated by ChatGPT (Ask AI), and the second written through the didactic sequence, in order to appreciate and analyze the written products from the stylistic perspective of the micro-story, namely: how the stories begin, what the central theme is, how the characters are presented, what roles they play, and how the text concludes. Similarly, the students were interviewed (Hernández et al., 2014) to learn their opinions about the didactic experience during the pre-writing, writing, and post-writing phases. and to reflect together on teaching practice. This is important to understand the participants' impressions during the writing experience, which included professional and inclusive support from the first session to the submission of the final product.

Finally, the ChatGPT was asked about the dangers of using AI in creative writing. Some of their responses are included in the following section, as resources for extrapolating the data obtained in the teaching sequence.

3. Results

From a general perspective, one of the most striking aspects was the extreme limitation of the stories generated by ChatGPT (Ask AI) in their use of the more refined and evocative terminology characteristic of fiction. This doesn't mean the stories should be filled with convoluted, grandiose, or sophisticated words, but rather with language that captivates and/or entralls the reader from the very first line.

While there are no spelling errors, this is secondary when you consider that the repeated use of terms or structures (ant, anthill, found, colony, crumb, leaf, big, small, path, once upon a time, among others) constitutes linguistic marker or pattern, a kind of cliché that reduces the communicative competence of the users (in this case, the students) and encourages intellectual laziness. Similarly, the phrases lack fluency because the narrative is restricted to a limited number of words and ideas; that is, micro-narratives with different plots and



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characters are not created, as they lack stylistic and discursive flexibility, as can be seen, for example, in Table 1. Furthermore, if the texts lack communicative competence, they lose the ability to construct aesthetically well-achieved texts, transforming literary writing into a new, banal product, as Chomsky et al. (2023) stated.:

However useful these programs may be in certain specific areas (they can be useful in computer programming, for example, or for suggesting rhymes for light verse), we know from the science of linguistics and the philosophy of knowledge that they differ greatly from the way human beings reason and use language. These differences impose significant limitations on what these programs can do, encoding them with flaws that are impossible to eradicate (para. 3)

For this reason, the texts lack lexical and semantic diversity and versatility, as well as a grammatical structure that would allow us to appreciate the construction of written and personal identities among the participants, in terms of style. These homogenized and homogenizing structures and content threaten one of the primary aspects of creativity: freedom. Therefore, individual qualities are nullified during the text-writing process. It suffices to point out that none of the texts generated by ChatGPT have a title (for the story), which marks the beginning of the narrative and captures the reader's attention.

On the other hand, while the texts generated by the AI do use terms that correspond to the context of the text production (ant, anthill, colony, leaf, small, path, crumbs, among others), these are insufficient to characterize the protagonists of the stories, their roles and qualities, such as solidarity, teamwork, work ethic, and ecological awareness. Based on the above, it can be stated that the texts produced by ChatGPT (Ask AI) lack linguistic competence; that is, their language is limited to a small number of words and linguistic forms, revealing their conceptual and stylistic limitations. The redundancies, although seemingly insignificant, visually and aurally affect the text, as they constitute a kind of babbling or stuttering that attempts to express something but fails. This is one of the fundamental problems: the micro-stories generated by the AI tend to homogenize ChatGPT users through the replication of words, phrases, character names, and stories, leading to a denial of the subjects' identity.

This would not occur if writing processes were conceived as creative experiences with a beginning, development, and end. The students had the opportunity to grow and evolve personally and academically through the design and implementation of the didactic sequence, and to give birth to their different literary creations. This experience can be briefly summarized as follows: First, we planned the teaching sequence, aligning it with each session of the course, in collaboration with our research assistants and the students. Then, we selected a model literary text for reading and stylistic analysis. This is essential, as all writing processes begin and are stimulated by a reading experience.

During oral and individual reading activities led by the teacher and some group members, the participants honed their listening skills and paid attention to specific elements of the narrative. Later, they consulted the dictionary to look up unfamiliar meanings; they worked with synonyms and antonyms; and they constructed sentences using terms they had never encountered before. This fostered dialogue, as they exchanged information, identified semantic fields, and mapped word families, first in pairs and then in groups of three.

Later, together with the teacher, and based on their work with the model texts (mentioned in the previous section), the students recognized the stylistic structure of the text and began some creative preparations: giving the character(s) a different name; proposing brief



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descriptions of the settings and beings; and rehearsing possible endings to the story, among other things. Subsequently, the second story was sent home for the students to work on, building upon their classroom experience. In the work session, some students shared the structure of the story "Fireflies" (Encalada, 2002), including the beginning, middle, and end, as well as the characterization and style.

In the final session, the students were asked to write a micro-story, with the ant as the main character, taking into account their experience during the two preceding sessions. The students began their creative task by developing outlines that included titles, characters, settings, and plot points. Others preferred to overcome their writer's block by venturing to write in one sitting. The most skillful and daring, meanwhile, dedicated themselves to writing their stories while drawing. There were moments of true joy and ecstasy: they changed the characters' faces, erased bodies, and corrected colors. This is how real writers are born: they draw, doodle, or photograph their characters. One student shared her experience with us after the exercise:

I really enjoyed what we did. Writing fosters respect for other people's ideas, as well as creativity, because it's important to know that everyone writes and thinks differently, and it makes us better people, because we learn to respect the ideas of others (E16, personal communication, June 25, 2024).

A creative person, as Gardner (2001) points out, is someone who consistently solves problems, develops products, or introduces innovations in a given area, since their "creative abilities can indeed be developed within a formal framework, through a pedagogy that knows how to activate them, for which it is necessary to know how to move from cognition to creation" (Labarthe and Vázquez, 2016, p. 22). It is worth repeating: human beings are essentially creative, as they possess unparalleled capacities to invent and explore possible worlds, to steer students (as educators) away from the false perception that comfort, complacency, channel surfing, procrastination, and high-end mobile phones guarantee happiness. López (2017), in this sense, affirms that:

Teaching creativity gives us the possibility of discovering life beyond the factory, the monopoly, the banking chain, and fashions and brands. Creativity, in education today, can certainly be linked to ethical relationships, coexistence, and the well-being of everyone and the planet. If it has been a territory primarily held, fortunately, by the arts and sciences and, less fortunately, by the capital market, it is legitimate and urgent to also link it to teaching and learning processes (p. 8).

The results were very positive, because after experiencing a real, experiential and accompanied activity, the students began to use other vocabulary to narrate stories, contexts, scenarios and even invent new characters.

4. Discussion

Regarding the style of the micro-narrative, ChatGPT (Ask AI) constantly repeats its form and content, as previously mentioned. In other words, the story told is based on the same premise and uses the same elements (see Table 1): "once upon a time," "an ant was walking," "an ant was looking for food," "an ant was looking for food or materials for its colony," "worker ant," among others.



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Student	Instructions for students: Request the following from the AI tool: "Write a micro-story whose main character is an ant."
E1	A small ant was walking along the ground in search of food for its colony. As it ventured deeper into the forest, it came across a huge piece of cake that someone had left there.
E2	An ant was walking through the garden in search of food for its colony. Suddenly, it found a huge breadcrumb that seemed bigger than it was.
E3	Once upon a time, there was a little ant who worked hard every day to bring food back to her colony.
E4	Once upon a time, there was a little ant named Anita who lived in an anthill in someone's garden.
E5	Once upon a time, there was a hardworking and diligent ant who always tried her best to bring food back to the anthill.
E6	Once upon a time, there was a little ant named Anita. Anita lived in a quiet anthill with her family and friends. She had always been a diligent and hardworking ant, but she felt that her life lacked excitement and adventure.
E7	Once upon a time, there was a little ant named Anita who lived in a dark, leafy forest

Table 1. Micro-stories generated by AI. Responses from ChatGPT (Ask AI, 2024)

These basic structures replicate the aesthetic and stylistic guidelines of Russian fantasy tales from the first half of the 20th century, which do not accommodate contemporary themes. It must be understood that storytelling methods have changed, just as humanity and its conceptions of work, the body, sex, love, the planet, and life have changed. In other words, ChatGPT is incapable of creating narratives that maintain a prudent distance from the precepts of classical rhetoric:

True intelligence is also capable of moral thought. This means constraining the otherwise limitless creativity of our minds to a set of ethical principles that determine what should and should not be (and, of course, subjecting those same principles to creative critique). To be useful, ChatGPT must be capable of generating novel results; to be acceptable to most of its users, it must steer clear of morally objectionable content. But the programmers of ChatGPT and other marvels of machine learning struggle, and will continue to struggle, to achieve this kind of balance (Chomsky et al., 2023, para. 17).

A curious detail observed in the texts generated by the tool, belonging to participants E4, E5, E6, and E7, is the recurring use of the protagonist's name (Anita), which ChatGPT (Ask AI) begins to replicate randomly, creating a vicious cycle. Similarly, it is important to note that none of the twenty-four stories generated by the AI includes a title, which, as mentioned above, is a key element for engaging readers.

Table 2 shows the stories written by students E1, E2, E3, E4, E5, E6, and E7, as a sample, after the learning sequence. In these stories, invention prevails over imitation: they inserted



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titles into the micro-stories, named the characters, diversified the narratives, used flashbacks, included supporting characters, and displayed humor and irony.

Student	Instructions for students: After reading and commenting on the literary texts of Oswaldo Encalada: "Write a micro-story whose main character is an ant".
E1	Ant Worker, worker, worker... But why didn't you think for a moment that you, too, have a life? That you need to love, to be loved. That love exists. Your death was another failure..
E2	The backpacking ant One morning, after a long night of rain and storms, I arrived home tired from work; from the back and forth carrying the leaves for mushroom cultivation on my rough back....
E3	Mad Dream I was in a dream, the most impure and repugnant dream, without a doubt. How crazy! We were all ants, and I was the prettiest ant, of course..
E4	A Part of the World Jack, an ant who lived far from the colony, went for a stroll around his home when he spotted a giant pole in the distance that almost touched the stars.
E5	Disenchantment Time passed and I no longer saw her. That ant walked, searching for a direction; she must find somewhere. She was capable of loving and hating at the same time, so distant and yet so near. She connected effortlessly with nature, so strong and so fragile. My only desire was to see her. But no more, ant who walks past my path, I will no longer open the door for you.
E6	God Somewhere hidden in the middle of the lush plains of the city of Cuenca, there lived an ant named Filomena. This was a very hardworking insect who used to get up early to look for food for her colony...
E7	The Importance of Teamwork The three friends: Sali, Lucy, and Dross. Sali was a small ant who liked to work every day, but she was shy; Lucy, a butterfly who didn't work much and had difficulty socializing with others; on the other hand, Dross, a small and friendly cricket...

Table 2. Stories (micro-stories) written by the students after the teaching sequence

The classroom became a "writing laboratory" (Piglia, 1986, p. 51) or, better yet, a literary kitchen (Bolaño, 2004, p. 321). Each participant experimented with devices, linguistic



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concoctions, modeled faces, and named characters. The classroom was buzzing with the sounds of writing, the satisfaction of accomplishments, music... Let's read some of the gems: "Worker, worker, worker... But why didn't you think for a moment that you too have a life? That you need to love, to be loved. That love exists. Your death was another failure." (E1, unpublished microfiction "Ant," June 18, 2024)

This text invites the reader to analyze it, interpret it, and extract a very personal meaning and, why not, to identify with the story. Likewise, it doesn't require a traditional structure to tell a story successfully. Another microfiction fragment showcases the imaginative capacity of humankind, creating not just one main character, but three. Let's read this text: "The oldest ant, named Ciro, was cunning and the largest of the three. Izan, the middle one, was an agile ant. And finally, Max, the smallest ant, who always avoids conflict" (E8, unpublished microfiction "To Do, You Have to Believe," June 18, 2024).

This approach enriches the narrative with diversification, not only in terms of characters but also in terms of actions, which impact the story's development. Another element found in the students' microfiction is the expression of their own subjectivity, whether intentional or not:

Time passed and I no longer saw her; that ant walked, searching for a direction, she had to find somewhere. She was capable of loving and hating at the same time, so distant and yet so near, she connected effortlessly with nature, so strong and fragile, my only desire was to see her. But no more, ant that walks past my path, I will no longer open the door for you. (E9, unpublished micro-story "The Glimmer of Greed", June 18, 2024).

This example presents a dual feeling of love and heartbreak. Although the subject loves the implied person, they recognize that they are in a labyrinth. In the end, they decide to let go of that love and move on with their life. This quality of the texts written by the participants demonstrates the sensitivity of the writing, of the people who imagined these stories, as a wonderful opportunity to externalize (or perhaps exorcise demons?) their deepest and most difficult-to-communicate feelings in everyday contexts. This is an aspect that Artificial Intelligence will never be able to imitate: "Writing microfiction has been a rewarding activity, but it is often very tiring. However, the more we write, the more we improve in some aspects of our writing, such as spelling, the use of connectors, and imagination..." (E9, personal communication, June 25, 2024).

This is one of the many testimonials from aspiring writers who express what they think, feel, and desire... A wonderful opportunity to develop as well-rounded, ethical individuals and distance themselves from the witch hunt of anti-plagiarism software (Turnitin, Urkund, Strikeplagiarism) to which academia is subjected. One student shared her experience after the exercise:

I really enjoyed what we did. Writing fosters respect for other people's ideas, as well as creativity, because it's important to know that everyone writes and thinks differently, and it makes us better people, because we learn to respect the ideas of others (E22, personal communication, June 25, 2024).

In this section, it's important to note that the same ChatGPT (Ask AI) was used to explore aspects of AI use in creative writing and its relationship to style, originality, and identity (Table 3). Let's examine this compelling data:



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Question	What are the risks or dangers of using Artificial Intelligence in writing?
Answer	<p>One of the main drawbacks of artificial intelligence in writing is the loss of the ability to communicate clearly and effectively. Many people have begun to rely on AI tools such as spell checkers and grammar checkers, which can lead to a decrease in their ability to write correctly on their own. Furthermore, these tools are not always accurate, which can lead to errors and confusion in the text. This can be particularly problematic in the world of marketing and advertising, where originality is key to standing out from the competition. In addition, artificial intelligence can also lead to a decrease in writing quality. Some AI tools can be used to automatically generate text, but this text does not always have the necessary quality to meet readers' expectations. This can lead to a decline in the overall quality of writing and a loss of content value.</p> <p>Finally, artificial intelligence can also affect the writer's identity.</p>

Table 3. Request (question) to ChatGPT about the dangers of AI in creative writing

We agree with De Vicente-Yagüe et al. when they state that Artificial Intelligence is a means, a tool for human use, not an end in itself to perform an activity entirely without any intervention (2023). It should be considered that ChatGPT and other AI tools can help us write (spelling and grammar checkers, use of synonyms and antonyms, for example); however, we need to provide our students, from the earliest levels of education, with a set of skills and competencies so they understand the nature of words, the creative processes through the syntagmatic and paradigmatic axes of text production, the activation of semantic fields, lexical families, metaphorization, among others, because human beings possess "a surprisingly efficient and even elegant system that works with small amounts of information" (Chomsky, et al., 2023, para. 5). Furthermore, the data generated by ChatGPT is not very reliable, as a UNESCO study (2023) maintains:

While some researchers have found that tools like ChatGPT can generate a well-structured or at least standard abstract (if given precise and accurate instructions), others have identified significant limitations in their use as a writing aid. (...) For example, ChatGPT can provide fabricated references, cannot adequately synthesize the literature, and tends to produce predictable text (...). Because MLEs like ChatGPT rely on information from the internet that may not be reliable (e.g., research containing outdated or inaccurate theories/data), they can present inaccurate or incorrect information as accepted knowledge (p. 41).

The processes and experiences of peer learning should be accompanied by activities that recognize the personal qualities of the students, which, unfortunately, AI cannot or does not know how to do.

5. Conclusions

Through this experience, it has been demonstrated that creative writing, approached as a vital and planned process (didactic sequence), enhances the creative abilities of student-



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writers. They exhibited a knowledge and use of the different components of the microfiction genre freely, narrating stories with diverse aesthetics, characters, plots, and endings that reflect their concerns, feelings, emotions, problems, and dreams. In other words, it fostered identities. Consequently, the study's objective is met, as we analyzed the ChatGPT's actual capacity to generate stylistically well-crafted microfiction in comparison to that written by students immersed in a systematic, reflective, dynamic, participatory, and personal creative process through a successful didactic sequence.

Indeed, during the writing process, the students and the teacher experimented with a series of creative tools, not exclusive to AI tools: they blurred semantic fields and lexical families; They experimented with the creative strategy through the use of syntagmatic and paradigmatic axes; they crossed out beginnings, erased endings, and rewrote titles. It has become clear that a writing class is not limited to an order or request to any Artificial Intelligence application. It is not an isolated task that operates based on patterns, replicas, or algorithms, but rather a liberating activity through which human beings, with all their differences, journey and grow.

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Declaration of authorship-CRediT

MANUEL VILLAVICENCIO-QUINDE: Lead author, conceptualization, formal analysis, research, methodology, and first draft.

ALISON FAJARDO-MARTÍNEZ: Formal analysis, methodology, and editing.

ALEJANDRA SUÁREZ-RIVAS: Formal analysis and methodology.

Declaration of the use of artificial intelligence

The authors report that they partially used the ChatGPT (Ask) tool, July 2024 version, during the micro-story generation stage on the theme of the "ant." Subsequently, the tool was asked to identify the challenges AI presents for creative writing, and its response is included in the article. AI was not used to draft the sections related to methodological design, data analysis, results interpretation, or academic discussion. No data, documents, or sensitive information were entered into the tool during its use.



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The quantitative and qualitative rubric in algebraic operations learning assessment in students of eighth year of general basic education

La rúbrica cuantitativa y cualitativa en la evaluación del aprendizaje de las operaciones algebraicas en estudiantes de educación general básica

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Abstract

This article analyzes the importance of designing a taxonomic rubric to assess the learning of algebraic operations in eighth-grade students in basic general education. The manuscript



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poses as a fundamental problem the lack of application of rubrics as an assessment tool that allows students to develop the skills, competencies, and abilities acquired in mathematics. To address this problem, the author designs a didactic guide for designing a taxonomic rubric that employs the Marzano and Kendall taxonomy, which focuses on mental processes and memory related to the information students acquire. It clarifies some guidelines regarding the principles and types of assessment, the learning cycle, and the assessment of learning in mathematics. It explains the characteristics, elements, and types of rubrics, the domains of learning, and the taxonomic levels with a view to achieving appropriate assessment. This research employs a mixed-methods approach, combining qualitative and quantitative methods, supported by various documentary and field sources, and includes a correlational scope, thus providing an existing perspective on the problem. Relevant findings include the deficiency in the use of rubrics due to the lack of information and descriptors to guide the evaluation process in order to achieve a detailed learning outcome, change the action of evaluating to valuing, experience changes in motivation and participation, and ultimately, rediscover the desire to learn with appropriate evaluation instruments.}

Keywords

Educational assessment, teaching guide, algebraic operations, quantitative rubric, qualitative rubric, Marzano and Kendall taxonomy.

Resumen

El artículo analiza la importancia del diseño de la rúbrica taxonómica para evaluar el aprendizaje de las operaciones algebraicas en estudiantes de octavo año de educación general básica. El manuscrito plantea como problema base la falta de aplicación de rúbricas como instrumento de evaluación que permiten a los estudiantes desarrollar las destrezas, competencias y habilidades adquiridas en el área de la matemática. Ante este problema el autor diseña una guía didáctica para el diseño de la rúbrica taxonómica que emplea la taxonomía de Marzano y Kendall orientado a los procesos mentales y la memoria sobre la información que va adquiriendo el estudiante. Aclara algunas pautas acerca de los principios y tipos de evaluación, ciclo del aprendizaje y la evaluación del aprendizaje en matemática. Explica las características, elementos y tipos de rúbricas, los dominios del aprendizaje y los niveles taxonómicos con miras a alcanzar una evaluación adecuada. Es una investigación con un enfoque cualitativo y cuantitativo que se respalda con varias fuentes de tipo documental, de campo y un alcance correlacional así logra una perspectiva existente de la problemática. Como hallazgos relevantes están la falencia en la utilización de la rúbrica debido a la falta de información y descriptores que guíe el proceso de evaluación con la finalidad de lograr un resultado detallado del aprendizaje, cambiar la acción de evaluar por valorar, experimentar cambios en la motivación y participación, en definitiva, redescubrir el deseo por aprender con instrumentos de evaluación apropiados.

Palabras clave

Evaluación educativa, guía didáctica, operaciones algebraicas, rúbrica cuantitativa, rúbrica cualitativa, taxonomía de Marzano y Kendall.

1. Introduction

The level of education in Ecuador reached a turning point with the 2020 pandemic, bringing about a radical shift in the methodology, content, and resources used for teaching. Thanks to significant technological advancements, the renowned artificial intelligence emerged in



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2022, capable of generating concrete answers to any question in seconds. In some ways, the development of this autonomous tool has devalued critical thinking, human judgment, and analytical skills due to the availability of pre-processed responses.

In education, assessment has traditionally focused on the grade of a final product or result, neglecting the development of genuine student learning. Similarly, the adaptability of digital educational resources has changed how we learn and has also fostered a reliance on applications that cater to the whims of completing assignments.

In Ecuador, teachers face a challenging process in applying assessment techniques, methods, and instruments that not only measure final results but also the process involved in achieving meaningful learning. Thus, rubrics are seen as an alternative that surpasses traditional assessment due to the advantages the tool provides. Well-implemented rubrics are instruments structured with clear criteria for evaluating an activity. Subject to various descriptors, they measure the step-by-step process of each partial achievement with a defined rating scale for each level. The final grade provides a broader perspective for identifying strengths and weaknesses during the learning process, supported by timely feedback. The assessment guidelines propose the regulations that must be followed in the Teaching and Learning Process (TLP), considering assessment not as an end in itself but as a means to improve educational processes. The goal is the student's holistic development through appropriate support and feedback at each stage of learning, determined by the teacher's high capacity, competence, and professionalism.

In mathematics, the usefulness of an assessment tool that values the process is essential; currently, students arrive at the answer using any application, but they are unaware of the process followed to arrive at that answer. For this reason, the rubric, with its taxonomic approach, allows for the demonstration of the development of skills that the student acquires in solving a problem or exercise. The rubric's value lies in its integration of Marzano and Kendall's taxonomy, which focuses on the development of thinking across six levels, emphasizing gradual learning. The incorporation of metacognition allows students to engage in deep reflection, as do cognitive, procedural, and attitudinal processes. This promotes the value of learning styles and leads to a more effective and meaningful evaluation.

Methodologically, this study has applications in education globally and specifically in the area of mathematics, encompassing the evaluation guidelines established by the Ministry of Education of Ecuador for student learning. It presents a qualitative and quantitative approach in a narrative, rather than experimental, manner. The method is interpretive for understanding the problem, and the scope is correlational in predicting a result. The research is documentary and field-based, culminating in a proposed didactic solution.

The manuscript is comprised of three sections: the first presents the theoretical framework explaining the research topic; specifically, it provides a conceptual explanation of the characteristics, types, and digital educational resources that generate rubrics as assessment tools in Mathematics. The second section explains the methodology used in the research process. The third section presents the results obtained from exploring the problem in relation to the characteristics of the research instrument, namely the rubric, as well as its application in learning assessment and the contribution of a guide for designing taxonomies and rubrics in the field of Mathematics.



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2. Literature review

This research aimed to analyze the usefulness of rubrics in mathematics education. It examined previous studies in the field of education related to the design of assessment instruments that offer a detailed perspective on learning. The theoretical framework addresses the study variables using information sources appropriate to the research problem.

2.1 The rubric

A rubric is a tool used to evaluate an activity or task according to specific parameters. Fraile et al. define it as a document that details a task according to certain evaluation criteria corresponding to a level of quality and assigning a grade (Fraile et al., 2017, p. 1328). From this perspective, a rubric is presented as a matrix that describes an action or set of actions using criteria that serve as a guide for assessing progress, and a grade related to the level of complexity can be assigned.

2.1.1 Elements of a rubric

A rubric is a matrix containing key elements for its correct application. In the process of developing a rubric, it is essential to define the descriptors, the rating scale, and the criteria (Gatica-Lara & Uribarren-Berrueta, 2013, p. 64). These components form three essential parts that must be logically and coherently interconnected to facilitate the effective evaluation of learning outcomes, as shown in Table 1.

Criteria Concepts/Categori es	Scales/Levels of performance			
	4	3	2	1
Aspects to be evaluated	Descriptors Evidence to be obtained			

Table 1. Key elements of a rubric. Source: (Gatica-Lara and Uribarren-Berrueta, 2013, p. 62).

2.1.2 Types of rubrics

Rubrics are defined in two main groups: analytical rubrics and holistic rubrics. These differ in their design, elements, and final results, as detailed below: Analytical rubrics offer a more detailed perspective compared to holistic rubrics, which provide a more general overview. Fraile et al. specify that analytical rubrics are more precise in their criteria, levels, and qualitative descriptions, while holistic rubrics are more general and do not highlight strengths and weaknesses (Fraile et al., 2017, p. 1328). As they explain, the application of a rubric depends on what is being evaluated, considering either the detailed process or the final product. If the goal is to identify strengths and weaknesses, an analytical rubric should consider a specific overview of the process. If the goal is to assess a final activity, a holistic rubric, which provides a comprehensive overview, should be used. Finally, the differences between each type of rubric are described as shown in Figure 2.



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Holistic	Analytical
Integrates the student's performance.	Part of the student's performance.
Levels of achievement focused on quality.	Levels of achievement focused on improvement.
Less time required to grade.	More time required to grade.

Figure 1. Differences between the holistic and analytical rubrics. Adapted from: (Gatica-Lara and Uribarren-Berrueta, 2013, p. 62).

2.2 Taxonomic rubric criteria

The taxonomic rubric has been proposed in the field of Mathematics to clearly define the level at which the indicators are intended to be achieved. There must be complete coherence between this level and the verbs used to assess mathematical learning (Tipán-Renjifo, 2022). The evaluation criteria are based on levels of increasing complexity, which are related to the taxonomy. Atonal argues that taxonomies allow for the classification of cognitive processes involved in learning, organizing them into levels that correspond to different degrees of mental complexity. These are structured around domains of knowledge that include everything from basic memorization skills to higher-level processes such as analysis, evaluation, and creation. Furthermore, the author emphasizes that the difference between the levels lies in the degree of difficulty of the mental process required for each one, which allows for more effective planning of learning objectives (Atonal, 2020, p. 86).

A detailed process is easy to understand when the actions to be followed are prioritized and systematized. In education, taxonomies are key for setting objectives and developing skills for student learning. Bloom's and Marzano-Kendall's taxonomies are the most widely used to ensure students' appropriate cognitive development.

In assessment, congruence between what is taught and what is learned is important for the application of an assessment instrument. Atonal explains the use of a taxonomy for assessment, stating that taxonomic levels link innate abilities in individuals (Atonal, 2020, p. 99). He also affirmed that during learning, progress is evident with a hierarchy of actions to be completed, highlighting skills and competencies acquired in relation to critical thinking, as shown in Figure 2.



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BLOM Learning objectives: <ul style="list-style-type: none"> - Remember - Understand - Apply - Analyze - Evaluate - Create 	MANZANO Information processing <ul style="list-style-type: none"> - Self-system - Metacognitive - Cognitive 	SOLO Understanding <ul style="list-style-type: none"> -Pre-structural -Uni-structural -Multi-structural -Relacional -Extended abstract
FINK Significant learning <ul style="list-style-type: none"> -Foundational knowledge <ul style="list-style-type: none"> -Application -Integration -Human dimension <ul style="list-style-type: none"> -Caring -Learning to learn 	WEBB Thinking complexity: <ul style="list-style-type: none"> - Rote/Memorization -Processing -Strategic -Extended 	ANDERSON Y KRATHWOHL Separates knowledge and process: <ul style="list-style-type: none"> -Factual -Conceptual -Procedural -Metacognitive

Figure 2. Types of taxonomies and levels. Adapted from: (Atonal, 2020, pp. 86-92).

2.2.1 Rubric Criteria for an Evaluation

The rubric, as an assessment tool, has its own structure that allows it to focus on a specific task. As Garcia-Valcarcel et al. mention, several criteria are related to the performance levels that define the quality of learning to be assessed. Furthermore, these levels allow for the establishment of clear descriptors that guide both the teacher and the student regarding what is expected to be achieved in each phase of the assessment process (Garcia-Valcarcel et al., 2020, p. 74). Consequently, the identification of criteria in an assessment will depend on the desired level within the assessment context, thus fostering self-assessment and peer assessment, which represents an achievable goal. The criteria highlighted in Figure 3 are shown below.

Student Reflection <ul style="list-style-type: none"> -Formative value - Achievement or failure in objectives 	Construction Value <ul style="list-style-type: none"> -Teacher-student interaction -Performance improvement 	Deep Learning <ul style="list-style-type: none"> -Concrete expectations - Quality
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Figure 3. Criteria to consider in the evaluation with a rubric. Adapted from: (Garcia-Valcarcel et al., 2020, p. 75)

2.3 Principles of Evaluation

Assessment is understood as a systematic process of gathering information that allows for the evaluation of student learning within a given educational context. To maintain its pedagogical character, it must be based on principles that guide its purpose, structure, and application. Sánchez-Mendiola and Martínez-González state that effective assessment requires clarity in the objectives to be evaluated, the use of methods appropriate to the learning context, and a variety of instruments that promote a comprehensive assessment of performance. They also emphasize that assessment should be understood as a means to support the continuous improvement of the educational process, not as an end in itself. These principles are essential for promoting fair, formative assessment practices aligned with learning objectives (Sánchez-Mendiola & Martínez-González, 2022, pp. 17-21).



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Likewise, the characteristics of educational assessment are related to student learning, starting with the question every teacher has thought about: "What am I going to assess?" This central axis is accompanied by appropriate techniques, strategies, and instruments that provide a current understanding of the student's knowledge acquired in class, as demonstrated in an assessment.

2.3.1 Evaluation criteria

Assessment criteria allow for the identification of achievement levels through clear and objective benchmarks that guide the evaluation of learning. They act as a bridge between educational objectives and the evidence gathered in the classroom, strengthening curricular coherence. Furthermore, they guide pedagogical decision-making and promote the continuous improvement of the learning process (Sánchez-Mendiola & Martínez-González, 2022, pp. 21-23). In the case of assessing algebraic operations using quantitative and qualitative rubrics, these criteria allow for the establishment of precise descriptors that guide both teachers and students toward the achievement of clear and measurable mathematical competencies.

2.3.2 Evaluation indicators

Assessment indicators allow us to observe and evaluate the degree of development of a competency or expected learning outcome through clear descriptions of student performance. In this sense, Gatica-Lara and Uribarren-Berrueta argue that assessment criteria, also called indicators or guides, are essential elements in rubric design, as they reflect the processes and content deemed significant for educational achievement. These must be accompanied by quality definitions that specify what the student should demonstrate at each achievement level and scoring strategies that allow us to distinguish between exemplary and emerging performance (Gatica-Lara & Uribarren-Berrueta, 2013, pp. 62-64). Applying this structure to mathematics, and particularly to the learning of algebraic operations, allows us to construct clear, objective, and formative rubrics that guide both the teaching, and the assessment of student progress based on observable and measurable evidence.

2.3.3 Types of Evaluation

In the academic sphere, assessment is an essential element of the teaching-learning process. It not only allows for the evaluation of student results but also generates relevant information for adjusting and improving pedagogical interventions. According to Sánchez and Martínez, educational assessment should be conceived as a systematic, continuous activity integrated into the learning process, fulfilling diagnostic, formative, and summative functions. Diagnostic assessment aims to identify prior knowledge, skills, and attitudes at the beginning of an educational cycle; formative assessment focuses on supporting learning by providing constant feedback; and summative assessment allows for the evaluation of achievements at the end of a unit or period (Sánchez-Mendiola & Martínez-González, 2022, pp. 17-23). This comprehensive view of assessment is fundamental for designing and implementing instruments such as quantitative and qualitative rubrics in mathematics, as it facilitates a more complete and contextualized evaluation of the learning of algebraic operations in eighth-grade students.

This perspective is especially relevant in the context of assessing algebraic operations. The implementation of quantitative and qualitative rubrics requires continuous, flexible evaluation focused on the student's actual learning, rather than solely on the final grade. At the end of the educational process, there is the summative assessment, which aims to evaluate all the knowledge acquired over a period of time. Its objective is to measure



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achievements and whether or not the learning objectives established in the respective lesson plans were met. The final summative assessment helps inform decisions regarding adjustments to the methodology or the overall lesson plan.

2.3.4 Evaluation Moments

Assessment in education unfolds in three fundamental phases: diagnostic, formative, and summative. These stages fulfill specific functions within the teaching-learning process, facilitating more effective pedagogical intervention focused on the student's needs. As Sánchez and Martínez point out, each type of assessment has a distinct purpose and is applied at different points in the educational process. These are represented schematically in Figure 4, which illustrates the sequence and relationship of the three phases within the assessment cycle (Sánchez-Mendiola & Martínez-González, 2022, p. 60).

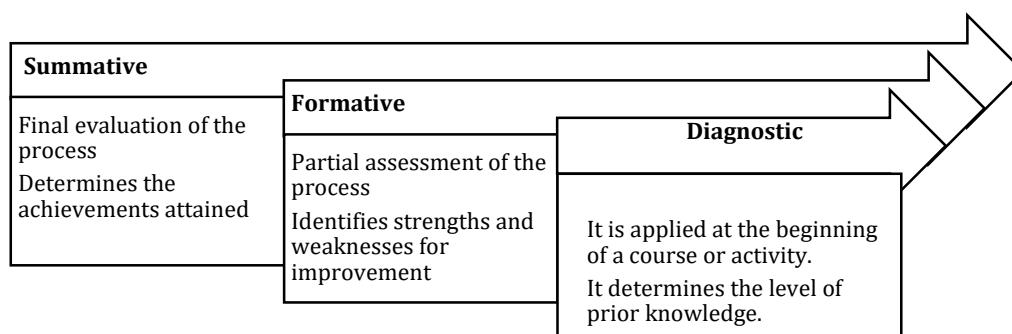


Figure 4. Evaluation moments. Adapted from: (Sánchez-Mendiola and Martínez-González, 2022, pp. 21-22)

2.3.5 Comprehensive Assessment in Mathematics

Comprehensive assessment in mathematics represents an approach that goes beyond simply measuring theoretical or mechanical knowledge. This type of assessment seeks to holistically evaluate students' competencies, considering both their conceptual understanding and their ability to apply content in real and meaningful situations. According to Castillo-Arredondo and Cabrerizo-Diago, a truly formative mathematics assessment should include different levels of analysis, from identifying basic procedures to solving complex problems, integrating logical reasoning, the use of mathematical language, data interpretation, and the ability to transfer learning to everyday contexts. This perspective allows for the evaluation not only of mastery of formulas and algorithms, but also of students' ability to interpret, argue, and make well-founded decisions from a mathematical perspective (Castillo-Arredondo & Cabrerizo-Diago, 2010, pp. 268-270). In this sense, the comprehensive approach contributes to the development of critical thinking and learner autonomy, key aspects for an education oriented toward performance and the resolution of real-world problems. One of the key aspects of a comprehensive assessment is the inclusion of activities that strengthen students' critical thinking and creativity. Problems should be presented that are relevant to everyday life to encourage logical problem-solving. Furthermore, the assessment allows for self-assessment and peer assessment among students, strategies that enable them to reflect on their own learning and receive feedback.



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2.3.6 Assessment of Mathematics Learning

In mathematics, the assessment of learning is of vital importance and can be carried out in various ways, such as written exams, practical tests, projects, and ongoing formative assessments. Ongoing assessments tend to be the most widely used, offering teachers the opportunity to identify areas for improvement or reinforcement, or to provide feedback on student knowledge.

2.3.7 Skills assessment

In the field of mathematics, skills-based assessment has emerged as a key methodology for evaluating learning because it focuses on measuring practical skills and specific competencies of each student. This approach to teaching emphasizes evaluating not only what students know, but also what they can do with the knowledge they have acquired. Skills-based assessment aligns with the societal shift of recent years, where practical skills and the ability to apply knowledge in everyday situations are highly valued. Thus, skills-based assessment goes hand in hand with the needs of the job market and various requirements of companies, which seek individuals who not only possess the knowledge, but also know how to apply it and put it into practice when solving problems.

The fundamental or most notable characteristic is its focus on authenticity. Assessments often involve projects, case studies, and simulations. They promote critical thinking, problem-solving, and self-assessment—essential competencies for today's world, where students must be able to adapt to new situations, innovate, and think critically and objectively.

2.3.8 Competency-Based Assessment.

Competency-based assessment refers to the combination of knowledge, skills, attitudes, and values that students need to perform in different aspects of their professional field. The shift to competency-based assessment implies a change in how teaching and learning are conceived and carried out. One of the main characteristics of competency-based assessment is the authenticity of the students; assignments, tests, and everything submitted are based on a real-world context, giving students the opportunity to demonstrate their competence in contexts in which they operate. This increases the relevance and importance of the learning. Furthermore, education becomes continuous and formative, providing students with regular feedback throughout the teaching and learning process, where students are responsible for their own progress. It also requires a more personalized approach to teaching; teachers not only develop specific competencies but must also adapt to the individual needs and contexts of their students.

In today's world, where technological evolution and scientific advancement are progressing exponentially compared to previous decades, competency-based assessment is gaining greater relevance. Educational institutions now seek to ensure that individuals not only possess practical knowledge related to different subjects, but also that they can apply it innovatively to problem-solving or innovation.

3. Methodology

This research has a broad scope in education and a specific focus on mathematics. It presents an interpretive method that aims to reveal the behavior of educational stakeholders in the learning process, guided by evaluation criteria. The study context allows for the exploration of visible behavioral changes in the phenomenon, with the final results presented in a positive light in the conclusions, enabling the generalization of the situation.



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The quantitative phase handles the non-experimental aspect through observation of the existing study situation, supported by the calculation of Cronbach's alpha, data tabulation, and the necessary numerical results. The qualitative phase employs a narrative approach through the analysis of the collected information, providing a general and specific view of the study situation based on the results of applying the data collection instruments.

The study variables are related within the educational field by calculating Pearson's correlation coefficient, which determines the degree of direct or indirect association. It is inferred that the evaluation instrument modifies the way specific content is learned, as reflected in the final results obtained. Designing a tool that provides a better overall or specific perspective on learning assessment will positively or negatively influence the student, taking into account their context. Furthermore, it draws on the expertise of students experiencing the current state of educational assessment as a primary source, supported by a review of online documents with research validity as a secondary source, and fieldwork through direct observation of the issues, accompanied by the application of instruments that gather the necessary information for the study.

3.1 Population and Sample

Two hundred students from the upper sub-level of Basic General Education enrolled in the 2023-2024 academic year were considered, forming the entire population. Due to the number of individuals, the population is considered as the sample for the information collection process, along with the five teachers from the Mathematics area detailed in Table 2.

Stratum		Educational institution
Students	Teachers	
40	1	Educational Unit Sagrados Corazones Centro
40	1	Intercultural Bilingual Community Educational Unit "Tinku Yachay"
40	1	Intercultural Bilingual Educational Unit Muyu Kawsay
40	1	American School of Quito
40	1	Educational Unit "Nelson Torres"
200	5	Total

Table 2. Population distribution.

3.2 Techniques for data processing and analysis

For collecting data from the student questionnaire, Google Forms survey management software was used due to its ease of access via a link. Subsequently, the database of all respondents was downloaded in Comma-Separated Values (CSV) format. Data tabulation and pie chart creation were performed using Microsoft Excel. Finally, the results were compiled and presented in a Microsoft Word document.

For the questionnaire for teachers, data collection was carried out through pre-scheduled interviews. Participants' responses were recorded and later transcribed into text format. Once all the information was gathered, the qualitative analysis software ATLAS.ti was used in AI mode to identify words and sentences that were congruent both with each other and with each of the questions posed. This process provided a clear and organized perspective for the study.



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4. Results

The results of the research validate the researcher's proposal to design rubrics that align taxonomic levels for appropriate assessment in mathematics. Using two instruments, the current situation regarding the application of assessment tools to 8th-grade students in basic general education is analyzed.

Figure 5 shows that 57% of students indicate that they only sporadically or never perceive a positive attitude toward the importance of achieving learning outcomes when a rubric is used in class. The rubric fosters the development of shared metacognitive skills between teachers and students (Alcón-Latorre & Menéndez-Varela, 2016). Assessment should focus on measuring what students are able to do with the acquired knowledge, building upon the meaningful learning developed in class. Furthermore, recognizing and motivating each partial achievement is an effective incentive for achieving overall success. Furthermore, the rubric offers a detailed view of each phase of the learning process, considering the completed achievements and allowing their verification in the final grades, thus favoring the articulation between the qualitative and the quantitative.

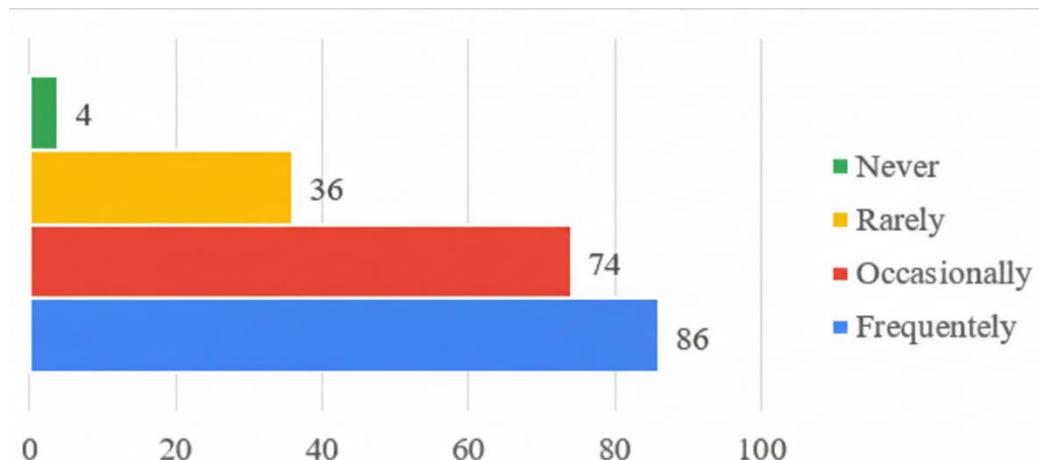


Figure 5. Use of the rubric to assess learning achievements.

Figure 6 shows that 52% of students indicate that they are unfamiliar with or have never used different assessment tools aligned with the learning process applied in teaching practice. The learning process varies among students due to their different learning styles; therefore, it is necessary to employ diverse methods to assess acquired knowledge. However, most students have been assessed solely through traditional instruments, considering written tests as an established tool. The variety of assessment methods continues to expand with the use of Information and Communication Technologies (ICTs), opening new possibilities for identifying emerging skills developed by new generations.



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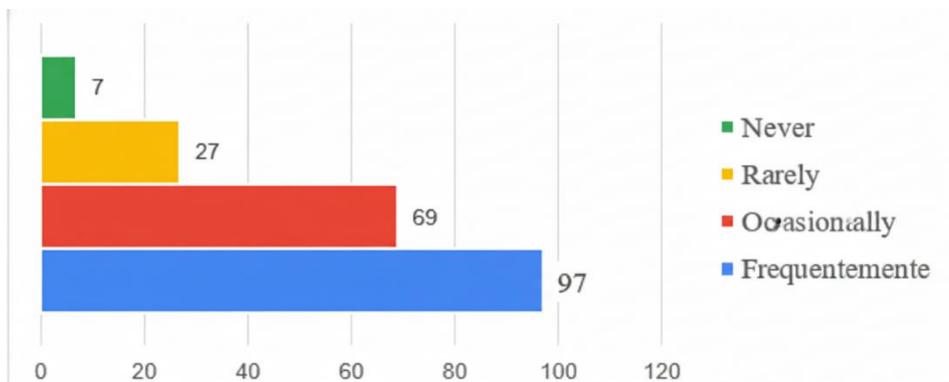


Figura 6. El docente aplica los instrumentos de evaluación adecuados en el proceso de aprendizaje.

Figure 7 illustrates the use of platforms to measure individual progress, adapting to new, effective, and inclusive systems aligned with learning objectives. Interaction with mathematical concepts is made accessible to all students through gamification, resulting in more engaging and personalized teaching that increases learning effectiveness and assessment accuracy.

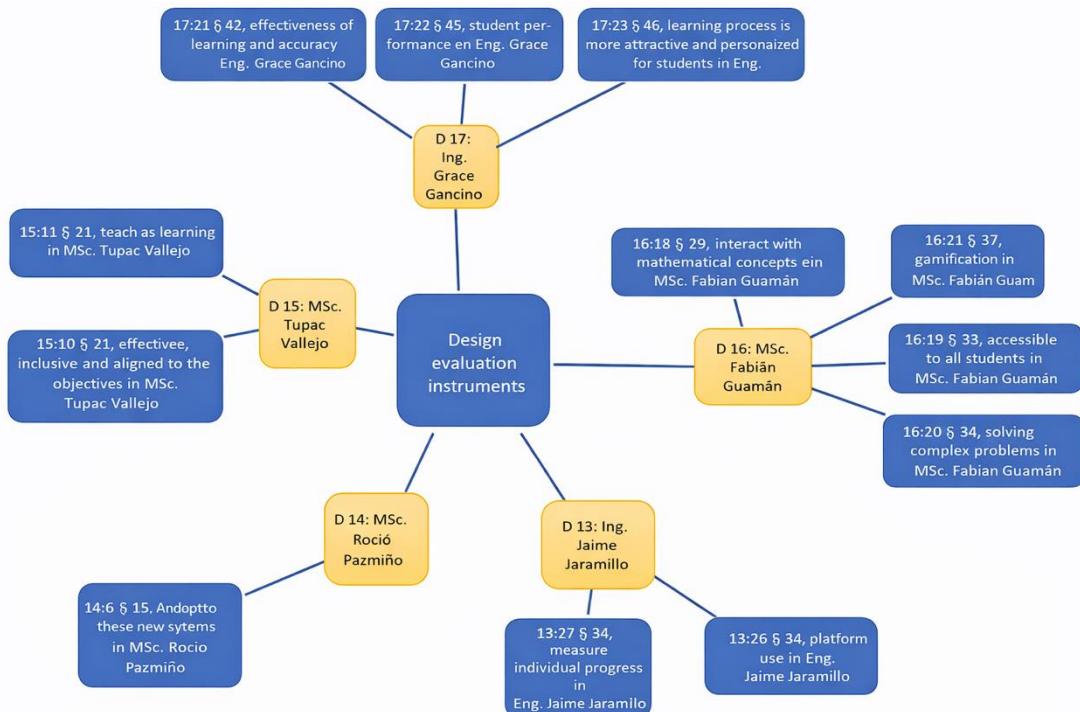


Figure 7. Consistent responses regarding the design of assessment instruments with digital tools.

5. Discussion

The structural characteristics of assessment rubrics were analyzed in relation to the guidelines established by the Ministry of Education of Ecuador. In this regard, Alcón-Latorre and Menéndez-Varela point out that an effective rubric must be aligned with curricular



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content, learning objectives, and quality standards, thus facilitating a coherent, objective, and transparent evaluation. Furthermore, they propose that rubric design should respond to specific criteria that allow for a clear assessment of students' performance level for each indicator. However, the results obtained in this study show that 37% of students believe that teachers do not present the information contained in the rubrics clearly, visibly, and appropriately, while 57% indicate that they do not perceive an objective assessment of their learning achievements when evaluated using this instrument. These perceptions contrast with those presented by Alcón-Latorre and Menéndez-Varela, who state that a well-designed rubric should contain precise, understandable descriptors aligned with quality criteria, which should be applied progressively throughout the learning process (Alcón-Latorre and Menéndez-Varela 2016, pp. 3-4).

Comparing the theoretical framework and background with the results, it is evident that the rubric was not applied correctly due to a lack of the necessary information to guide the evaluation process. This prevented good results and generated a negative impact, attributable to a poorly structured instrument implemented by the teacher. The rubric lacks the characteristics of being objective, structured, and efficient from the process to the final result, in relation to parameters that assess the construction of knowledge acquired by the student. The lack of descriptors makes the rubric an ineffective instrument for the desired level of achievement and fails to fulfill its function of evaluating skills and abilities during the learning process.

The assessment of algebraic operations learning in eighth-grade students was contextualized, considering current approaches to the use of instruments such as rubrics. Within this framework, Buelvas et al. emphasize that formative assessment should be geared towards reinforcing students' prior knowledge in order to develop competencies meaningfully, allowing for more conscious and participatory learning (Buelvas et al., 2023, p. 56). According to the results obtained in this study, 40% and 45% of students indicated a lack of clarity regarding the assessment guidelines, demonstrating a lack of explanation on the part of the teacher. Furthermore, 52% of respondents stated that they did not perceive an appropriate application of assessment instruments during class. These data are complemented by the percentages of 72% and 76% of students who stated that digital educational resources are only occasionally or never used as part of an assessment with differentiated formats. These results highlight the need to improve both the planning and communication of assessment criteria in the classroom, as well as to integrate digital tools that diversify the ways of assessing mathematical learning.

Sixty percent of students do not feel motivated during the assessment process, supported by 50% and 41% of students who do not understand the actions taken by the teacher, such as preparatory activities, participation, and appropriate feedback at each stage of the assessment. Thus, 57% and 58% of students do not perceive a positive attitude from the teacher during the learning process, but rather a focus solely on the final result. These data are related to the guidelines for implementing learning assessment processes proposed by the Ministry of Education in 2023, which value the teacher's role in the acquisition of skills and abilities at each level, as reflected in an assessment. The results are indicators of improvement in the teaching-learning process.

Comparing the theoretical framework and background with the results, there is a lack of dialogue between teachers and students regarding changes in evaluation guidelines. Furthermore, the diverse evaluation instruments detailed in current Ministerial Agreements are not being used, and digital resources are underutilized during the evaluation process. The need for evaluation remains, and the lack of motivation,



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participation, and feedback from teachers in class continues to be a source of concern. Students observe that evaluation focuses solely on the final result, disregarding the process they followed to arrive at a correct or incorrect answer.

Medina et al. analyze teachers' perceptions of rubric use in formative assessment and conclude that rubrics are valued for their clarity, objectivity, and contribution to analyzing students' academic performance. While their benefits for strengthening skills such as critical thinking and self-reflection are acknowledged, it is also noted that their effective application depends on teacher training and the educational context (Medina et al., 2023). These perceptions support the use of rubrics as a teaching tool that promotes inclusive and formative assessment, key aspects for improving the learning of algebraic operations in mathematics.

The design of a teaching guide based on the use of rubrics as a key pedagogical resource was proposed to facilitate the achievement of learning related to algebraic operations. In this context, Medina et al. maintain that rubrics constitute an effective assessment tool in the area of Mathematics; they not only allow for the evaluation of final products, but also the formative processes through which students develop skills and abilities. The results obtained reflect a consensus among the participating teachers regarding the usefulness of rubrics for strengthening competencies such as critical thinking, reflection, and problem-solving. They also underscore the need to integrate appropriate resources, continuous feedback, and inclusive strategies that promote more equitable and contextualized assessment within the classroom.

Comparing the theoretical framework and background information with the results, teachers are aware of the skills students should master in mathematics, and this is reflected in the grades. Assessment is traditional, using exercises and answers, and despite training on assessment methods, teachers do not experiment with new assessment tools. A rubric, however, is an instrument that provides detailed feedback on the process and final product, which are key to mathematics. An effective rubric for evaluating the learning of algebraic operations in eighth-grade students should combine qualitative and quantitative elements. Qualitatively, the rubric should clearly describe the performance levels, the specific skills at each level, and the ability to solve exercises. Quantitatively, it should assign numerical scores to each performance level, allowing for a precise and objective evaluation.

The rubric should include criteria that consider the problem-solving process, not just the final result, as this constitutes a comprehensive assessment of student learning. An example of a quantitative and qualitative rubric for the assessment of learning algebraic operations is presented.

6. Conclusions

An analysis of the structural characteristics of assessment rubrics was conducted in relation to the guidelines of the Ecuadorian Ministry of Education. On average, 47% of teachers do not use rubrics appropriately in assessments, according to the guidelines established by the Ministry. The main issues affecting the structure of a rubric as an assessment tool are the following: 37% (failing to specify the necessary information) and 57% (failing to assess learning outcomes). This is because the rubric lacks the necessary guidance for students during the activity, resulting in low grades that do not accurately reflect the level of achievement of the student or group of students being assessed.



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The assessment of learning among eighth-grade students in basic general education is contextualized, revealing that, on average, 57% of students perceive the assessment of algebraic operations as a tedious process to be completed without any appeal. This is evidenced by data such as: 42.5% (lack of knowledge of the assessment parameters), 52% (lack of recognition of the assessment instruments), and 74% (lack of use of digital educational resources) in relation to the assessment tool used. Similarly, 54% of students perceive the teacher's activity as weak, based on data such as: 60% (lack of motivation), 46% (lack of participation in activities), and 58% (lack of perception of a positive attitude) in relation to the environment before, during, and after an assessment. This indicates that the assessment processes in algebraic operations are mechanical, based on solving exercises in anticipation of a good grade, neglecting the purpose of a comprehensive assessment that involves student participation.

A teaching guide based on rubrics was deemed beneficial for clarifying the mathematical skills students should develop. According to teachers, these skills are primarily demonstrated through problem-solving in traditional, standardized tests. Teaching materials and assessments are typically created individually, without experimentation with new assessment tools and instruments. Ongoing professional development in teaching and learning topics provides opportunities for change in the approach and methods of evaluating content. This study proposes the design of quantitative and qualitative rubrics for assessing the learning of algebraic operations in eighth-grade students. It addresses the issue of rubrics not being effectively applied in assessments due to the instrument's structure, the specific skills being evaluated, and a lack of experience among mathematics teachers who focus solely on correct and incorrect answers without recognizing the student's progress as they tackle exercises or problems on tests. The assessment for algebraic operations is mediocre without the support of digital educational resources, which are a trend in current education, at every stage—before, during, and after—resulting in mediocre grades and failing to fulfill the purpose of a test, which is to identify students' strengths and weaknesses to improve the teaching-learning process.

Acknowledgment

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Declaration of authorship-CRediT

DIEGO TIPÁN-RENJIFO: Problem statement, theoretical development, methodology, validation, data analysis, and drafting of the first draft.

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Artificial intelligence usage statement

The authors report that they partially used the ChatGPT tool – GPT-4 model (OpenAI), July 2025 version – during the manuscript preparation stage, specifically for: support in the syntactic restructuring of some paragraphs, the creation of alternative versions of titles and subtitles, and the generation of preliminary examples that were subsequently reformulated



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manually. Artificial intelligence was not used to draft sections related to methodological design, data analysis, interpretation of results, or academic discussion. All content suggested by the tool was critically reviewed, verified, and modified by the authors, who assume full responsibility for the final text, its accuracy, and its scientific rigor.



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Integration of gamification into the andragogical process of the physics area for intensive evening high school students

Integración de la gamificación en el proceso andragógico del área de física para estudiantes nivel bachillerato nocturno intensivo

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Abstract

This research analyzes the low academic performance, lack of motivation, and limited participation of adult and senior citizens with incomplete schooling in the Physics course within the intensive evening high school program. This problem is crucial, as it affects a traditionally excluded group whose education is vital for their personal and social development. Classical teaching strategies have proven insufficient to achieve meaningful learning and active participation in this andragogical context. The central proposal consists of incorporating gamification into the teaching process, based on the characteristics of adult learning. To make the teaching of complex concepts, such as density, dynamic game



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elements and specific digital platforms (Websim and Spatial) were used. The methodology employed is a mixed-methods approach, based on the Sequential Exploratory Design (DEXPLOS) model, integrating qualitative analysis (interviews and observation sheets) and quantitative analysis (satisfaction surveys). The study was conducted with students and educators in the intensive evening program in the city of Azogues, Ecuador. Among the main results, a significant improvement was observed in motivation, conceptual understanding, active participation in the classroom, collaborative work, and the development of critical thinking. Contextualized and accessible gamification proved capable of transforming the teaching and learning process, fostering meaningful and resilient knowledge. This proposal represents an inclusive and replicable alternative for optimizing the teaching of Physics in vulnerable contexts.

Keywords

Andragogy, academic performance, gamification, and motivation.

Resumen

La presente investigación analiza el bajo rendimiento escolar, la escasa motivación y la limitada participación de estudiantes adultos y adultos mayores con escolaridad inconclusa en la asignatura de Física, dentro del bachillerato intensivo nocturno. Esta problemática es crucial, pues afecta a un grupo tradicionalmente excluido, cuya formación educativa es vital para su desarrollo personal y social. Las estrategias didácticas clásicas han demostrado ser insuficientes para lograr un aprendizaje significativo y una participación activa en este contexto andragógico. La propuesta central consiste en incorporar la gamificación en el proceso de enseñanza, tomando como base las características del aprendizaje adulto. Para dinamizar la enseñanza de conceptos complejos, como la densidad, se utilizaron elementos de juego y plataformas digitales específicas (Websim y Spatial). La metodología empleada es de enfoque mixto, bajo el modelo Diseño Exploratorio Secuencial (DEXPLOS), integrando análisis cualitativo (entrevistas y fichas de observación) y cuantitativo (encuestas de satisfacción). La aplicación se realizó con estudiantes y educadores de la sección nocturna intensiva en la ciudad de Azogues-Ecuador. Entre los principales resultados, se evidenció una mejora significativa en la motivación, la comprensión conceptual, la participación activa en el aula, el trabajo colaborativo y el desarrollo del pensamiento crítico. La gamificación contextualizada y accesible demostró ser capaz de transformar el proceso de enseñanza-aprendizaje, fomentando un conocimiento significativo y resiliente. Esta propuesta representa una alternativa inclusiva y replicable para optimizar la enseñanza de la Física en contextos de vulnerabilidad.

Palabras clave

Andragogía, desempeño académico, gamificación y motivación.

1. Introduction

This research is the result of thesis work, focusing on relevant aspects of Gordon-Salcedo and Noguera-Vásconez (2018). The analysis of gamification integration stems from the deficit in academic performance, lack of motivation, and limited active participation of adult and senior citizens with incomplete schooling who, for various reasons, have been unable to finish their studies, constituting a vulnerable group in the andragogical educational process. Gamification has positioned itself as an innovative and revolutionary strategy in education, especially in the training of this population group. According to Franco-Segovia,



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the integration of this methodology into the andragogical process seeks to enhance student motivation, performance, and participation, particularly in Physics, considered a complex subject. This strategy is based on the use of game elements in educational contexts to optimize learning (Franco-Segovia, 2023, p. 846). This application of gamification not only facilitates the understanding of abstract physics concepts but also fosters critical thinking, collaborative participation, and the comprehensive development of cognitive skills in adult learners.

Andragogy is not just an educational process; it encompasses lifelong learning. It is aimed at adult students who work and have various obligations, and who are parents with diverse needs, seeking active and participatory learning in the educational and social spheres. This is why there is a need to integrate new teaching and learning methodologies for both teachers and students (Caraballo-Colmenares, 2007). Knowles et al., for their part, state that andragogy offers fundamental principles that allow for the design and implementation of more effective educational processes (2001). This context refers to the particularities of the learning situation and, therefore, is applicable to different adult education contexts, promoting methodological change in educational institutions, especially those serving vulnerable groups. Zambrano et al. indicate that gamification is also known as ludification, playfulness, and gameification; all these terms refer to the use of game mechanics, strategies, and processes within an activity (2020). In this sense, the sole purpose of gamification is to generate student engagement and motivation that facilitates the improvement of educational environments. This integrated perspective not only analyzes educational contexts from a playful viewpoint but also provides opportunities to enhance andragogical learning. By including playful dynamics, the approach goes beyond simply relating content and promotes emotional and social growth by addressing the respective challenges of daily life.

On the other hand, Angell et al. state that conventional physics teaching is based on traditional techniques that, despite having been effective in the past, do not always manage to capture students' attention or promote the practical application of the knowledge learned (2004). Since Physics is a complex discipline, it is essential to capture students' attention during class. For this reason, gamification emerges as a key option that focuses on transforming complex academic topics into dynamic, engaging, and motivating experiences, facilitating not only the understanding of concepts but also the development of skills. This study also emphasizes exploring the contribution of gamification and the development of cognitive abilities to the academic performance of high school students.

It is worth noting that integrating gamification can present several challenges, such as resistance to change and the digital divide among both teachers and students, a lack of resources, and the need for ongoing, progressive training to ensure the proper integration of new methodologies, among others. Alongside the integration of these methodologies, according to Ayala, the scarcity of technological resources should be taken into account, as this can be a limiting factor for access to interactive platforms and gamification systems suitable for teaching. Therefore, technological availability can be a key facilitator for accessing innovative methodologies such as gamification, which can also be used in different areas of the teaching process (Ayala-Escudero, et al., 2024).

In this regard, it is worth emphasizing that the use of gamification in the educational process can enhance student interest when properly designed from an educational approach that aligns with the student's pedagogical needs. However, despite the strategies implemented and resources allocated, many students continue to face significant learning gaps in the



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subject. These difficulties contribute to low academic performance and a lack of motivation for active participation in the educational environment. Thus, the use of well-structured game-based activities could be an effective change in their academic process, especially in Physics, which is considered a complex subject.

Furthermore, the application of active methodologies such as gamification can develop soft skills that are considered important for collaborative problem-solving, problem-solving, and critical thinking in our students. This research aims to answer the following question: How could the integration of an andragogical model based on gamification contribute to the learning, motivation, and development of critical thinking skills in high school students in the evening program in the area of Physics? This approach invites reflection on the positive contributions that the integration of this methodology could generate in the classroom. Its constructivist principle implies not only technical mastery of the digital tools used, but also the need for a teaching model that facilitates the active construction of knowledge. Furthermore, it raises the need to analyze ways to reduce the existing challenges that hinder its effective application.

According to Alonso-García et al., there are several factors that can delay the implementation of the proposal, such as a lack of teacher training, resistance to change in the use of gamified platforms, and resistance to methodological change. These represent significant barriers to teaching and applying new methodologies in andragogical environments. Therefore, it is necessary to develop pedagogical models that incorporate gamification in a structured way and ensure its alignment with the foundations of adult learning and the curricular objectives of Physics. At the same time, teachers' competence in facilitating and monitoring this learning will also support its effective development (Alonso-García et al., 2021) to face the challenges of the contemporary world with a critical and creative attitude. The objective is to analyze the motivational contribution to the andragogical process of third-year high school students in the area of Physics when gamification is integrated, thus opening the possibility of implementing and designing a didactic proposal in the future that incorporates game elements to improve this emotional factor and, consequently, conceptual learning and active student participation.

Certain public educational institutions are interacting within a new ecosystem whose axes are technology, digitalization, and innovation. However, those institutions offering educational programs for young people, adults, and older adults with incomplete schooling face challenging situations such as limited interest in and collaboration with digital practices, a lack of resources, and insufficient support for innovative educational methodologies (Rodríguez-Laz & Rodríguez-Álava, 2024). Therefore, the effective integration of gamification with constructivist principles in educational programs for adults and older adults with incomplete schooling presents a multifaceted challenge. This type of teaching not only requires technical mastery of the digital tools used but also a model that facilitates the active construction of knowledge (Alonso-García et al., 2021). Within the constructivist framework, learning is enhanced as students autonomously engage in meaningful, contextualized, and emotionally stimulating environments.

Similarly, the lack of teacher training, resistance to change in the use of gamified platforms, and resistance to methodological change pose significant barriers to teaching and applying new methodologies for implementation in andragogical environments (Navarro et al., 2021). Therefore, it is necessary to develop pedagogical models that incorporate gamification in a structured way and ensure its alignment with the foundations of adult learning and the curricular objectives of Physics. At the same time, teachers' competence in



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facilitating and monitoring learning will also support its effective development (Alonso-García et al., 2021) to face the challenges of the contemporary world with a critical and creative attitude.

According to Martínez-Cortes and Parrales-Loor, economic and social factors, health conditions, family problems, geographic displacement, and a lack of educational resources present obstacles for individuals with incomplete schooling in resuming their education (2024). This situation significantly limits their employment opportunities, perpetuating poverty and inequality within society. Muñoz-Ortiz et al. warn that educational exclusion not only affects students' personal and professional development but also has negative repercussions for the national economy (Muñoz-Ortiz et al., 2023). It is essential to implement public policies that address these barriers and promote safe and accessible educational inclusion.

To analyze the results obtained, a pedagogical proposal based on the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model is suggested for integrating gamification into the andragogical process of Physics. This proposal is aimed at high school students in the intensive evening program with incomplete schooling in the city of Azogues. The ADDIE model was chosen for its emphasis on instructional design in flexible learning contexts, centered on student needs. Various studies have verified that this model improves motivation and performance in Physics, and also aids in the understanding of abstract concepts through virtual tools and simulators. Zainuddin et al. state that andragogical-based gamification enhances autonomous learning, intrinsic motivation, and the connection of knowledge to real-world contexts. This proposal evaluates autonomy, collaboration, and the critical appropriation of knowledge, making it an inclusive and transformative approach (Zainuddin et al., 2020).

Regarding the article's structure, Section 2 addresses the main theoretical concepts that underpin the research and presents an analysis of various bibliographic sources. Section 3 describes in detail the methodology used to develop the study. Section 4 presents the results and analysis of the instruments used. Finally, Section 5 presents the conclusions derived from the results obtained.

2. Literature review

2.1 Gamification

Gamification focuses on teaching through playful games to motivate students in their educational process, helping to improve their academic performance. Considered a tool capable of radically modifying self-directed learning, gamification also aims to differentiate how students' learning progress is assessed and is designed to be centered on real-time learning. Furthermore, the term "gamification," derived from the English word "game," refers to the way game techniques are used to maintain motivation, in this case, among vulnerable students, including adults and older adults with diverse educational, social, and economic needs (Zambrano et al., 2020, p. 350). Therefore, gamification is a strategy that has modified conventional learning, since the implementation of new pedagogical approaches through games radically alters academic performance through a fun and engaging experience. Thus, the student shows evident alterations in terms of their interest in active and collaborative learning, facing challenges and receiving feedback.



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2.2 Gamification as an educational innovation

Instruction and learning are constantly evolving processes, where both teachers and students must adapt throughout their own educational journey. Mercado-Borja et al. (2024) consider resistance to change to be a significant challenge, so much so that pedagogical innovation provides effective strategies that contribute to improved outcomes and induce genuine change in the teaching and learning processes (2024). This academic progress not only requires the incorporation of new technologies but also a positive attitude towards approaches that foster critical thinking and active student engagement. In the words of Carbonell et al. (2015), educational innovation is directed towards the search for appropriate and efficient methods to improve the teaching-learning process. These same authors state in their work that this innovation is linked to the development of personal skills and the modification of traditional education, creating a space where current strategies can be implemented to improve critical and creative reasoning in both students and teachers.

Instruction and learning are constantly evolving processes; teachers and students must adapt throughout their own educational journeys. Therefore, pedagogical innovation provides effective strategies that contribute to improved outcomes and foster genuine change in the teaching-learning process, creating educational environments where creativity and critical thinking are considered key components. However, according to Rodríguez-Laz and Rodríguez-Álava, adults and older adults with incomplete schooling face challenging situations such as limited interest in and participation in digital practices, and a lack of resources and support for technologically innovative educational processes (Rodríguez-Laz & Rodríguez-Álava, 2024). These challenges demonstrate the importance of developing new, inclusive, and easily accessible strategies so that all students experience educational equity. The effective integration of gamification into education requires not only mastery of digital tools but also the commitment of students and teachers to overcome technological barriers and resistance to change. In this way, we can move towards an innovative and motivating education.

2.3 Theoretical foundations of gamification in education

Gamification, understood as the application of game design elements and principles in non-game contexts, such as education, constitutes a pedagogical strategy aimed at enriching teaching and learning processes (Deterding et al., 2011). In this sense, it is not limited to the simple incorporation of game components, but rather is based on study methods that integrate reward and challenge systems with the purpose of improving learning. Thus, according to Zambrano-Álava, it fosters the development of cognitive and social skills in students, in a context that stimulates creativity and the ability to solve real-life problems (Zambrano-Álava, 2020). If pedagogical methods and models are implemented with a more dynamic, meaningful, and active teaching and learning design, students could be provided with learning experiences in which they are able to construct their knowledge through interaction, experimentation, and reflection (Kapp, 2012). This reading supports a constructivist culture, where teaching is more exploratory and less traditional, positively influencing academic performance, group participation in class, and the development of soft skills such as autonomous or group collaboration or problem-solving ability (Deterding, et al., 2020, p. 6).

2.4 Principles of andragogy

As Córdova-Córdova et al. indicate, andragogy is defined by the characteristic of autonomous adult learning, considering prior experience, intrinsic motivation, and the



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capacity for self-reflection as its fundamental pillars in the educational process (2025). For this approach, enabling adult learners to be active participants in a continuous learning process translates into a facilitating element for problem-solving within the educational context and fostering skills useful in their professional and social lives. In the Ecuadorian context, Vásquez-Aguilar et al. point out that the country has made progress in inclusive policies aimed at guaranteeing equitable access to education, especially for adults with educational disadvantages (2024). However, structural challenges still exist that restrict the completion of their studies, especially for a vulnerable group, as demonstrated by the Ministry of Education in its reports on the educational situation. Thus, regulatory progress and social realities highlight the need to implement more comprehensive strategies that address access to, retention in, and completion of their studies.

According to the Ministry of Human Development, in 2023, Ecuador had approximately 1,049,824 people over 65 years of age, representing 6.5% of the total population. It is projected that by 2054, this group will reach 18%, which poses significant challenges in terms of public policies and assistance programs aimed at this sector (Ministry of Economic and Social Inclusion, 2023). Furthermore, an analysis by DVV International indicates that, in 2020, approximately 5.7 million young people and adults in Ecuador were illiterate or had incomplete schooling. This fact underscores the importance of strengthening educational programs aimed at this population group (Crespo-Burgos and Larrea-Robalino, 2023).

The Organic Law of Intercultural Education (LOE), in Article 6, section (i), regarding the state's obligations concerning the right to education, emphasizes "promoting lifelong learning processes for adults and the eradication of pure, functional, and digital illiteracy, and overcoming educational backwardness." Established within the legal framework and by ministerial agreement, this law promotes the education of young people and adults with incomplete schooling. The Ministry of Education of Ecuador is implementing the "Todos ABC" Campaign, a program focused on literacy, basic education, and intensive high school studies named after Monsignor Leónidas Proaño. This campaign aims to provide lifelong learning opportunities for Ecuadorians, fostering their skills and abilities.

Andragogy, conceived as the art and science of helping adults learn, is based on the premise that adult learners have different characteristics and needs than children (Knowles et al., 2001). The authors identified several key principles of andragogy, including the need to understand the reasons for learning, the importance of prior experience, a problem-solving orientation, intrinsic motivation, and the individual needs of each learner. Andragogy rejects a learner-centered approach, promotes self-direction, and recognizes the value of experiential learning as an integral part of the learning process (Knowles, 2001). According to Caraballo-Colmenares, adult education should focus on the learner's prior experience, since this directly influences how new knowledge is absorbed. In contrast to children, adults achieve more solid learning when they relate information to their own experience (Caraballo-Colmenares, 2007).

The use of diverse andragagogical strategies in higher education increases the motivation and academic performance of adult learners. It is important to highlight that autonomy and self-regulation are key factors in this process, promoting more effective and confident learning and facilitating time management for students (Córdova-Córdova et al., 2024). These factors reflect the adult learner's experience, helping them construct knowledge in a more relevant way and connect with their own reality. Thus, it can be seen how andragogy not only



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contributes to academic performance but also facilitates more autonomous and meaningful learning for personal and professional growth.

Andragogy has two principles: horizontality and participation. The first occurs when the adult learner becomes aware that they can manage their own learning and feels motivated to continue the process; the second, the principle of participation, is defined as the adult learner's decision to become involved and take a more active role (Torres, 2000). For this approach, making the adult learner an active participant in a continuous learning process translates into a facilitating element for problem-solving within the very reality of an educational context that also fosters skills useful for their work and social life. Therefore, andragogical principles and postulates contribute to the transfer of knowledge in adult learning (Gutiérrez et al., 2021). In the Ecuadorian context, Vásquez-Agilar et al. point out that "the country has made progress in inclusive policies aimed at guaranteeing equitable access to education, especially for adults with educational disadvantages" (2024).

2.5 Challenges in the teaching and learning of Physics in high school

Regarding the educational changes proposed in the 2008 Ecuadorian Constitution, the curriculum was updated and strengthened in 2010. This update is based on the principles of critical pedagogy and the development of macro-skills and performance-based skills, strengthening the process of interpreting and solving problems. It emphasizes that students can achieve meaningful learning when they solve real-life problems by applying different concepts and tools from the subject area (Gallegos et al., 2018).

Physics, as one of the fundamental pillars of science, is seen as a very important subject, although students often perceive it as an abstract, complex, and disconnected area of study (Angell et al., 2004). A lack of understanding of abstract concepts, weak mathematical skills, and the absence of pedagogical strategies that foster curiosity and exploration could contribute to demotivation and low performance in this subject. While misconceptions about physics have been documented, and these beliefs and values persist throughout secondary education, efforts are underway to eradicate them by moving away from the traditional approach of solving mechanical problems, which is insufficient for adequate conceptualization. To this end, Halloun and Hestenes propose innovative pedagogical alternatives that encourage student participation in class, using their own context as a methodology (Halloun & Hestenes, 1985).

From a pedagogical perspective, platforms such as Spatial and WebSim can be used, which make it possible to reconstruct physical concepts through playful and accessible experiences. For example, the combined use of gamified simulators to explore concepts like nature, density, and mechanical energy fosters a more dynamic understanding, aligned with the development of scientific thinking in students. This, in turn, promotes a culture of active, meaningful learning that connects emotionally with students. Gowin's V strategy in experimental Physics teaching allows for the structuring of cognitive processes, as well as fostering cooperative interaction in the classroom, in addition to encouraging the development of analytical and critical skills in students (Andrade-Vélez and Álvarez-Alvarado, 2024, p. 85).

2.6 Integration of gamification in the teaching of Physics

The pedagogical value of playful elements in physics teaching fosters a highly meaningful relationship between students and the academic content being taught. By reducing the perceived complexity, learning becomes more accessible, emotionally motivating, and conducive to the construction and retention of physical knowledge. Gamification has



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revolutionized education as a technique with great potential for addressing the challenges of instruction and learning. With playful components in educational tasks, it is expected to foster intrinsic motivation, encourage participation, and offer a meaningful context for introducing physical concepts (Espinoza-Gaona et al., 2025). This approach allows for a more constructive relationship with the content, overcoming any apprehension about this method and creating a pleasant environment for study. Landers points out that poor gamification can generate distractions and decrease the effectiveness of learning. Thus, teachers must design activities focused on cognitive skills and not on superficial designs that only address rewards. Continuous feedback should also be integrated as a central pedagogical element, as it offers the possibility of guiding the learning process and, at the same time, fostering a better understanding of the physics concepts being studied. Gamification, by incorporating game elements, generates meaningful learning and allows students to integrate theoretical concepts into practical contexts (2014).

2.7 Andragogy as a framework for gamification in high school

Øjeda and Zaldívar state that gamification is a methodology that can integrate students' socio-emotional factors into the teaching and learning process. It is not only the playful component, but can also generate learning alternatives that foster creativity, promote self-directed learning, and encourage a greater understanding of extrinsic and intrinsic motivation (2023).

In this way, gamified dynamics place students at the center of the educational process, generating meaningful learning experiences that link the teaching and learning processes. Córdova-Córdova et al. explain that the inclusion of andragogical principles in secondary education can result in improved student autonomy and engagement (2024). This idea is reinforced by linking gamification with cognitive processes that promote decision-making and the resolution of real-world problems, fostering more meaningful learning. At the same time, without diminishing the teacher's role as a facilitator of active and reflective experiences, this strategy helps students become more motivated and take a more active role in the classroom.

According to Hamari et al., incorporating playful elements into the learning process is one way to promote the retention of difficult-to-grasp concepts (2014). This argument proposes gamification as a well-founded didactic intervention approach that would transform physics content into motivating experiences where critical thinking skills, such as analytical thinking, are developed. Hamadah, for his part, states that features like immediate feedback and peer assessment empower students in their learning process. These characteristics allow students not only to develop autonomy but also to become active participants in their learning, where knowledge is constructed collaboratively and academic performance is enhanced within a gamified environment mediated by methodologies that respect the individual needs of each student (Hamadah, 2023).

Kapp states that by including clear goals, constant feedback, and meaningful rewards, it is possible to improve engagement with the content, especially in areas related to physics, where abstract concepts often generate resistance or little interest (Kapp, 2012). The gamified structure offers the opportunity to adjust the difficulty according to each student's pace and promotes educational inclusion in an attractive and motivating way.

2.8 Gaps in the research and justification of the study

Berrones-Yaulema et al. point out that gamification has been extensively analyzed within the framework of basic education; however, its contribution to teaching complex physics



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concepts to secondary school students is still a new line of research (2023). This statement indicates clear evidence of the absence of playful teaching methods in adult education, as well as in physics teaching. Therefore, didactic proposals must be developed that incorporate andragagogical principles, including gamified resources tailored to the cognitive and emotional context of the adult group.

Quiroz-Peña et al. indicate that most studies focus on short-term conclusions without considering that gamification centers on knowledge retention and the development of analytical skills over time (Quiroz-Peña et al., 2022). This statement highlights the need for research that allows us to evaluate not only the immediate impact but also the sustained progress of critical thinking skills in physics learning. According to Navarro, gamification can be used not only for entertainment but also as a long-term training strategy in the teaching-learning process, enabling students to achieve autonomy and develop critical thinking skills (Navarro et al., 2021). Therefore, this study seeks a theoretical and practical framework for introducing gamification into physics teaching, ensuring that the resources used are, above all, effective, accessible, and relevant to different educational settings, thus achieving the student's ongoing and meaningful participation in their learning process.

3. Methods and materials

The study was conducted at a public school in the city of Azogues, located in the province of Cañar, Ecuador. A non-probabilistic, purposive sampling method was used, consisting of 10 adult and senior citizen students enrolled in the unified high school program (intensive evening section) and 23 teachers from the same institution. Participant selection was based on accessibility, time availability, and educational relevance, with the aim of obtaining valuable information from this focused group.

This type of sampling is widely used in educational studies where random procedures are not feasible, especially when working with specific or vulnerable populations. The inclusion criteria for this student population were: being over 18 years of age, enrolled in the evening program, at the high school level, and having incomplete schooling. According to Asiamah et al., non-probability sampling allows for obtaining valuable information from focused groups when population parameters are unknown or difficult to identify individually (2017), making it a valid strategy for exploratory and applied research in education.

Regarding the teachers, their selection was based on their availability, the andragagogical characteristics they exhibit in their pedagogical practice, and their direct connection to the level where the gamified approach was implemented. This population was not selected randomly but was intentionally defined by belonging to a vulnerable social, work, and family context, whose conditions directly influence the learning process. The research is structured under a pragmatic paradigm that combines mixed methods; therefore, in the qualitative phase, interviews were conducted with two experts in gamification and physics, as well as observation sheets to record experiences with the activities designed using play-based strategies. In addition, during the quantitative phase, Likert-scale satisfaction surveys were administered to 23 teachers and 19 students to assess their perceptions of the methodology used in these activities. It is worth noting that the instruments used were validated by experts, thus ensuring their reliability through Cronbach's alpha coefficient (Hernández et al., 2014), with the closer to one indicating better reliability.

The research also employed the DEXPLOS exploratory design, based on Diversity, Experience, Practice, Play, Information, and Meaningfulness, which aims to create a dynamic learning environment to integrate gamification into physics teaching. The data



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obtained were analyzed using SPSS software, and it is important to emphasize that the participants' authorization and consent were obtained to share the information. While this study is contextualized within a specific setting, it is hoped that the results will provide valuable insights for implementing gamification as a motivational and inclusive strategy applicable in diverse educational environments with similar characteristics.

4. Results y discussion

Pegelajar-Palomino argues that gamification is a methodological strategy that incorporates game elements into the teaching and learning process, thus establishing a link between the student and the content from a different perspective (Pegelajar-Palomino, 2021). However, constant monitoring of these methodological approaches in the classroom is necessary, as, despite their benefits, they do not guarantee teaching success if they are not aligned with the class objectives (Gonzalez-Moya et al., 2021).

In relation to the above, Alonso-García et al. point out that one of the reasons gamification has become a more frequently used resource by teachers is its close relationship with both extrinsic motivation (rewards and satisfying challenges) and intrinsic motivation, which arises from the individual (Alonso-García et al., 2021). In other words, gamification as a teaching strategy becomes an ideal resource for use in teaching practice, allowing for meaningful learning by mobilizing diverse skills that, in turn, lead to the development of competence (Ramos-Vera & Ramos-Vera, 2021).

The researchers agree with the authors that the aforementioned strategies are fundamental for more holistic learning, and that the implementation of playful activities inherent in pedagogical methods such as gamification not only strengthens and improves motivational aspects but also contributes to improved academic performance. At the same time, it is considered necessary to strengthen these practices through teacher training to ensure that these strategies are effectively applied in the classroom.

4.1. Main findings in the qualitative analysis

The research analysis began with interviews with informants, which allowed for the identification of learning needs in Physics and the incorporation of gamification into the subject. Identifying problems (such as lack of motivation or low academic performance) was the necessary first step to solicit the opinions of teachers experienced in addressing these issues through gamification. The questions posed to the informants focused on students' needs and the different teaching strategies that foster autonomy and problem-solving. Therefore, these interviews constitute a good starting point for consolidating more effective teaching approaches that are better suited to the educational context.

4.1.1 Analysis of expert interviews

The qualitative analysis used the MAXQDA program to code the expert interviews according to the variables of Physics and gamification. See Table 1.

Question or objective it answers	Expert's answer	Code	Analisis
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<p>Identify student academic performance and motivation in an andragogical context in the area of physics.</p>	<p>Motivation is affected by the relevance of the content and its connection to students' daily lives.</p>	<p>Motivation</p>	<p>The connection between the content and daily life is analyzed, as it is essential for increasing motivation and academic performance, especially for adult learners and older adults with incomplete schooling, who require practical activities within the classroom.</p>
<p>Design gamified strategies that promote autonomy and problem-solving in physics, considering the principles of andragogy.</p> <p>Select gamified activities that foster teamwork and collaboration among students, strengthening their skills and abilities.</p>	<p>Strategies should include the possibility of choosing and personalizing tasks, allowing students to make decisions about their learning.</p> <p>Activities that require group work and have common goals are effective in fostering collaboration and teamwork.</p>	<p>Autonomy and Personalization</p>	<p>Fostering autonomy through task personalization is key to motivating students and facilitating problem-solving, aligning with andragogical principles.</p> <p>Gamified activities that promote collaboration help strengthen essential personal and communication skills in the learning environment.</p>
<p>Evaluate the change in student academic performance through the integration of gamification in the area of physics.</p>	<p>Clear rules should be established to evaluate the contribution of gamification, including exams, projects, and self-assessments.</p>	<p>Assessment and Rules</p>	<p>The implementation of well-defined rules is fundamental to assessing the contribution of gamification to academic performance, allowing for a comprehensive analysis of learning.</p>



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How can gamification improve students' academic performance and the development of critical thinking in the andragagogical process?	Gamification can increase motivation by making learning more interactive, comprehensive, and relevant, thus stimulating the development of students' critical thinking skills.	Interactivity, Relevance, and Critical Thinking	Interactivity and relevance are key elements in gamification, as they contribute to students improving their academic performance and developing their critical thinking skills in problem-solving and decision-making.
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Cuadro 1. Entrevista a experto 1 resultado de análisis cualitativo

The interview results highlighted that applying concepts through gamification facilitates the understanding of topics taught in the area of Physics and enhances student motivation by progressively addressing cognitive conflicts. According to García-Casaus et al., this methodology facilitates student participation and critical thinking by integrating playful dynamics that stimulate intrinsic motivation and promote problem-solving (2020).

Question or objective it answers	Expert Answer 2	Code	Analisis
Identify student academic performance and motivation in an andragagogical context in the area of physics	Intrinsic student motivation is essential. Strategies must consider the diversity of the players and their needs	Intrinsic Motivation, Diversity	To ensure the success of gamification in the classroom, it is essential to personalize the strategy according to the characteristics of the students. Therefore, autonomy and understanding of the objectives must be fostered to increase academic performance.
Design gamified strategies that promote autonomy and problem-solving in physics, considering the principles of andragogy	Motivation is key for psychological students, keeping in mind the needs of each individual student.	Autonomy and Problem Solving	Gamification strategies should be organized according to the students' interests and encourage their freedom to facilitate the assimilation of the physics content.



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<p>Enable students to make decisions through gamified activities that enhance cooperation and group participation to increase their capacities and skills.</p>	<p>A number of student skills must be integrated to achieve common goals, with the consequent improvement in coexistence and recognition of those skills.</p>	<p>Collaborative Work and Skills</p>	<p>Gamification can facilitate collaboration by focusing on shared goals, promoting an inclusive and diverse learning environment, and strengthening communication skills.</p>
<p>Evaluate the change in student academic performance through the integration of gamification in the area of physics</p>	<p>Indicators of motivation, independent work, and achievement of established goals must be clearly defined</p>	<p>Performance and Compliance Indicators</p>	<p>Evaluation should include both qualitative and quantitative aspects, ensuring that progress in motivation and engagement is measured progressively.</p>
<p>How does the integration of an andragogical model based on gamification influence learning, motivation, and the development of critical thinking skills in third-year high school students in the area of physics??</p>	<p>It is important to thoroughly understand the concepts and design original gamified strategies, without simply replicating others..</p>	<p>Individual Design and Critical Thinking</p>	<p>Clearly understanding the difference between gamification and ludification is crucial for integrating effective strategies that foster students' critical thinking and are adapted to the specific needs of the educational context.</p>

Table 2. Interview with expert 2, result of qualitative analysis

The effects derived from this framework highlight elements such as reward, motivation, and a clearly defined game strategy, which are essential for engaging students in the work. Therefore, well-structured gamification, through the presentation of accessible challenges with symbolic rewards, improves intrinsic motivation and allows for rapid feedback.

4.1.2 Gamified class application process

In the implementation phase, which consisted of a demonstration class, the virtual platforms for use in the classroom were introduced for the first time by the group of students. These platforms allowed for real-time interaction, demonstrating the students' interest and commitment. During the evaluation phase, a satisfaction survey about the



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demonstration class was administered to both teachers and students. A qualitative analysis was also conducted through interviews and observations, and the results confirmed the positive impact of gamification on academic performance and student participation. In this regard, the development of this proposal clearly demonstrates the possibility of transforming physics learning for adult university students into an enriching, inclusive, and motivating process through contextualized and accessible instructional design. The proposal was implemented as a demonstration class, in which students interacted with simulators and gamified challenges, leading to changes in motivation and improved comprehension of physics concepts.

The experts defined the pedagogical intervention process for the class, clarifying how to apply gamification to physics content. The intervention took place in a practical class on the concept of density, introduced with an initial explanation of the topic. WebSim and Spatial tools were used, facilitating a dynamic and motivating approach to physical concepts for the students through virtual environments. During the session, students interacted with real-time visual simulations on their own devices, both independently and collaboratively, and completed activities throughout the class. This approach fostered the understanding of complex concepts related to density. Following this, a challenge was presented in which students could apply the concepts they had learned by working collaboratively with their classmates to solve practical work-related problems. This approach not only encouraged hands-on learning but also helped students put theoretical concepts into practice.

Through its progressive assessment, the Websim platform was used, which allows for online quizzes and enabled students to answer in a fun and dynamic way. The gamification of the subject was complemented by the implementation of reward elements using the Websim platform and Deck Toys, where students received points and recognition based on their participation and performance. This strategy, on the one hand, allowed students to easily assimilate knowledge and, on the other hand, created a collaborative and enthusiastic learning environment. Students felt motivated to participate fully in their learning process.

At the end of the demonstration class, the results were positive, as evidenced by the surveys administered to students and teachers. The use of interactive tools facilitated the assimilation of complex concepts related to density, allowing students to approach the content in an accessible and motivating manner. Likewise, working with real-time visual simulators promoted both independent learning and collaborative work. Furthermore, the challenges presented encouraged collaborative work, allowing the application of theoretical concepts in practical situations. The progressive evaluation through online questionnaires via the Websim platform made the process more dynamic and fun, and the student demonstrated their interest in learning. Thus, these results reflect how gamification transformed the dynamics in the classroom with a different and more interactive educational experience.



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Figure 1. Demonstration class application of Spatial

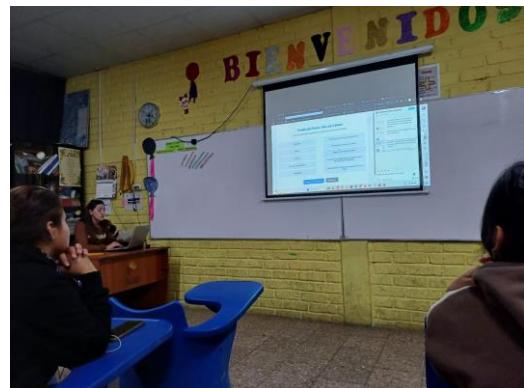


Figure 2. Demonstration class application of Websim

4.1.3 Analysis of observation sheets

During the gamified practical class, observation sheets were integrated for qualitative analysis, showing how each student responds to the change in teaching strategy, resulting in the following frequency table according to the observation category.

OBSERVATION CATEGORY	ALWAYS	ALMOST ALWAYS	NEVER
Interaction with peers	9	8	2
Demonstration of skills	12	5	2
Understanding of tools	10	7	2
Interest in learning	10	8	1
Enthusiasm for new challenges	11	6	2
Involvement in the platform	13	4	2
Relationship of concepts	14	4	1
Participation in collaborative work	11	7	1
Expression of ideas	13	4	2
Application of concepts	10	5	2

Table 3. Frequency of observation sheets.

Following the analysis using observation sheets, the findings regarding students in the area of Physics, particularly in the playful activities related to the topic of density, revealed a high degree of interaction and participation. The majority of students, close to 70%, showed a desire to continue learning during the sessions, while also demonstrating clear motivation



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to face various challenges once their training had concluded. This behavior indicates that gamification is on the right track in motivating students, given its tendency to create a learning environment focused on cooperative work and classroom activities.

Furthermore, it was observed that by participating interactively and contextualizing the topic in Physics, the material is understood more fully through the gamified approach. Once again, student participation and engagement were significant. In this regard, several authors emphasize that the use of game elements in educational contexts increases both motivation and engagement, fostering a collaborative and dynamic environment that facilitates the understanding of complex ideas and helps students adapt to new learning techniques (Deterding et al., 2011; Kapp, 2012).

However, areas for improvement were also observed: very few students (approximately 10%) experienced difficulties integrating and fully participating in the activities. There is a clear need to implement additional strategies to support more introverted participants. Nevertheless, the data reflect a positive effect on learning physics concepts through gamification, as demonstrated by students' ability to apply learned concepts in practical scenarios, such as their own definition of the density of different materials (Deterding et al., 2011; Kapp, 2012). As Deterding et al. indicate, gamification can transform the learning experience (2011). Likewise, the results also guide teachers to transform their pedagogical practice by introducing gamification into their classes in an attractive and appropriate way..

4.2 Relevant findings in the quantitative part

The results of the satisfaction survey administered to the 23 high school teachers showed a positive opinion regarding the integration of gamification in Physics classes. Furthermore, 78.3% of the teachers believe that gamification fosters autonomy in learning, indicating that students become more proactive in their educational process. The surveys demonstrate the effectiveness of game-based activities not only in optimizing academic performance but also in advancing interpersonal and communication skills among students. According to Sarabia-Guevara and Bowen-Mendoza, the success of gamification lies in a suitable design that integrates appropriate understanding among participants, as well as the mission and incentive that motivates them to continue with their academic process (Sarabia-Guevara and Bowen-Mendoza, 2023). Thus, the incorporation of gamification into teaching is essential as an attractive, dynamic, and effective study method during the teaching-learning process.

When asked, "Do you think that gamification has increased the motivation and commitment of adult high school students in the subject of Physics?", 65.2% of the teachers who participated in the development of the class emphasized that gamification is a key aspect in generating motivation among students at all educational levels; highlighting it as an alternative to increase students' academic performance (Ojeda and Zaldívar, 2023).



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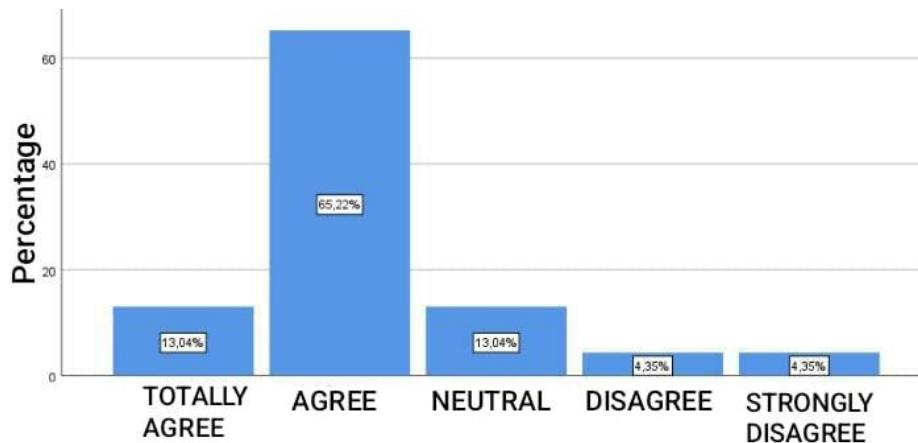


Figure 3. I believe that gamification has increased the motivation and engagement of adult high school students in the area of physics

Regarding the results of the student surveys, a positive assessment of gamification as a pedagogical tool is evident. In this respect, 79% of respondents stated that interactive activities encourage them to participate more actively in the school environment, while 74% emphasized that such activities allow them to better understand abstract physics concepts. Furthermore, 68.4% of students indicated that gamification facilitates connecting the knowledge acquired with their personal experiences, thus strengthening appropriate learning. These findings indicate that gamification not only enhances content comprehension but also fosters more contextual and relevant learning for students. Similarly, it is important to highlight that, according to the survey conducted, gamification is a good way to learn Physics, especially for people who are resuming their studies. This is relevant because it reflects students' opinions on the effectiveness of gamification in their learning process, particularly for those returning to formal education after several years of educational setbacks.

Based on the question, "Do you think gamification is a good way to learn Physics, especially for people like you who are resuming their studies?", it was found that 36.84% of students strongly agreed and 47.37% agreed. This result is significant, reflecting a widespread positive perception of the effectiveness of gamification in the learning process of adults with incomplete schooling. This trend coincides with the findings of Espinoza-Gaona et al., who state that gamification in experimental Physics not only increases motivation but also facilitates the understanding of complex Physics concepts and strengthens critical thinking in students facing educational challenges in their learning process (Espinoza-Gaona et al., 2025).



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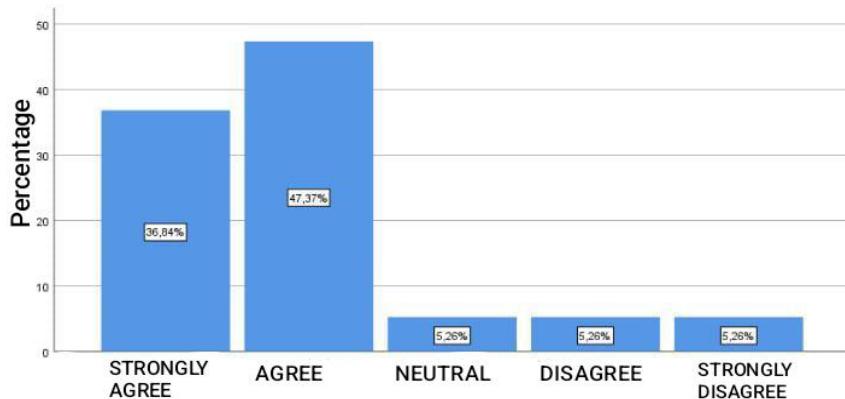


Figure 4. I believe that gamification is a good way to learn physics, especially for people who, like me, are resuming their studies.

The application of gamification in physics instruction for adult and senior citizens in evening high school demonstrated clear improvements in motivation, autonomy, and understanding of abstract concepts. More than 78% of teachers and 84% of students expressed positive perceptions, highlighting the effectiveness of the game-based activities integrated into physics, as well as the improvement in academic performance.

5. Conclusions

Regarding the content presented in the literature review, it can be emphasized that gamification is a pedagogical model that enhances learning; through playful interaction, it allows students to construct meaning from their own definitions and experiences. Furthermore, the research employed a pragmatic paradigm with theoretical methods such as historical-logical analysis and empirical methods such as observation and interviews. The design of the proposal was based on theoretical and methodological findings related to gamification, focusing on the area of Physics. Therefore, its development consisted of analyzing games aimed at encouraging problem-solving and critical thinking. The intervention was implemented with the objective of increasing motivation and optimizing students' understanding of abstract concepts. Finally, to understand the perception of the proposal in relation to the structure and mechanics of the games in the designed activities, interviews were conducted with students and teachers. This process facilitated understanding its feasibility of implementation and its potential to transform the teaching-learning experience.

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