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Editorial: The green dilemma
of Artificial Intelligence

17 articles: Ecuador, Colombia, Spain, India,
Argentina, the Philippines, Peru, the USA



MASKANA (searching in quechua), the name of the scientific journal of the ViceRectorate for Research of the University of Cuenca (VIUC), relies directly to the definition of research, which in the broadest sense means searching for advancement in knowledge via gathering of data, information and facts.

MASKANA (búsqueda en quechua), el nombre de la revista científica del Vicerrectorado de Investigación de la Universidad de Cuenca (VIUC), se refiere directamente a la definición de investigación, que en el sentido más amplio se entiende como la búsqueda del avance del conocimiento a través de la recopilación de datos, información y hechos.

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Editorial: The Green Dilemma of Artificial Intelligence

Editorial: el dilema verde de la Inteligencia Artificial

José Luis Crespo Fajardo

Editor of Maskana – University of Cuenca

The journal Maskana continues its process of consolidation on the global research stage, an arena increasingly shaped by the impact of artificial intelligence (AI). Our original dilemmas, which perhaps once revolved around securing greater visibility for regional issues within the international research landscape, are now intertwined with other, more urgent courses of action; among them, the paradoxes of the green dilemma.

We cannot turn a blind eye to the evidence of two major transformations the world is currently facing at the same time. On the one hand, we are witnessing unprecedented extreme temperatures, extraordinary droughts, typhoons torn from verses of Revelation, and an atmospheric chrysalis scarred by the effects of climate change. On the other hand, the fifth horseman rides forth, disguised in revolutionary garb: the vertiginous development of artificial intelligence. Both circumstances converge as they slip from our grasp, like the prelude to a future that is extremely difficult to discern.

In this context, it is worth asking whether the powerful tools of generative AI would serve any purpose if they were turned toward thinking about clouds driven by the wind, the blossoming of peach trees, or the grass needed by livestock. Can AI be our ally in safeguarding the environment? Academic research is “gray

literature,” but it is nourished by hopes and dreams that battle against uncertainty. Today, scientists, supported by AI, can predict patterns that help warn of natural disasters, or optimize electrical grids to improve the efficiency of solar panels. Through computational processes, water is saved in agricultural crops with the intention of caring for the planet, yet few mention the hidden cost behind these new technologies.

We may ignore the dark truth, but the ecological sacrifice is direct; it is evident that we are trapped in a moral labyrinth. The data centers and hyperscale infrastructure that give life to AI consume copious amounts of energy. They also require millions of liters of fresh water to cool, through evaporation, the high temperatures generated by their servers; in some cases, they also produce considerable greenhouse gas emissions. It is abundantly clear that these technologies come with a high degree of pollution, which means that attempting to defend our environment through means that contribute to its deterioration is a contradiction in terms. If we continue this way, what will become of us in a decade? Nothing will remain except the stars and our memories.

At Maskana, with its orientation toward multidisciplinary science, we are aware of the importance of these paradoxes. It is necessary to form groups of experts capable of determining the limits of consumption and exploring

alternative possibilities. Engineers should work in coordination with ecologists and economists, as well as with politicians, sociologists, and environmental advocates, in order to address this emerging problem collectively. Scientific journals can act as catalysts for such encounters and help design a green future for AI. What is urgent and unavoidable now is to take a position and demand, together, a science that is sustainable and respectful of nature.

Financial Education and Labor Well-Being within the Framework of the Welfare Economy in Ecuador

Educación financiera y bienestar laboral en el marco de la economía del bienestar en Ecuador

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Financial education and labor well-being within the framework of the welfare economy in Ecuador

Educación financiera y bienestar laboral en el marco de la economía del bienestar en Ecuador

Resumen

This study analyzes the relationship between financial education and labor well-being among Ecuadorian workers, from the perspective of the welfare economy. A quantitative, non-experimental, cross-sectional, and correlational approach was employed, based on a sample of 551 individuals. Data were collected through a structured survey and analyzed using descriptive and non-parametric correlational statistics. The results reveal positive and significant associations between the dimensions of both variables, highlighting the role of financial literacy in shaping labor perceptions. The study offers implications for organizational management and future sector-specific research.

Palabras clave: financial education; labor well-being; welfare economy; financial literacy; ecuadorian workers

Abstract

Este estudio analiza la relación entre educación financiera y bienestar laboral en trabajadores ecuatorianos, desde la perspectiva de la economía del bienestar. Se empleó un enfoque cuantitativo, no experimental, de tipo transversal y alcance correlacional, con una muestra de 551 personas. Los datos se recolectaron mediante una encuesta estructurada y se analizaron con estadística descriptiva y correlacional no paramétrica. Los resultados evidencian asociaciones positivas y significativas entre las dimensiones de ambas variables, destacando el papel de la alfabetización financiera en la percepción laboral. Se aportan implicaciones para la gestión organizacional y futuras investigaciones sectoriales.

Palabras clave: educación financiera; bienestar laboral; economía del bienestar; alfabetización financiera; trabajadores ecuatorianos.

1. Introduction

Welfare economics is an analytical approach that seeks to understand development from a people-centered perspective, rather than focusing solely on traditional economic indicators (García et al., 2021; Sánchez & García, 2021). From this perspective, progress is assessed through effective access to opportunities, the enhancement of personal skills, and improvements in quality of life. In contrast to the classical and neoclassical traditions focused on gross domestic product or per capita income, the welfare economy—along with other heterodox approaches to economics—places individuals, their living conditions, and their freedom to make decisions at the center of the analysis (Pattanaik, 2018; Sumba & Sánchez, 2024a).

This economic paradigm is particularly relevant given that intellectual capital represents a strategic resource that organizations must retain through measures—beyond monetary compensation—that promote workers' well-being, in a context where the digital economy, through tools such as remote Work, enables talent to operate autonomously without necessarily being tied to a formal structure. Authors such as Sen (1999) and Stiglitz et al. (2009) have helped consolidate this perspective by arguing that well-being should be measured in terms of people's actual freedoms to achieve their goals, participate in their environment, and develop across multiple dimensions, including economic, social, and occupational.

Traditional economic approaches explain progress in terms of efficiency, income, and production. However, these approaches do not account for inequalities in access to opportunities or in human experiences. Welfare economics emerged to overcome these limitations by incorporating quality-of-life criteria, shifting the focus from macroeconomic indicators to people's actual living conditions (Pattanaik, 2018). According to the human capabilities approach, well-being is defined by the effective freedoms that enable people to do and be what they value (Sen, 1999; Stiglitz, Sen, and Fitoussi, 2009). This

aligns with current trends, such as contributions from behavioral economics that describe biases in financial decision-making and, in turn, social responsibility, which links human capabilities to sustainability and workplace well-being (Sumba Nacipucha & Sánchez-Bayón, 2024b; García Vaquero et al., 2021; Sánchez-Bayón & García Ramos, 2021). Given this context, strengthening financial education improves decision-making, reduces economic vulnerabilities, and promotes more satisfying and economically stable perceptions of Work (Fisher, 2010; Warr, 2007).

In Latin America, the disparity between economic growth and perceptions of well-being is evident. The expansion of productive sectors has not always been accompanied by proportional improvements in employees' living conditions—a situation that requires urgent attention from both government and private organizations. Studies such as that by Barrientos (2024) describe how labor markets in the region combine high rates of informality with low levels of social protection, which diminish perceived well-being. In this context, incorporating workplace well-being as a key focus of study will make it possible to determine whether corporate economic growth processes are reflected in the quality of life of their employees, in the case of the present study, Ecuadorian workers.

Ecuador has experienced a combination of economic stagnation, growing informality, and unequal access to job opportunities—factors that affect the well-being of its workforce. Although progress has been made in knowledge, digital skills, and technology adoption, these improvements have not been sufficient to address the persistent gaps in job quality, economic security, and emotional stability among workers. In this regard, and according to data from INEC (2025), only 35.4% of the economically active population has adequate employment (workers who earn at least the minimum wage, work 40 hours per week or more, and do not express an intention to increase their work hours), while 19.3% are underemployed, and 29.9% hold jobs

that do not guarantee a minimum income or job stability. These figures highlight an occupational distribution that limits the possibility of building sustainable career paths and increasing levels of workplace well-being.

This situation calls for viewing workplace well-being as a business strategy that goes beyond traditional indicators, incorporating subjective and relational dimensions that reflect the concrete experiences of those participating in the world of Work. Within this framework, financial literacy emerges as a relevant variable—one that is also crucial to manage—since it fosters planning, informed decision-making, and a sense of stability in the workplace (Farfán et al., 2025). In other words, strengthening financial competencies is consistent with expanding effective freedoms and improving the work experience (Sen, 1999; Stiglitz et al., 2009), thereby increasing perceived levels of well-being at Work.

1.1. Financial Education

Adequate financial education strengthens the ability to make informed decisions in everyday economic life, thereby positively influencing perceptions of well-being. More than just knowledge about financial products, this concept encompasses a set of skills, attitudes, and practices focused on the responsible management of resources, anticipating needs, and adapting to changing circumstances (Lusardi & Mitchell, 2014; Feitó-Madrigal & Portal-Boza, 2025). This knowledge is valuable when it enables individuals to achieve personal goals supported by work effort and mindful income management, as greater financial stability tends to lead to a more positive assessment of the work environment. Understanding and applying financial principles facilitates spending control, planning for unforeseen events, and developing greater resilience in the face of economic challenges, both personally and at Work (Figure 1).

The specialized literature has identified three dimensions that constitute financial literacy: a) financial knowledge, b) financial behaviors, and c) financial confidence. The first refers to understanding basic concepts such as inflation, compound interest, risk, and diversification (Lara



Figure 1. Relationship between financial education, work, and perception of workplace well-being
Source: Authors (2025)

Serna et al., 2025). The second is described as the habitual practice of planning expenses, managing income, and avoiding impulsive consumption and debt decisions (García et al., 2021), and it is here that the contributions and applications of behavioral economics can have positive repercussions (Sumba & Sánchez, 2024b). Finally, financial confidence refers to the subjective perception of having adequate skills for managing resources, which influences one's willingness to cope with unforeseen events and to save or invest with confidence (Xiao & Porto, 2017; Farrell et al., 2016). In studies conducted in the Ecuadorian context, the dimensions described have also been recognized as important components for promoting responsible resource management and a stronger link between financial practices and corporate social responsibility (Cueva et al., 2020), with well-being being an important component of the latter concept.

Previous studies have documented a positive relationship between financial literacy and well-being, both in economic and emotional terms. In this regard, it is argued that individuals with higher levels of financial literacy experience lower levels of stress, greater control over their work-related decisions, and greater satisfaction with their economic situation (Kempson et al., 2013; Lusardi & Streeter, 2023). This demonstrates that financial literacy acts as a protective factor against economic uncertainty by equipping people with tools to cope more effectively with potential workplace instability. However, in Ecuador, where structural gaps in access to information and basic financial education persist, the relationship between financial literacy and workplace well-being has yet to be empirically explored.

1.2. Workplace Well-being

Well-being at Work has been analyzed in various fields of study, ranging from organizational psychology to behavioral economics. Although its definitions vary across disciplinary approaches, there is consensus that it describes employees' subjective experience of their Work and their working conditions (Fisher, 2010; Warr, 2007). This experience is not limited to job satisfaction; it also involves perceptions of personal fulfillment, work-life balance, overall emotional well-being, and recognition within the organizational environment (Irawanto et al., 2021).

Among the most studied dimensions are job satisfaction, understood as the overall evaluation of the work experience (Steger et al., 2012); work-life balance, which reflects employees' ability to manage their professional responsibilities without negatively affecting their personal lives (Kalliath & Brough, 2008); emotional stability in the workplace, which refers to the absence of chronic stress, anxiety, or prolonged tension (Mark & Smith, 2012); and recognition, consistent with perceptions of fairness, appreciation, and autonomy in assigned duties (Humphrey et al., 2007).

In Latin America, empirical research has documented that factors such as contract type, income stability, and access to social benefits are associated with better or worse perceptions of well-being at Work (Mark & Smith, 2012; Castillo, 2022). Other studies have highlighted the importance of psychological and relational factors—such as leadership quality, opportunities for professional development, and organizational climate—in shaping positive work experiences (Cueva-Estrada & Sánchez-Bayón, 2024). However, there is a lack of research on this topic in the region, which, as previously noted, is of great interest given the importance of talent retention for organizations within the framework of corporate social responsibility (Cueva-

Estrada & Sánchez-Bayón, 2025). Therefore, an empirical gap persists regarding its analysis in relation to human development variables, such as financial literacy.

The relationship between financial literacy and workplace well-being is particularly important in contexts where economic security is not guaranteed and employment conditions are highly variable. In Ecuador, where inequalities in access to financial education and employment conditions persist, it is relevant to examine whether individual financial capabilities influence perceptions of well-being at Work. Considering this relationship enables the incorporation of a largely unexplored dimension into the assessment of the work environment, thereby contributing to the design of public policies and organizational strategies tailored to workers' actual conditions.

Within this framework, the overall objective of this research is to determine the relationship between financial literacy and the perception of workplace well-being among Ecuadorian workers. The study is based on the understanding of workplace well-being as a subjective construct influenced by both organizational factors and individual conditions, and of financial literacy as a personal competency that can be promoted through business management to foster improvements in that perception. The analysis is conducted from the perspective of welfare economics, which values individuals' ability to make free and informed decisions, including those that affect their economic and emotional stability. From this perspective, two hypotheses are proposed:

- (1) Workers with higher levels of financial literacy tend to report a greater perception of workplace well-being
- (2) The dimensions of financial literacy are positively correlated with those of job well-being.

2. Methodology

This study adopts a quantitative, non-experimental, cross-sectional design with a correlational scope. Its objective was to determine the relationship between financial literacy and the perception of workplace well-being among Ecuadorian workers, within the framework of welfare economics. The target population consisted of workers in Ecuador's economically active population (EAP), estimated at approximately 8.5 million people (National Institute of Statistics and Censuses, 2024). Sampling was non-probabilistic and convenience-based, and the final sample comprised 551 participants. This sample size was determined using the formula for infinite populations, considering a 95% confidence level and a 4% margin of error (Levin & Rubin, 2004).

Data collection was conducted using a structured survey designed in Microsoft Forms. The variables were measured through self-report; consequently, the results reflect perceptions of financial literacy and workplace well-being. The instrument included a section on sociodemographic variables and two main scales that measured the study variables. The independent variable, financial literacy, was assessed based on three dimensions: financial knowledge (5 items), financial behaviors (5 items), and financial confidence (4 items). The dependent variable, workplace well-being, was measured across four dimensions: job satisfaction and meaning (3 items), work-life balance (3

items), stress and emotional stability (3 items), and autonomy and recognition (3 items). In total, the instrument consisted of 14 items for financial literacy and 12 for workplace well-being. All items were rated on a 5-point Likert scale, with higher scores indicating greater agreement with each statement, as shown in Table 1.

To assess the instrument's reliability, Cronbach's alpha was calculated, yielding $\alpha = .946$ for the financial literacy scale and $\alpha = .941$ for the workplace well-being scale, indicating high internal consistency (Hernández et al., 2014). Data analysis was performed using IBM SPSS Statistics software, version 30.0. Descriptive statistics were used to characterize the sample, cross-tabulations to explore associations between categorical variables, and reliability tests were conducted. Subsequently, the normality of the main variables was verified using the Kolmogorov-Smirnov test, which indicated a non-normal distribution ($p < .001$); therefore, Spearman's correlation coefficient was used instead.

The study adhered to the principles of confidentiality, informed consent, and voluntary participation. Data were collected anonymously, and all participants agreed to participate after being informed of the survey's research objectives.

3. Results

The sample consisted of 551 Ecuadorian workers. Regarding the age variable, the group aged 28-43 years was the largest (37.2%), followed by those aged 18-27 years (34.1%). 25.6% were in the 44-59 age range, and 3.1% were over 60. Regarding gender, 51.4% identified as female and 48.1% as male, while the remaining 0.6% selected other

options. In terms of educational attainment, the majority reported having completed or not completed a university degree (50.1%), followed by graduate studies (17.6%) and high school (16.2%). Participants with technical or vocational training accounted for 15.4%, and only 0.7% reported having completed only elementary school.

Table 1. Variables involved in the study

Source: Authors based on: Farrell et al., (2016); Humphrey et al., (2007); Kalliath and Brough (2008); Lusardi and Mitchell (2014); Mark and Smith (2012); Steger et al., (2012); Xiao and Porto (2017).

Variable Independent	Dimensión	Ítem
Financial literacy	Financial knowledge	I know what inflation is and how it affects prices.
		I understand how interest works when I save or borrow money.
		I know the difference between saving and investing.
		I know what it means to diversify an investment.
		I understand what credit is and how it works.
	Financial behaviors	I keep track of my income and expenses or have a budget.
		I compare prices or conditions before making major purchases.
		I try to save something every month, even if it's just a little.
		I plan my expenses to cover future needs.
		I avoid using credit if I cannot afford to pay it back.
	Financial confidence	I feel capable of managing my money well.
		I know what to do if I have an unexpected expense.
		I feel confident when making decisions about my finances.
		I get informed before making important financial decisions.
Variable Dependent	Dimension	Item
Work well-being	Job satisfaction and meaning	I am satisfied with the work I do.
		My work has a purpose that I value.
		I feel good about what I achieve during my workday.
	Work-life balance	I am able to balance my time between work and my personal life.
		My job allows me to have free time to rest or spend time with my family.
		I can disconnect from work at the end of the day.
	Stress and emotional stability	I feel calm when I think about my work.
		I don't usually feel stressed about my job responsibilities.
		I feel emotionally stable in my workplace.
	Autonomy and recognition	I have the freedom to make decisions at work.
		I feel that my efforts at work are valued.
		I receive recognition when I do my job well.

The city with the highest concentration of respondents was Guayaquil (77.0%), followed by Quito (10.7%), Cuenca (7.8%), and other locations throughout the country (4.5%). In terms of economic activity, the most represented sectors were commerce (23.0%), education (18.0%), and industry (13.2%). People working in professional services (10.9%), healthcare (8.5%), and the public sector (7.3%) also participated. An analysis of monthly income showed that 37.2% earn between \$500 and \$999, while 33.4% earn less than \$500. Only 12.9% reported an income of \$1,500 or more. Regarding job stability, 29.0% of respondents stated they had been in their current job for between one and three years.

Similar proportions were found among those who had been there for less than a year (26.9%) and those who had been there for more than six years (26.1%). Finally, 69.7% Work full-time, 14.2% part-time, and 10.5% on an hourly basis. The predominant work arrangement was in-person (85.7%), with a marginal presence of hybrid arrangements (7.3%) and remote Work (2.9%).

After characterizing the sociodemographic profile of the sample, we examined the general perceptions of the study's core variables. First, we analyzed the level of perceived financial literacy, as illustrated in Figure 2, based on the classification of total scores across the

dimensions of knowledge, behaviors, and financial confidence.

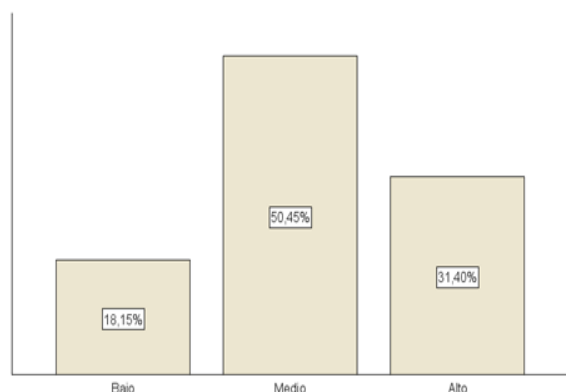


Figure 2. Level of financial education perception in the sample studied
Source: Authors, (2025).

In addition, Figure 3 shows the distribution of the perceived level of workplace well-being, constructed based on the four dimensions considered: job satisfaction and meaning, work-life balance, stress and emotional stability, and autonomy and recognition. In both cases, categorization was based on the sum of the items comprising each scale, with scores organized into low, medium, and high levels according to previously defined ranges.

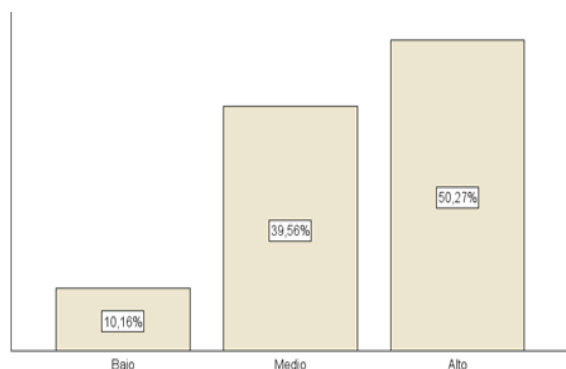


Figure 3. Level of perceived well-being at work in the sample studied
Source: Authors, (2025).

The levels observed for both variables revealed a generally positive perception among the sample, both in terms of financial literacy and workplace well-being. Based on this, a cross-tabulation analysis was conducted to examine in greater detail the relationship between the two variables, taking into account the participants' sociodemographic characteristics. Table 2 below

shows the distribution of perceived workplace well-being according to financial literacy level.

Table 2. Distribution between level of financial education and level of perceived job well-being
Source: Authors (2025).

Perception of financial literacy	Perception of Job Well-being			Total
	Low	Medium	High	
Low	28.0	47.0	25.0	100.0%
Medium	7.2	41.7	51.1	100.0
High	4.6	31.8	63.6	100.0
Total	10.2	39.6	50.3	100.0

The intersection of these two variables suggests a clear trend: the higher the perceived level of financial literacy, the greater the proportion of reported workplace well-being. In particular, more than 60% of those who reported a high level of financial literacy also reported high levels of well-being. This result supports the proposed hypothesis, indicating that a higher perception of financial literacy is associated with higher perceived levels of stability, satisfaction, and work-life balance.

In Table 3, the cross-tabulation of educational level and perceived financial literacy reveals a general trend: the higher the level of formal education, the greater the proportion of participants with high financial literacy. However, significant percentages of individuals with a college or graduate degree were found to be at the medium or low levels. This variation suggests that formal education, while related, does not by itself guarantee a high level of financial literacy. Consequently, there is a clear need to promote specific training initiatives in this area, even at advanced stages of the educational system.

The relationship between monthly income and perceived workplace well-being (Table 4) reveals significant differences. Those reporting incomes between \$1,000 and \$1,499 account for the highest percentage of high well-being (60.4%), suggesting a positive association between economic stability and well-being in the workplace. In contrast, the group with incomes below \$500 has the highest proportion reporting low well-being (15.8%), highlighting the subjective implications of wage conditions

Table 3. Distribution between educational level and perceived level of financial literacy
Source: Authors (2025).

Educational level Complete or incomplete	Perception of Financial Literacy			
	Low	Medium	High	Total
Primary education	50.0	50.0		100.0
Secondary education	21.3	58.4	20.2	100.0
Technical or technological training	28.2	50.6	21.2	100.0
University education	14.5	51.4	34.1	100.0
Postgraduate studies	15.5	40.2	44.3	100.0%
Total	18.1%	50.5%	31.4%	100.0

Table 4. Distribution of perceived level of job satisfaction according to monthly income
Source: Authors, (2025).

Monthly income	Perception of Job Well-being			
	Low	Medium	High	Total
Less than \$500	15.8	39.7	44.6	100.0
Between \$500 and \$999	6.3	42.9	50.7	100.0
Between \$1,000 and \$1,499	4.4	35.2	60.4	100.0
\$1,500 or more	14.1	35.2	50.7	100.0
Total	10.2	39.6	50.3	100.0

for the work experience. Next, we present the inferential analysis based on the formulated hypothesis and the study's objectives.

Before proceeding with the normality analysis, the internal reliability of the scales used to measure the main variables was evaluated. Cronbach's alpha coefficients indicated high internal consistency for both the financial literacy scale ($\alpha = .946$; 14 items) and the workplace well-being scale ($\alpha = .941$; 12 items). These values exceed the acceptability threshold, indicating consistency among the items and justifying their joint use in subsequent analyses. Next, the normality of the financial literacy and workplace well-being variables was tested using the Kolmogorov-Smirnov test; the results indicated significant deviations from normality ($p < .001$ in both cases). Consequently, we

opted to apply nonparametric statistical tests for hypothesis testing. All data processing and statistical analysis were performed using IBM SPSS Statistics, version 30.0.

The results of the correlation analysis presented in Table 5 show positive, statistically significant associations between the dimensions of financial literacy and those of workplace well-being. In particular, the components of financial behavior and financial confidence exhibit the highest coefficients for job satisfaction and perceptions of work-life balance. Although the observed correlations fall within the moderate range, their consistency suggests a perceived link between the management of financial matters and a more favorable subjective work experience (Hernández et al., 2014).

Table 5. Correlations between dimensions of financial education and workplace well-being
Note. Values calculated using Spearman’s correlation coefficient. **p < .01 (two-tailed).
Source: Authors (2025).

Variables		Work well-being			
		Job satisfaction	Autonomy and recognition	Work-life balance	Stress and emotional stability
Financial education	Financial behavior	0.416**	0.336**	0.434**	0.343**
	Financial Knowledge	0.406**	0.268**	0.357**	0.283**
	Financial Confidence	0.437**	0.310**	0.404**	0.363**

To provide a general overview of the association between the study’s key variables, a graphical representation of the relationship between financial literacy and workplace well-being is shown below (Figure 4).

Subsequently, the association between the two variables was evaluated using Spearman’s correlation coefficient (Table 6), calculated based on the total scores for financial literacy and workplace well-being. The value obtained ($\rho = 0.436$; $p < .01$) corresponds to a moderate positive

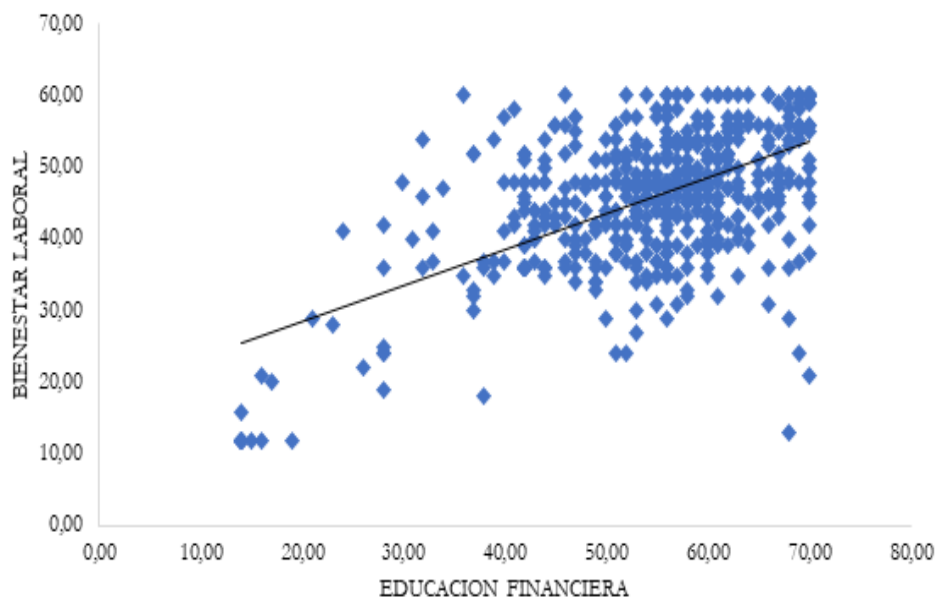


Figure 4. Association between the perception of financial education and perceived workplace well-being
Source: Authors (2025)

Table 6. Correlation analysis
Source: Authors (2025).

		Financial education	Well-being Work
Spearman’s Rho	Financial Education	Correlation Coefficient	1,000
		Sig. (two-tailed)	,436**
		N	<,001
	Work Well-being	Correlation coefficient	551
		Sig. (two-tailed)	551
		N	1,000

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

association between perceived financial literacy and perceived workplace well-being; (Hernández et al., 2014). Given the cross-sectional design and self-report measurement, no causal direction can be inferred. Although the strength of the link is not high, the result is statistically significant, which makes it worthwhile to continue investigating this relationship in other organizational contexts and populations.

Overall, the results support a statistically significant association between perceived financial literacy and workplace well-being. Although the observed correlations are moderate,

their consistency across both individual dimensions and overall scores provides relevant empirical evidence for understanding how perceived financial capabilities can influence the subjective experience of Work. This result supports the proposed hypothesis and provides a foundation for developing strategies to strengthen financial literacy as a component of organizational well-being. In particular, the positive relationship between financial education and workplace well-being ($\rho = 0.436$; $p < .01$) was confirmed, as was the significant correlation across all dimensions considered ($p < .01$).

4. Discussions

The results of this study revealed a positive and statistically significant association between the perception of financial literacy and perceived workplace well-being, which is consistent with the principles of welfare economics, which emphasize the importance of strengthening individual capabilities as a means of improving quality of life (Sen, 1999; Stiglitz et al., 2009). From this perspective, financial competencies are associated with a greater perceived sense of control over resource management and with more favorable evaluations of the work environment, particularly regarding emotional security, job satisfaction, and work-life balance (Cueva-Estrada & Sánchez-Bayón, 2025). These results should be interpreted as associations; they do not allow us to establish the direction of the effect and are consistent with alternative interpretations (for example, that greater perceived well-being is associated with higher self-reported levels of financial literacy).

In line with previous research, financial literacy was associated with higher levels of satisfaction, work-life balance, and lower emotional distress in the workplace (Xiao & Porto, 2017; Farrell et al., 2016). In particular, the dimensions of financial behavior and financial confidence showed moderate correlations with well-being indicators, supporting the idea that responsible management of personal finances can create favorable conditions for a more positive work

experience (Lusardi & Streeter, 2023; García Mata et al., 2021). Although favorable patterns were observed in groups with higher levels of formal education, cases of low financial literacy were also identified among individuals with undergraduate or graduate degrees. This finding is consistent with the reports by Kempson et al. (2013) and Lara Serna et al. (2025), who note that formal education does not guarantee adequate financial literacy. This highlights the need to incorporate content that builds financial literacy skills in both educational and workplace settings, both from a technical perspective and as part of an organizational culture focused on holistic well-being (García Vaquero et al., 2021).

Organizations face higher costs and lower productivity when their employees are burdened by debt or poor financial planning, as this phenomenon negatively affects their performance, increasing absenteeism and staff turnover (Black et al., 2024). In this regard, implementing financial workshops and counseling can strengthen the work environment and reduce employees' financial stress. A significant improvement is also observed in personal financial stability, as well as in satisfaction and commitment, confirming that financial education serves as an important tool for enhancing workplace well-being and organizational efficiency (Prawitz & Cohart, 2014).

However, evidence suggests that the relationship between financial literacy and work-life balance is not linear but rather depends on specific conditions. Lahav and Shavit (2025) showed that components of work-life balance—such as stress, boundaries, and flexibility—have varying impacts on future financial well-being, health, and community relationships. These findings suggest that the effect of work-life balance on financial decisions and well-being is not uniform but is conditioned by individual perception and the organizational environment. This study found that although financial literacy is positively associated with workplace well-being, the strength of that relationship varies by income and educational level, suggesting that its impact is not uniform.

Consistent with this international evidence, this study found that those reporting higher

monthly incomes tend to exhibit higher levels of workplace well-being. This relationship has been documented in previous research, which highlights how economic security serves as a protective factor against stress and job dissatisfaction (Castillo Fernández, 2022; Mark & Smith, 2012). However, the results also indicate that perceptions of well-being do not depend solely on income but are influenced by factors such as autonomy, recognition, and work-life balance (Fisher, 2010; Humphrey et al., 2007). All of the above highlights the strategic value of promoting financial education as a tool for human development within organizations (Cueva et al., 2020). The evidence obtained calls for a rethink of workplace well-being programs, incorporating training initiatives to strengthen employees' financial autonomy, which could lead to healthier, more resilient work environments.

5. Conclusions

The results confirm a consistent association between perceptions of financial literacy and workplace well-being in the Ecuadorian context. This empirically supported relationship supports the argument that certain financial capabilities are associated with how workers evaluate their workplace experience. The study thus contributes to the field of welfare economics by demonstrating that variables related to personal resource management can affect the subjective dimensions of organizational well-being. Consequently, financial literacy is associated with more efficient management of economic resources and a greater sense of control and security in workers' economic and professional lives—elements recognized by welfare economics as necessary conditions for the perception of subjective well-being.

This study broadens the traditional focus on workplace well-being by incorporating financial literacy as a resource associated with higher perceived levels of autonomy, emotional stability, and job satisfaction. However, the study design does not allow for inferring causality or ruling out reverse relationships. Thus, it provides

a useful empirical basis for designing business strategies that link individual development to collective well-being. Furthermore, it provides evidence from a Latin American country with high occupational heterogeneity, which is relevant to the debate on job quality in developing economies. Including workers from different sectors and income levels allows us to observe how financial literacy interacts with other work-related and personal factors to shape well-being.

Among the study's limitations is its cross-sectional design. Furthermore, the sample showed a significant concentration of participants in the city of Guayaquil, with underrepresentation of workers in Quito, Cuenca, and other locations across the country, which limits the ability to generalize the results to the entire nation. It should also be noted that the measurement was based on self-reported perceptions, which are susceptible to individual biases, rather than on objective competencies. This design limits causal inference and opens the possibility of reverse causality, as well as effects of unobserved variables (personality traits, management

practices, organizational climate) that could partially explain the association.

As future lines of research, we suggest including financial performance tests or behavioral data, as well as longitudinal studies that allow for the observation of the evolution of the relationship between financial literacy and well-being over time. Furthermore, it would be relevant to explore

this link in specific sectoral contexts, incorporate mediation or moderation models with other variables, and evaluate the effect of training programs in real-world work environments. These efforts will enhance our understanding of the role of financial education in strengthening well-being and human capital in emerging economies.

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Artificial Intelligence Model Based on DenseNet-121 for Feline Facial Landmark Detection

Modelo de Inteligencia Artificial Basado en DenseNet-121 para la Detección de Puntos Anatómicos Faciales en Gatos

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Artificial Intelligence Model Based on DenseNet-121 for Feline Facial Landmark Detection

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Abstract:

The aim of this work was to evaluate a modular artificial intelligence model based on DenseNet-121 for the automatic detection of 48 facial anatomical landmarks in cats, supporting welfare monitoring and veterinary clinical practice. The proposed approach comprises four phases: face detection, identification of anatomical regions, landmark localization, and hierarchical assembly. Three optimizers (Adam, AdaMax, and AdamW) were trained and compared using accuracy and error metrics, together with statistical tests. Results showed that Adam achieved the best performance, significantly outperforming AdaMax ($p < 0.05$). On external images, the assembly minimized errors, and clinical validation confirmed anatomical accuracy of 99–100%. In conclusion, the model represents an innovative and applicable tool for the objective assessment of feline pain and welfare, strengthening clinical judgment and reducing subjectivity in veterinary observation.

Keywords: landmark detection, cats, computer vision, DenseNet-121, animal welfare

Resumen:

El objetivo de este trabajo fue evaluar un modelo modular de inteligencia artificial basado en DenseNet-121 para la detección automática de 48 puntos anatómicos faciales en gatos, con el fin de apoyar el monitoreo del bienestar y la práctica clínica veterinaria. El enfoque propuesto comprende cuatro fases: detección del rostro, identificación de regiones anatómicas, localización de landmarks y ensamblaje jerárquico. Se entrenaron y compararon tres optimizadores (Adam, AdaMax y AdamW) mediante métricas de precisión y error, junto con pruebas estadísticas. Los resultados mostraron que Adam alcanzó el mejor desempeño, superando significativamente a AdaMax ($p < 0.05$). En imágenes externas, el ensamblaje redujo los errores a valores mínimos, y la validación clínica confirmó precisión anatómica del 99–100%. En conclusión, el modelo constituye una herramienta innovadora y aplicable para la evaluación objetiva del dolor y bienestar felino, reforzando el criterio clínico y reduciendo la subjetividad en la observación veterinaria.

Palabras clave: detección de puntos, gatos, visión por computadora, DenseNet-121, bienestar animal.

1. Introduction

The automatic analysis of facial expressions in animals is an emerging field that has gained relevance in veterinary medicine, as noted by Feighelstein et al. (2022), Martvel et al. (2023), Martvel et al. (2024c), and Wang (2024), as it allows for the identification of emotional and welfare states based on morphological characteristics of the face, as demonstrated by Feighelstein et al. (2022). Accurate assessment and recognition of pain are essential for pain management and animal welfare assessment, as highlighted by Robinson and Steagall (2024). However, existing tools for manual facial analysis are susceptible to subjectivity and human bias and often require specialized experience and training, as reported by Feighelstein et al. (2022, 2023), Martvel et al. (2023), Martvel et al. (2024a), and Robinson and Steagall (2024). These limitations have driven the development of objective assessment methods that reduce dependence on human observation, as proposed by Chiavaccini et al. (2024), Martvel et al. (2024a), and Martvel et al. (2024b).

One of the most promising strategies in this context is the localization of facial anatomical landmarks, proposed by Martvel et al. (2023, 2025), Martvel et al. (2024a), Martvel et al. (2024b), and Martvel et al. (2024c). These points are reliable indicators for assessing pain, emotions, and nonverbal communication in domestic species such as cats (*Felis catus*), according to Finka et al. (2019), Martvel et al. (2023), Martvel et al. (2024a), Martvel et al. (2024b), and Martvel et al. (2024c). The Cat Facial Action Coding System (CatFACS), an adaptation of the human FACS, has made it possible to map 48 facial landmarks in cats, selected for their relationship to the underlying musculature and their relevance to feline facial action units, as noted by Broomé et al. (2023), Chiavaccini et al. (2024), Feighelstein et al. (2022, 2023), Finka et al. (2019), Martvel et al. (2023), Martvel et al. (2024a), Martvel et al. (2024b), and Martvel et al. (2024c).

In veterinary medicine, artificial intelligence (AI) has shown great potential for transforming

the diagnosis and prediction of animal diseases, as noted by Alkhanifer and AlZubi (2025). Although its applications are not as extensive as in human medicine, its effectiveness has been demonstrated in multiple areas. Akar and Yıldırım (2022) report the use of AI to predict conception in cattle and classify quail eggs, while Fernandes et al. (2020) highlight automatic systems for livestock monitoring and disease detection. More recently, Tagoe et al. (2024) proposed a non-intrusive computer vision-based approach to identify and monitor pig movement, demonstrating the usefulness of deep learning in animal welfare management. In parallel, convolutional neural networks (CNNs) have been developed for medical tasks such as detecting liver degeneration by ultrasound or classifying corneal lesions, according to Banzato et al. (2021). Alkhanifer and AlZubi (2025) even highlight that DenseNet-121 achieved 93.2% accuracy in detecting lumpy skin disease in cattle, reinforcing the potential of machine learning in the veterinary field.

In felines, research has advanced toward automated pain recognition. Feighelstein et al. (2022) compared the performance of convolutional networks (ResNet50) with models based on geometric landmarks, achieving more than 72% accuracy in cats undergoing ovariohysterectomy. Subsequently, Feighelstein et al. (2023) expanded the study to 84 cats of different breeds, ages, and medical conditions. In this case, the landmark-based approach achieved an accuracy of over 77%, compared to 65% achieved by direct deep learning, as reported by Feighelstein et al. (2023), Martvel et al. (2024a), and Martvel et al. (2024b). In addition, this study highlighted the importance of explainability, showing that the nose and mouth are key regions for automatic pain classification. At the same time, the ears are less relevant, as noted by Chiavaccini et al. (2024), Feighelstein et al. (2023), and Martvel et al. (2024b).

A key resource for this research is the CatFLW dataset, with 2,091 images and 48 annotated

feline landmarks, developed by Finka et al. (2019), Martvel et al. (2024b), and Martvel et al. (2024c). This dataset surpasses previous databases, such as the CAFM (Cat-like Animals Facial Model) presented by Sun and Murata (2020) and the proposal by Zhang et al. (2008). However, limitations related to sample size, racial diversity, and capture conditions persist, affecting the generalization of the models. Key challenges include: a) anatomical variability between breeds, b) the scarcity of feline databases in contrast to abundant human resources, and c) the difficulty of identifying critical regions such as eyes and nose due to coat variability, as noted by Finka et al. (2019), Martvel et al. (2024b), Sun and Murata (2020), and Zhang et al. (2008).

To overcome these limitations, new methodological approaches have been proposed. Enhanced Normalized Mean Error (ENME) Loss, developed by Lai et al. (2019), improves the robustness of predictions in scenarios with high variability. Similarly, recent studies highlight that the choice of optimizer affects training stability; in this regard, Llugsi et al. (2021) compared Adam, AdaMax, and AdamW, suggesting that the latter provides greater regularization. Other research, such as that conducted with the Oxford-IIIT Pet Dataset by Parkhi et al. (2012), reinforces that facial features are key to identifying species and breeds, while Sexton et al. (2023) highlight the relationship between anatomical characteristics and emotion perception in studies on facial morphology and expressiveness.

In this context, DenseNet-121 emerges as a particularly suitable architecture. Initially applied in human medicine by Gokul Siddarth and Chokkalingam (2024), its design enables information reuse across layers, optimizing the recognition of complex patterns while maintaining computational efficiency. It has proven helpful in the analysis of human medical images, as noted by Hasan et al. (2021) and Huang et al. (2017), as well as in the automatic classification of canine radiographs, according to Banzato et al. (2021), and in veterinary thoracic radiology, according to Kumar Saxena et al. (2023). Its choice in this work is justified because it has not yet been implemented in the field of feline landmarks, despite its effectiveness in tasks such as COVID-19 detection in radiographs, classification of pathogenic microorganisms, and automatic breast cancer detection.

In this context, the present study aims to evaluate a modular AI model based on DenseNet-121, implemented in a workflow (pipeline) described by Steidl et al. (2023) and consisting of four phases: face detection, anatomical region segmentation, facial landmark localization, and integration into a hierarchical assembly. This clinically validated, tiered architecture seeks to provide a reproducible framework applicable to veterinary practice. For optimization purposes, the performance of three algorithms was evaluated: Adam, AdaMax, and AdamW. Beyond technical metrics, the study aims to demonstrate the model's clinical utility as a complementary tool for objective assessment of feline pain and well-being.

2. Materials and methods

2.1. Data and image sources

The CatFLW dataset, described by Martvel et al. (2023), was used, consisting of 2,079 cat images annotated with 48 facial anatomical landmarks. The images vary in lighting, pose, and morphology, providing a realistic scenario for automatic detection. For the experiments, the dataset was divided into 80% for training

and 20% for testing. Additionally, to validate the generalization capacity, 36 external cat images were collected via a survey and reviewed and validated by a specialist veterinarian.

2.2. Methodological design

The study followed the CRISP-ML(Q) methodological framework proposed by Studer

et al. (2021), structuring the process into iterative and reproducible phases. The stages included: (1) understanding the problem, focused on the detection of feline facial landmarks to support veterinary clinical practice; (2) data preparation, through normalization and resizing of images to 224×224 pixels, in accordance with the implementation by Martvel et al. (2024b) and Martvel et al. (2024c); and (3) data augmentation, applying rotation, brightness variation, contrast, Gaussian noise, and blurring techniques to increase the robustness of the model, as suggested by Hun Yoo et al. (2024).

2.3. Model architecture

A modular model based on DenseNet-121 was implemented, as described by Gokul Siddharth and Chokkalingam (2024) and Hasan et al. (2021), organized in a workflow (pipeline) of four sequential stages (Figure 1). In the first stage, face detection, three progressive configurations were trained, with FaceDetector V3—with data augmentation and without dropout (a regularization technique that omits neurons during training)—performing best, significantly reducing training and validation losses. The second stage corresponded to the detection of facial regions (ears, eyes, and nose). The Regions V2 model, which applied precise cropping and data augmentation, showed greater accuracy by focusing on relevant anatomical areas. In the third stage, landmark localization, preprocessing with specific cropping and alignment improved accuracy; for example, in the left ear, the Normalized Mean Error (NME) was reduced from 0.1120 (V1) to 0.0807 (V2). Finally, in the fourth stage, hierarchical assembly, the models trained with three optimizers (Adam, AdaMax, and AdamW) were integrated. The results confirmed that Adam offered the best balance between accuracy and stability, achieving an NME of 1.5444 and a validation loss of 81.63..

2.3.1. Configuration of the DenseNet-121 architecture

In this work, DenseNet-121 was used as a feature extractor within a modular approach, adapted for a regression task to localize facial anatomical points. The final classification layer of the original architecture was replaced with a fully connected layer with a linear output of 96 values, corresponding to the (x, y) coordinates of the 48 facial landmarks. The selection of DenseNet-121 is based on an adequate compromise between accuracy and computational efficiency. During the experimental development of the work, deeper architectures were analyzed, such as DenseNet-169 and ResNet-101, which have significantly more parameters. However, these architectures did not show proportional improvements in the primary evaluation metric (Normalized Mean Error, NME), resulting in increased computational cost without substantial benefits. In contrast, DenseNet-121 achieved competitive performance with less complexity, which is particularly relevant for practical applications and veterinary clinical support.

2.4. Training and optimization

The DenseNet-121 models were trained for 300 epochs with a batch size of 16 (i.e., 16 images per iteration). Three optimizers (Adam, AdaMax, and AdamW) were used, and performance was evaluated using two primary metrics: (1) Normalized Mean Error (NME), which measures relative accuracy as a function of facial region size; and (2) Mean Squared Error (MSE), which directly quantifies errors in landmark coordinates. These metrics allowed us to evaluate both the accuracy and stability of the models.

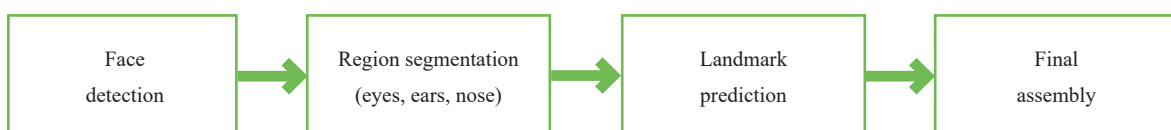


Figure 1: Modular workflow (pipeline) of the AI model
Source: Authors (2025)

2.5. Clinical validation

Clinical validation was performed using 36 external images, in which a specialist veterinarian verified the correspondence between the detected landmarks and the facial structures of interest. This step confirmed the model's applicability in a real-world veterinary practice setting.

2.6. Statistical analysis

Statistical analysis was performed to compare the performance of the Adam, AdaMax, and AdamW optimizers in the automatic detection of facial landmarks. Since the metrics used, Normalized Mean Error (NME) and Mean Squared Error (MSE), correspond to continuous variables, parametric comparison tests were applied.

The Student's t-test was used to make direct comparisons between two optimizers in specific scenarios. In comparison, analysis of variance (one-way ANOVA) was used to simultaneously compare the performance of the three optimizers evaluated. In all cases, a significance level of 5% ($p < 0.05$) was considered.

The purpose of this statistical analysis is comparative, aimed at supporting the

interpretation of the experimental results obtained during model training and validation, and not inferential at the population level.

2.7. Computing environment and reproducibility

Training was performed on an NVIDIA GTX 1660 Ti GPU using the Python programming language, as described by Raschka et al. (2020), and the PyTorch framework (Paszke et al., 2019). The code and results are available in public repositories, which guarantee reproducibility: GitHub (<https://goo.su/23jLE>) and Google Drive (<https://goo.su/PN1Szax>).

2.8. Ethical considerations

This work complies with the guidelines for "Studies Exempt from Review" issued by the Human Research Ethics Committee (CEISH) of the National University of Loja. By using images from public repositories and surveys that do not contain sensitive data, the research is classified as exempt from review. In addition, no direct intervention on animals was involved, ensuring compliance with the institution's ethical and regulatory principles.

3. Results

3.1. Validation of the modular model

The main objective of this work was to propose a modular AI model based on DenseNet-121 capable of detecting facial landmarks in cats. The results confirm that this objective was achieved: the model processed images with variations in pose, lighting, and coat; automatically detected the face, anatomical regions (eyes, ears, and nose), and landmarks; and showed statistical consistency in its metrics, validating its practical applicability in a clinical setting.

3.2. Overall model performance

Three variants of the model were trained with different optimizers (Adam, AdaMax, and AdamW). As shown in Table 1, the NME values were stable across the three configurations (1.540–1.550, 95% CI), demonstrating robust predictions. However, Student's t-test showed significant differences in validation loss between Adam and AdaMax ($p < 0.05$). This indicates that although the three optimizers achieve similar accuracy, Adam achieves a better fit on the validation set, suggesting the best balance between stability and efficiency.

Table 1: Overall performance of the modular model with different optimizers (DenseNet-121)
Source: Authors (2025)

Optimizer	NME ($\pm 95\%$ CI)	Val Loss ($\pm 95\%$ CI)	Student's t-test (vs Adam)	Significance ($p < 0.05$)
Adam	1.5444 (1.540–1.549)	81.6282 (81.0–82.2)	—	—
AdaMax	1.5417 (1.538–1.546)	92.2951 (91.4–93.2)	$t=2.31$	Si
AdamW	1.5454 (1.541–1.550)	81.5080 (80.9–82.1)	$t=0.21$	No

Clinical interpretation: these results meet stage 1 of the pipeline (face detection), confirming that the model is stable and can be applied to different cat images without degrading its performance (Figure 2).

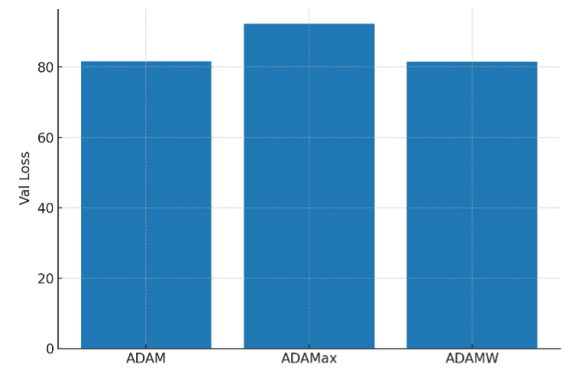


Figure 2: Overall performance: Val Loss by optimizer (Adam, AdaMax, AdamW).
Source: Authors (2025)

Clinical interpretation: this meets stage 2 of the pipeline (detection of anatomical regions), demonstrating that the model reliably distinguishes subtle variations in the ears and nose, which are key to assessing pain and well-being, although it still faces limitations in the eyes (Figure 3).

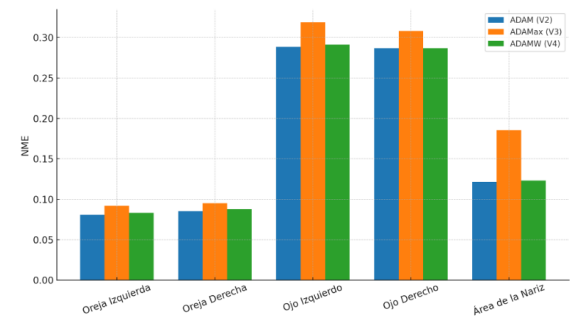


Figure 3: NME by region and optimizer (grouped bars)
Source: Authors (2025).

3.3. Accuracy in anatomical regions

The analysis by region showed that the model was most accurate in the ears and nose. At the same time, the eyes presented greater challenges, as expected due to the variability in coat color and texture. In all regions, Adam consistently outperformed AdaMax and AdamW (Table 2). ANOVA by region showed significant differences in the eyes ($p < 0.05$), confirming that this area is the most sensitive to training variations.

3.4. Visualization of detections

The supplementary figures illustrate each stage of the modular pipeline. Figure 4 shows the face detector (FaceDetector V3) accurately locating the face. Figure 5 illustrates how the model predicts landmarks in specific regions, such as the ears and eyes. Figure 6 illustrates the final assembly, composed of specialized submodels

Table 2: Model accuracy by facial region (NME)
Source: Authors (2025)

Region	Adam (V2) $\pm 95\%$ CI	AdaMax (V3) $\pm 95\%$ CI	AdamW (V4) $\pm 95\%$ CI	ANOVA (p)
Oreja Izquierda	0.0807 (0.078–0.083)	0.0920 (0.089–0.095)	0.0833 (0.080–0.086)	0.04
Oreja Derecha	0.0854 (0.083–0.088)	0.0950 (0.092–0.098)	0.0876 (0.085–0.090)	0.05
Ojo Izquierdo	0.2885 (0.282–0.295)	0.3189 (0.310–0.327)	0.2912 (0.285–0.297)	0.02
Ojo Derecho	0.2868 (0.281–0.293)	0.3081 (0.302–0.314)	0.2869 (0.281–0.292)	0.03
Nariz	0.1214 (0.118–0.124)	0.1855 (0.181–0.190)	0.1231 (0.120–0.126)	0.01

(face detection, facial regions, and landmarks by region).

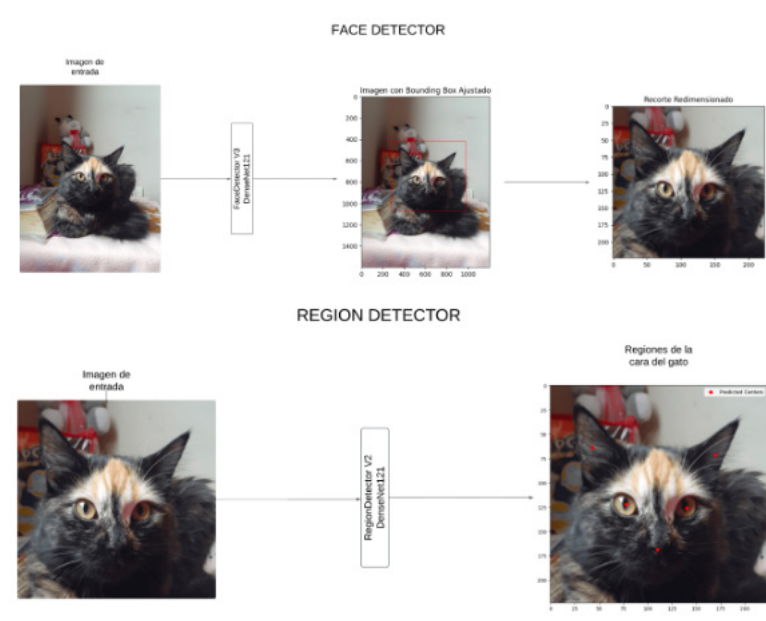


Figure 4: Example of face detection (face detector) and region segmentation (region detector). The red box visible in the image represents the model's prediction and its ability to detect the cat's face (FaceDetector V3). The red dots on the image represent the region detector's predictions after passing through the model (RegionDetector V2).

Source: Authors (2025).

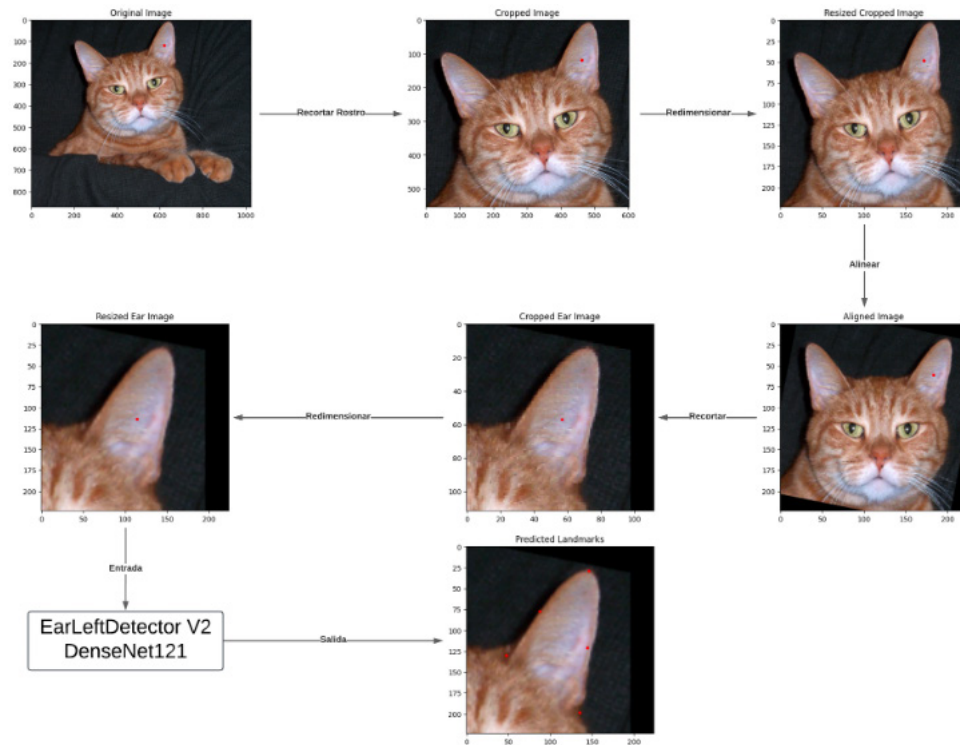


Figure 5: Visualization of landmark predictions by anatomical regions (eyes, ears, and nose). The initial red dot represents the center of the ear. After passing through the model, the observable red dots are the model's predictions on the crop.

Source: Authors (2025)

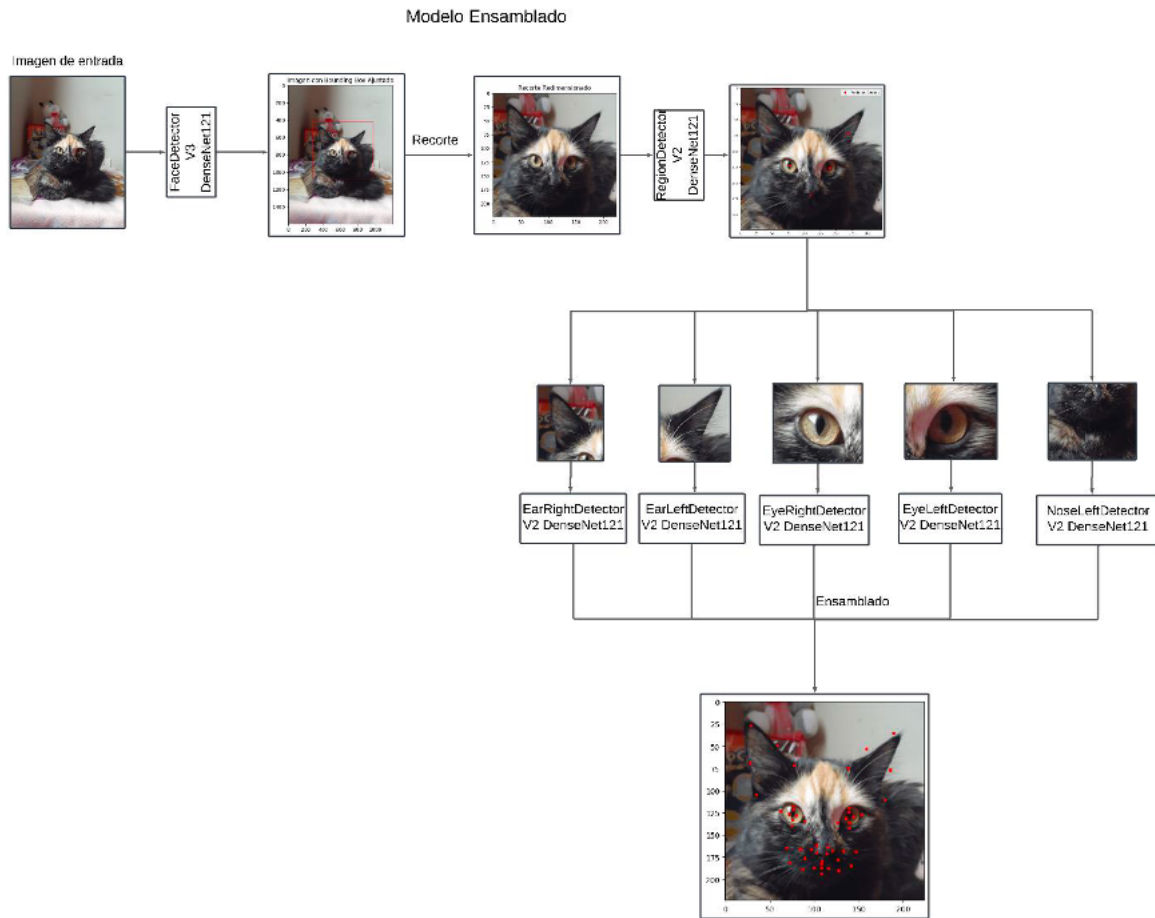


Figure 6: Final assembly of the models. Three different assembled DenseNet-121 models were developed for the landmark task, using a different optimizer: Adam, AdaMax, and AdamW. Each assembly consists of seven specialized submodels, organized into three consecutive stages: a model for face detection, a model for identifying key facial regions, and five independent models dedicated to predicting landmarks in specific areas of the face: left eye, right eye, left ear, right ear, and nose area. This modular approach allows each part of the face to be treated more accurately, adapting the models to the anatomical structure of the cat.

Source: Authors (2025)

Clinical interpretation: this demonstrates stages 3 and 4 of the pipeline (landmark localization and assembly), confirming that modularity allows the models to be adapted to each anatomical structure of the cat.

3.5. External and clinical validation

In the evaluation with 36 external images not included in the training, the model achieved an overall NME of 0.0177 and an average MSE of 143.87 (Table 3). The expert review, performed based on CatFACS and supported by Feighelstein et al. (2023) and Finka et al. (2019), confirmed anatomical accuracy: 33 images showed 99–100% agreement and 3 images showed 98% agreement, with an average clinical score of 99.56/100 (Figure 7).

Clinical validation was performed by a veterinarian with experience in feline clinical practice, who visually evaluated the model's predictions by comparing them with manual annotations adjusted according to the anatomical guidelines of the CatFLW dataset and the CatFACS guide. For each image, a score was assigned on a scale of 1 to 100, based on the degree of anatomical correspondence between the predicted landmarks and the actual facial structures.

The results showed high agreement, with scores of 98–100 across all evaluated images and no negative clinical observations, reinforcing the usefulness of the system as a tool to support objective assessment of feline welfare.

Table 3: External validation and clinical review
Source: Authors (2025)

Metric	Result	95% CI
Overall NME (36 images)	0.0177	0.015–0.020
Average MSE	143.87	140–147
Clinical validation	33/36 images with 99–100% (3 images with 98%)	—
Average clinical score	99.56 / 100	—

Clinical interpretation: this result supports clinical applicability, validating that the model not only works under experimental conditions, but also offers objective and reproducible predictions that complement professional assessment in veterinary practice.

to evaluate them. In this context, the results obtained—both in terms of metrics and expert qualitative validation—constitute solid initial evidence of the applicability of the proposed approach.

3.6. Comparison with other models

The comparison with more complex architectures such as EfficientNetV2S, evaluated by Saxena et al. (2023) with an NME of 2.83, and ConvNeXtTiny, analyzed by Bouamrane et al. (2025) with an NME of 2.78, is made for reference purposes, based on results reported in previous studies. It should be noted that these models were trained and evaluated under different data sets and experimental protocols, so this is not a direct comparison under the same conditions.

In this context, the comparison allows us to situate the proposed approach with respect to model complexity and general performance trends. The model based on DenseNet-121 has a significantly lower number of parameters while maintaining competitive results, reinforcing its viability for scenarios with limited computational resources and for clinical applications focused on animal welfare.

Clinical interpretation: the model offers a lighter and more practical technological alternative without sacrificing accuracy, which is essential for its implementation in real clinical settings.

3.7. Achievement of the objective of the work

The modular model based on DenseNet-121 integrated face detection, anatomical region segmentation, and landmark localization with high accuracy. Statistical tests (Student’s t-test, ANOVA, 95% CI) confirmed the stability and

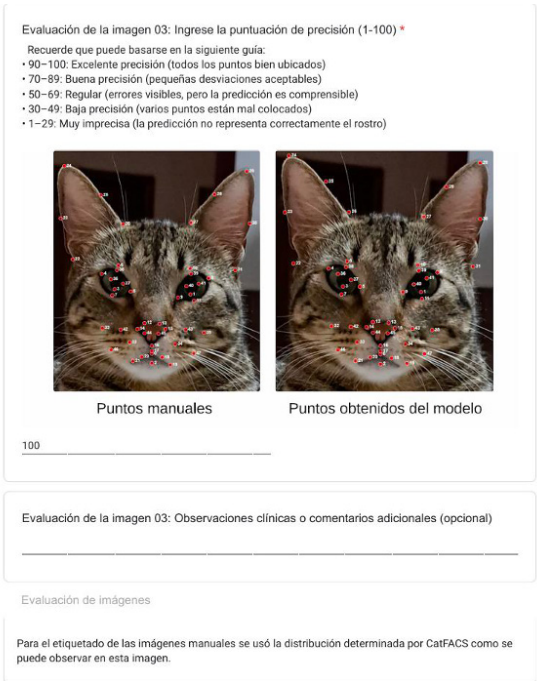


Figure 7: Comparative clinical validation between model and veterinarian
Source: Authors (2025)

Validation with external images was conceived as an exploratory evaluation of the model’s generalizability under uncontrolled conditions. Although the sample size (n = 36) does not allow for statistical inferences at the population level, it is adequate as a preliminary test to analyze the system’s behavior in real clinical application scenarios.

Collecting this type of data involves practical limitations, such as the availability of labeled images and the need for veterinary experts

robustness of the results. External validation and clinical review support its usefulness as a complementary tool for the objective assessment of feline welfare and pain.

4. Discussion

The modular AI model based on DenseNet-121 achieved stable and low NME values, confirming its ability to detect feline landmarks with high accuracy. These findings are consistent with those reported by Martvel et al. (2023), Martvel et al. (2024a), Martvel et al. (2024b), and Martvel et al. (2024c), who highlight the relevance of facial landmarks as objective indicators in the assessment of pain and well-being in cats. The statistical consistency observed in the tests applied (Student's t-test, ANOVA, 95% CI) reinforces the robustness of the model, demonstrating that its applicability is not limited to an experimental setting but also offers clinical reliability. Although it does not replace professional judgment, it is a complementary tool that reduces subjectivity in the assessment of feline pain.

Unlike human facial recognition, where large volumes of standardized data and relatively controlled capture conditions are available, computer vision studies in animals face greater morphological variability, frequent occlusions due to fur, and limited availability of annotated datasets. These characteristics make it challenging to generalize large-scale trained monolithic models. In this context, the proposed modular approach is particularly suitable, as it allows learning to be specialized to relevant anatomical regions and reduces the problem's complexity, thereby favoring the interpretability and robustness of the system in real veterinary application scenarios.

Compared to previous studies, this work expands the scope of AI in veterinary medicine. Research such as that by Akar and Yıldırım (2022) and Fernandes et al. (2020) has focused on livestock and poultry, while here we explore its potential in domestic cats, a species rarely addressed in

the literature. In relation to landmarks, previous work has been based on restricted datasets, such as the CAF dataset presented by Sun and Murata (2020), or on the proposal by Zhang et al. (2008). In contrast, the use of the CatFLW dataset, described by Martvel et al. (2023), with 2091 images and 48 landmarks, provided diversity and greater anatomical detail, representing a methodological advance over previous studies. Furthermore, when comparing architectures, it was observed that more complex models, such as EfficientNetV2S and ConvNeXtTiny, were less accurate ($NME > 2.7$), whereas the modular approach with DenseNet-121 was more efficient and accurate. This finding confirms that smaller models, when designed under a modular scheme, can outperform more sophisticated architectures in practical scenarios.

This work has three main contributions: i) the first modular implementation of DenseNet-121 in felines for the detection of landmarks and facial regions, optimizing accuracy through sequential stages; ii) the integration of advanced data augmentation techniques, which increase robustness against variations in breed, pose, or lighting; and iii) the comparative evaluation of optimizers (Adam, AdaMax, and AdamW) in assembled models, which constitutes a novel methodological contribution. These advances open new possibilities for understanding feline emotions and behaviors through facial patterns, expanding their applications in clinical practice and academic research. However, the lack of a more comprehensive comparison among optimizers is a pending issue for improving the generalizability of the results.

Clinical validation, with anatomical accuracy greater than 99%, demonstrates the feasibility

of integrating this model into animal welfare assessment protocols. Its agreement with expert review suggests it may be beneficial in contexts where rapid, objective pain assessment is required. In addition, the model's computational efficiency makes it viable in clinics with limited resources and opens opportunities in feline ethology, animal welfare, and clinical management studies. A key aspect is that this approach can be linked to already validated clinical scales, such as the Feline Grimace Scale proposed by Evangelista et al. (2019), allowing automatic predictions to be correlated with tools currently used by professionals.

Although the results are robust, limitations have been identified. The detection of landmarks in eyes showed greater variability, in line with the findings of Sun and Murata (2020) regarding difficulties with structures that exhibit high variability in texture and coloration. Likewise, the number of external images used in the validation (36) remains low, which limits the extrapolation

of the findings. Finally, the model was trained only on cats, so its application to other species requires retraining.

In future work, this modular approach could be strengthened by integrating it into mobile applications for primary care veterinary clinics and by extending it to other companion species (e.g., dogs, rabbits). Expanding the dataset to include a greater diversity of breeds and capture conditions will improve the model's generalization. Likewise, linking it to clinical scales such as the Feline Grimace Scale will reinforce its usefulness in professional practice.

The combination of a modular pipeline, rigorous statistical analysis, and expert clinical validation confirms that the proposed model meets the stated objective. This work represents a significant step toward integrating AI into small-animal veterinary medicine, providing an objective, reproducible tool that complements traditional clinical assessment of feline pain.

5. Conclusions

The modular AI model based on DenseNet-121 demonstrated high accuracy in detecting facial landmarks in cats, achieving stable NME values and clinical validation exceeding 99%. The integration of a hierarchical pipeline—face detection, anatomical region segmentation, landmark localization, and assembly—with rigorous statistical analysis (t-tests, ANOVA, 95% CI) yielded reproducible results with proven clinical relevance.

In veterinary practice, this model is an innovative and applicable tool that complements the clinical assessment of feline pain and well-being, reducing subjectivity and increasing the reliability of professional observation. It does not replace the veterinarian's judgment; rather, it strengthens it through objective predictions.

The modular architecture of DenseNet-121 proved more efficient and accurate than more complex architectures, supporting its viability for

implementation in clinical settings with limited computational resources. Although eye detection showed greater variability, external validation and expert review confirmed the model's robustness, reinforcing its applicability as a diagnostic aid in veterinary medicine.

Among the main limitations of the study are the dependence on available labeled datasets and the small size of the external validation set, which is typical of studies with specialized clinical evaluation. Likewise, certain extreme lighting conditions or atypical facial expressions may affect the model's performance.

Future lines of work include expanding the external dataset, incorporating interobserver assessments, and exploring emerging architectures, such as Vision Transformers and multimodal approaches, that integrate visual information with other physiological or behavioral indicators for a more comprehensive assessment of feline well-being.

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We would also like to express our gratitude to the DokyVet Veterinary Clinic, veterinarian Camila Jaramillo, and the Information and Computing Technologies Research Group (GITIC) at the UNL, whose support and collaboration have contributed significantly to the development of this research.

7. Declaration of use of Generative Artificial Intelligence (GAI)

The authors declare the use of generative artificial intelligence (GAI) in the research and writing process. In accordance with the GAIDeT taxonomy (2025), the following tasks were delegated to GAI tools under full human supervision: research design, data analysis, text generation, text summarization, formulation of conclusions, translation, and reformatting.

The GAI tools used were: ChatGPT 5, NotebookLM, and Gemini.

Responsibility for the final manuscript rests entirely with the authors.

The AI tools are not included as authors and assume no responsibility for the final results.

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Educational robotics boosts Science, Technology, Engineering, and Mathematics training for secondary school teachers

Robótica educativa potencia la formación Ciencia, Tecnología, Ingeniería, y Matemáticas en docentes de secundaria

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Educational robotics boosts Science, Technology, Engineering, and Mathematics training for secondary school teachers

Robótica educativa potencia la formación en Ciencias, Tecnología, Ingeniería, y Matemáticas en docentes de secundaria

Abstract:

This study aimed to validate a pedagogical strategy based on educational robotics to develop STEM skills in secondary school teachers in Bogotá, Colombia. The methodology was pre-experimental with a quantitative approach and correlational-descriptive scope. A plan of 25 sessions with a constructionist design and problem-based learning was applied. The data, collected using expert-validated Likert instruments, were analyzed using a bivariate regression model (Pearson). The results showed a statistically significant relationship, with educational robotics explaining 58.4% of the variation in the development of STEM skills. It was concluded that the strategy effectively fosters key skills in teachers, such as creativity, problem solving, and critical thinking. As a direct implication, it was observed that teachers design and apply teaching sequences that promote complex problem solving in their students, positively impacting the achievement of learning standards in areas such as science and mathematics.

Keywords: STEM education, technology, robotics, teaching, critical thinking.

Resumen:

Este estudio tuvo como objetivo validar una estrategia pedagógica basada en robótica educativa para desarrollar competencias STEM en docentes de secundaria de Bogotá, Colombia. Metodología de tipo preexperimental con un enfoque cuantitativo y alcance correlacional-descriptivo. Se aplicó un pre y postest con diseño cuasiexperimental y aprendizaje basado en problemas. Los datos, recolectados mediante instrumentos Likert validados por expertos, se analizaron con un modelo de regresión bivariado (Pearson). Los resultados demostraron una relación estadísticamente significativa, donde la robótica educativa explicó el 58.4% de la variación en el desarrollo de competencias STEM. Se concluyó que la estrategia fomenta efectivamente en los docentes habilidades clave como la creatividad, la solución de problemas y el pensamiento crítico. Como implicación directa, se observa que los profesores diseñan y aplican secuencias didácticas que promueven en sus alumnos la resolución de problemas complejos, impactando positivamente en el logro de estándares de aprendizaje en áreas como las ciencias o la matemática.

Palabras clave: educación STEM, tecnología, robótica, docencia, pensamiento crítico.

1. Introduction

Educational robotics has emerged as a powerful tool in STEM education (STEM is an acronym for Science, Technology, Engineering, and Mathematics), offering new learning mediations that can transform traditional teaching practices (Joya et al., 2024). However, many educational contexts still use traditional methods that fail to engage students, posing a significant challenge for educators (Roman-Acosta et al., 2023). This challenge requires the training of teachers in skills such as entrepreneurship, collaboration, communication, technology use, Creativity, innovation, design, critical thinking, and problem-solving (Roman-Acosta & Barón Velandia, 2023; Diaz-Colón & Ereú-Ledezma, 2024).

According to Sánchez (2019), who emphasizes the need to train teachers capable of implementing technology in basic education through educational robotics (a position supported by González et al., 2020, and González-Fernández, González-Flores, and Muñoz-López, 2021), this tool creates flexible, creative, and interdisciplinary learning environments (Overview of educational robotics in favor of STEAM learning. This work focused on developing STEM competencies in secondary school teachers in postgraduate training, through a pedagogical proposal based on educational robotics. A sequence of teaching units based on problem-based learning was designed to establish a correlation between robotics and its influence on participants' ways of thinking, working, using tools, and living.

The diversity of fields of knowledge and the lack of prior robotics experience made this a meaningful learning experience. Fuentes and González (2017) affirm that the education system must face new challenges by training teachers to develop competencies in the knowledge society from an integrative perspective. Bagiya (2017) proposes developing a pedagogical approach to STEM education that fosters dialogue between students and teachers, enriching the experience, motivating students, and complementing knowledge.

Various studies have highlighted the need to adapt educational practices to incorporate emerging technologies (Medina and Vélez, 2016). Educational robotics can stimulate Creativity, problem-solving, critical thinking, and the appropriation of technologies, although its effective implementation in teacher training faces significant challenges (Pamies et al., 2022). Quílez et al. (2017) emphasize the importance of developing a flexible teacher professionalization proposal that can be adjusted to the needs of research and innovation, with STEM education considered part of their pedagogical work. In this regard, Beltrán et al. (2018) suggest examining the teaching practices implemented in schools to review and renew teaching and learning strategies and methods for integrating knowledge.

Azcaray (2019) argues that a technology-mediated environment encourages the generation of creative and innovative ideas, integrating STEM disciplines as new research paradigms in education. Reframing this knowledge is crucial; Santillán et al. (2019) highlight the need to prepare society in the field of knowledge to make contributions in the human, social, political, cultural, and educational spheres. STEAM education is presented as an essential alternative for addressing real problems and finding creative solutions.

For their part, Arabit and Prendes (2020) reflect on the methodology that best privileges students' experience to improve teaching and learning and develop the skills required in the 21st century. Moreno and Bautista (2019) propose that teachers should foster STEM skills, abilities, and competencies by integrating technology and robotics to address contemporary challenges in education. The pedagogical and epistemological elements that underpin this proposal are essential. Despite advances in integrating educational robotics, there is a gap in understanding its specific impact on teachers' STEM skill development. Studies such as those by Morales Almeida (2021) and Vivas-Fernández and Sáez-

López (2019) have shown benefits for students. However, research is lacking on how these technologies affect educators' pedagogical skills and technological competencies. Venegas et al. (2021) address the development of computational thinking in the classroom but do not delve into the crucial role of teachers in implementing these tools.

This study seeks to fill that gap by providing empirical evidence on the impact of educational robotics training on the development of STEM competencies in teachers, contributing to a better understanding and implementation of these technologies in education.

The study focuses on developing and implementing a pedagogical strategy based on educational robotics for secondary school teachers in Bogotá, Colombia. Through a 25-session intervention plan, it seeks to integrate a constructionist pedagogical design and a PBL (Problem-Based Learning) approach to foster STEM competencies in teachers. The central question is: How does a pedagogical strategy grounded in educational robotics influence the development of STEM skills among secondary school teachers in the Edumatica master's degree program? The objective is to develop, apply, and validate this pedagogical strategy using a quantitative approach and a pre-experimental design to establish the relationship between educational robotics and the development of key skills among teachers.

1.1 Constructionism

The pedagogical model adopted was Papert's (1999) constructionism, which holds that individuals assimilate and accommodate knowledge as needed, leading to new experiences and social constructions through interaction with the environment. This interaction is fundamental to creating mental structures that organize information based on everyday experiences. Pitti et al. (2010) affirm that this theory promotes the creation of spaces that stimulate students' creative and imaginative abilities.

Savery and Duffy (1995) emphasize that knowledge is an individual construction, but

learning must be related to the environment. Individual understanding is enhanced in collaborative work, helping to develop mental structure. Dussel and Quevedo (2010) add that reducing the gap in access to and use of new technologies significantly favors the teaching-learning process.

Constructionism has proven effective for developing STEM skills through educational robotics, as observed in seven public schools in the Region of Murcia, where teachers' Creativity, problem-solving, and critical thinking improved (Arabit & Prendes, 2020). This approach, which promotes the active creation of knowledge through interaction with the environment, coincides with practices highlighted by Ungerer and Hartmann (2015) and engineering experiences described by Downey et al. (2022), encouraging collaboration and autonomous learning. Thus, integrating emerging technologies and constructionist methodologies enhances both technical competencies and pedagogical and innovative skills among teachers (Vera-Sagredo et al., 2024).

1.2 Problem-Based Learning (PBL)

The methodological proposal is based on Problem-Based Learning (PBL), which encourages teachers to discover and construct their knowledge, in line with constructionism. This approach addresses topics through problem-solving, encouraging peers to engage in recursion and adaptation. Del Valle and Villa (2008) highlight that PBL focuses students on their own learning, allowing them to take active initiatives to solve problems.

The teacher acts as a guide, participating in the development of the case, keeping a low profile during discussions of solutions, monitoring work plans, advising on the use of learning resources, and evaluating the outcomes. Sandoval et al. (2010) emphasize integrating prior knowledge and the self-construction of fundamental concepts in research projects.

Vargas Vargas et al. (2020) also highlight the effectiveness of PBL mediated by information technologies in overcoming learning difficulties in

mathematics, showing significant improvements in students' academic performance.

1.3 STEM education and robotics

STEM education and educational robotics are integrated pedagogical approaches that promote active STEM education and educational robotics are integrated pedagogical approaches that promote active learning and the development of critical skills. STEM focuses on problem solving, the practical application of knowledge, and interdisciplinarity, preparing students for the challenges of the 21st century (Rodríguez & Medina, 2021; López et al., 2020). Educational robotics, based on constructivist theories, uses robot construction and programming to develop skills such as computational thinking, Creativity, autonomy, and motivation (Sokolonski, 2020).

This methodology has been shown to improve academic skills and motivation in elementary school students in scientific and technological concepts (Zorrilla-Puerto et al., 2023). According to Kelley and Knowles (2016), an integrated approach to STEM education increases motivation and performance in mathematics, as exemplified by the use of systems, such as pulleys, to facilitate understanding of practical concepts.

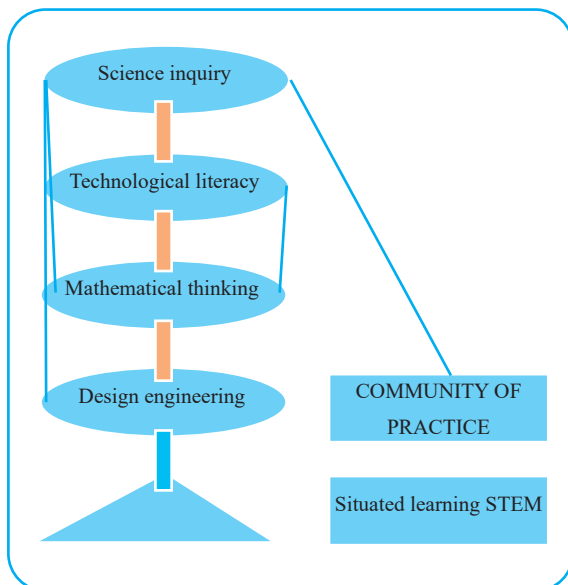


Figure 1: Conceptual framework for STEM education.
Source: Adapted from: Kelley and Knowles (2016).

According to Moore et al. (2014), effective STEM environments require experimentation, concrete manipulation, and multiple representations, integrating disciplines through collaboration in realistic contexts.

Analysis of US initiatives (K-12) reveals two key approaches: 1. Robotics as a tool: A means to facilitate learning, and 2. Robotics as a goal: Learning content in itself. Both perspectives demonstrate the versatility of STEM education, offering multiple pathways for integrating interdisciplinary knowledge. Figure 2 presents the disciplinary fields that are integrated to promote the problem-solving process.

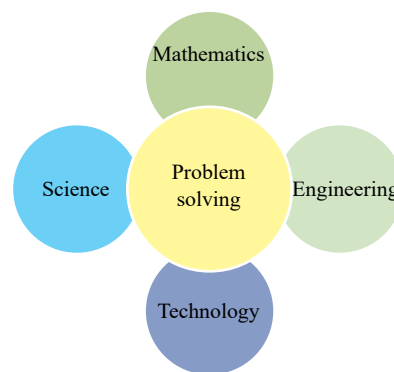


Figure 2: Areas of STEM education that promote problem solving
Source: Own elaboration, 2026.

Colombia is making significant progress in implementing STEM education (Gómez et al., 2020), although crucial challenges remain, such as integrating STEM into the curriculum and adopting technology. However, recent research (Greca and Meneses, 2018; López et al., 2020) recognizes the key role of this approach in developing scientific skills and responding to current global challenges.

1.4 Considerations for the STEM curriculum

In terms of needs and objectives, UNESCO, in its IBE study, Special Alert STEM Education (2016), highlights the need for a STEM curriculum and notes the concern about the steady decline in young people's interest in science (Adhikari, 2023).

In the curriculum design of Taba's (1974) pedagogical proposal, seven key stages are identified: determining the need, formulating objectives, selecting and organizing content, selecting and organizing learning experiences, and evaluation. This approach ensures a systematic and structured curriculum (Portillo et al., 2020).

UNESCO (2016) urges the implementation of STEM to counteract dropout rates in science.

Its practical approach (Lynch, 2017), geared toward the development of higher-order skills (DeAngelis, 2015), transforms educational practices (Ramadhan et al., 2023).

In terms of assessment, Jolly (2016) suggests three crucial questions: What are students learning? What do they think? Moreover, what skills are they acquiring? These questions must be adapted to a flexible and formative assessment model (Hanifah, 2023).

2. Materials and methods

The quasi-experimental research was conducted at the Fundación Universidad Autónoma de Colombia, with a population of 30 teachers, who represented a census sample of third-semester students in the Edumática master's program. The study adopted a deductive-quantitative approach, analyzing educational phenomena through empirically verifiable hypotheses. Following Maita (2018), patterns of regularity were sought through controlled measurements, treating the subject and object of study as independent entities.

An experimental methodology was implemented with:

- Quantitative data analysis
- Numerical processing and symbolic comparisons
- Statistical regression to evaluate the impact of the independent variable on the dependent variable.

The research adopted a correlational approach to analyze the relationship between educational variables mathematically. A pre-experimental design was used with a sample of 30 secondary school teachers to evaluate their perceptions of the acquisition of STEM skills. Table 1 details the dimensions and variables considered in the pedagogical proposal implemented. The instrument was designed on a Likert scale with 90 indicators, yielding a Cronbach's alpha of over

0.85 across all categories, indicating reliability. The application was a virtual post-test.

The pedagogical proposal consisted of developing 25 teaching units, applied in 25 sessions of 2 hours each, with a theoretical-practical methodology, each oriented by the chair of robotics and learning in the Edumática master's degree.

Across the six dimensions proposed in the two data collection instruments, the Alpha reliability coefficient is above 0.90, indicating high internal consistency across all aspects.

The following are the results of the instrument's overall reliability, as measured by internal consistency, in the research.

The pedagogical design (Figure 3) comprised three modules: an initial module on mechanics, electronics, and programming; an intermediate module using commercial platforms (LEGO) for teaching robotics; and an advanced module with free software and hardware tools (ARDUINO). The methodology favored problem-based learning, with applied exercises, evaluation, and reflection processes based on the results of the practical work. The intervention consisted of 25 face-to-face sessions with 25 teaching units, integrating simulators, software, and free hardware to develop STEM skills through declarative, procedural, and attitudinal content.

Table 1: Categories of the dependent variable of STEM skills development.
Source: Own elaboration, 2026.

Dimensions	Subcategories	Number of indicators	ALPHA reliability coefficient
1.1. Ways of thinking	1.1.1 Creativity and innovation	5	No. of elements 20 Cronbach's alpha 0.93
	1.1.2 Critical thinking	5	
	1.1.3 Problem solving	5	
	1.1.4 Learning to learn	5	
1.2 Tools for working	1.2.1 Appropriation of digital technologies	5	No. of items 10 Cronbach's alpha 0.876
	1.2.2 Information management	5	
1.3 Ways of working	1.3.1 Communication	5	No. of items 10 Cronbach's alpha 0.8
	1.3.2 Collaboration	5	
1.4 Ways of living in the world	1.4.1 Life and career:	5	No. of items 15 Cronbach's alpha 0.91
	1.4.2 Personal and social responsibility	5	
	1.4.3 Local and global citizenship	5	

Table 2: Categories of the independent variable educational robotics (ER).
Source: Own elaboration, 2026.

Dimensions	Subcategories	Number of Indicators	ALPHA reliability coefficient
2.1 Robotic Design	2.1.1 Mechanics	5	No. of elements 20 Cronbach's alpha 0.963
	2.1.2 Electronics	5	
	2.1.3 Computer science	5	
2.2 Teaching robotics	2.2.1 Curriculum	5	No. of items 20 Cronbach's alpha .91
	2.2.2 Teaching methods	5	
	2.2.3. Evaluation	5	
	2.2.4. Research	5	

Table 3: Reliability analysis results
Source: Prepared by the author, 2026.

Cronbach's alpha	Cronbach's alpha based on standardized items	N of items
.940	.937	90

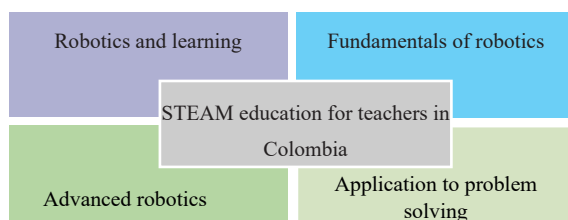


Figure 3: Design of the pedagogical strategy in educational robotics for STEM development
Source: Own elaboration, 2026.

The project was guided by ethical and bioethical principles that ensured respect, protection, and justice for participants. Their dignity and well-being were prioritized, ensuring that the benefits outweighed the risks (principle of beneficence). The selection of participants was fair and equitable (justice), avoiding any harm (non-maleficence). These ethical foundations were essential pillars of the research.

The team ensured transparent and responsible management of information at all stages of the project, in line with the principles of habeas data and participants' rights over their personal data. Prior informed consent was obtained, with a clear explanation of the use and purposes of the collected data. In addition, the absolute confidentiality of all information and records generated during the research was ensured.

The information and data obtained were used solely for the generation of knowledge and products for social appropriation, as well as for the generation of new knowledge within the academic and scientific framework.

Informed consent forms were signed for the use of images, testimonial texts, and photos, among others, enabling multiple interpretations and inferences about the realities of those who participated.

3. Results

In the process of managing the results, a bivariate regression model using Pearson's method was implemented to correlate variables and to validate a pedagogical strategy based on educational robotics to develop STEM skills in secondary school teachers in Bogotá, Colombia. The results were quantified using a predefined rating scale, whose categorization ranges (Table 4) allowed for statistical analysis of the variable means.

Table 4: Reliability analysis results

Source: Adapted from systematic perception of organizational climate through organizational development practice, 2026.

Ranges for Hypothesis Testing

Categorization	Range
Strong	3.1 – 4
Neutral	2.1 – 3.09
Weak	1.1 – 2.09
Extremely weak	0 – 1.09

The basic statistics for the variables are shown in Table 5. It can be seen that, according to the categorization of the variables, all dimensions, except Ways of Living in the World (MVM) and Robotic Design (DR), show strong categorization in terms of the mean. This means they are indeed of considerable importance in determining the variables of interest: STEM Education Competencies as the dependent variable and

Educational Robotics as the independent variable. It is noteworthy that both variables are categorized as Strong.

This categorization allows us to identify the degree of presence of the dimension or indicators under study in the individuals in the sample. This study is carried out in the average sense, based on the fact that the mean is the value a variable would take if there were no differences among individuals.

Table 6 shows the statistical relationship between Educational Robotics and the variables associated with STEM Education competencies. Pearson's correlation coefficient measures the degree of linear association between two variables, under the hypothesis system:

H0: There is no linear correlation between the variables / H1: There is a linear correlation between the variables

As in all cases shown in Table 6, the significance level ($\alpha=0.05$) is greater than the associated P-value (two-tailed), the null hypothesis is rejected, and it is concluded that there is a linear correlation between the variables. It is important to note that a correlation coefficient greater than 0.70 indicates a strong relationship between the

Table 5: Basic Statistics of the Variables

Source: Own elaboration, 2026.

	Dimension Ways of Thinking (MP)	Dimension Tools for Working (WWT)	Dimension Ways of Working (MTP)	Dimension Ways of Living in the World (MVM)	Competencies in STEM Education (CSTEM)	Robotic Design Dimension (DR)	Pedagogical Design Dimension (DP)	Educational Robotics Competency (RE)
Average	3,32	3,15	2,85	3,29	3,15	3,09	3,24	3,17

variables. In this experimental study, a correlation coefficient greater than 0.50 is considered a strong correlation between variables.

Table 6: Correlation between the educational robotics variable and the dependent variable and its dimensions
Source: Own elaboration, 2026.

		RE
Competencies in STEM Education	Correlación de Pearson	,764
	Sig. (bilateral)	,000
Ways of Thinking	Correlación de Pearson	,598
	Sig. (bilateral)	,000
Tools for Working	Correlación de Pearson	,782
	Sig. (bilateral)	,000
Ways to Work	Correlación de Pearson	,653
	Sig. (bilateral)	,000
Ways of Living in the World	Correlación de Pearson	,498
	Sig. (bilateral)	,005

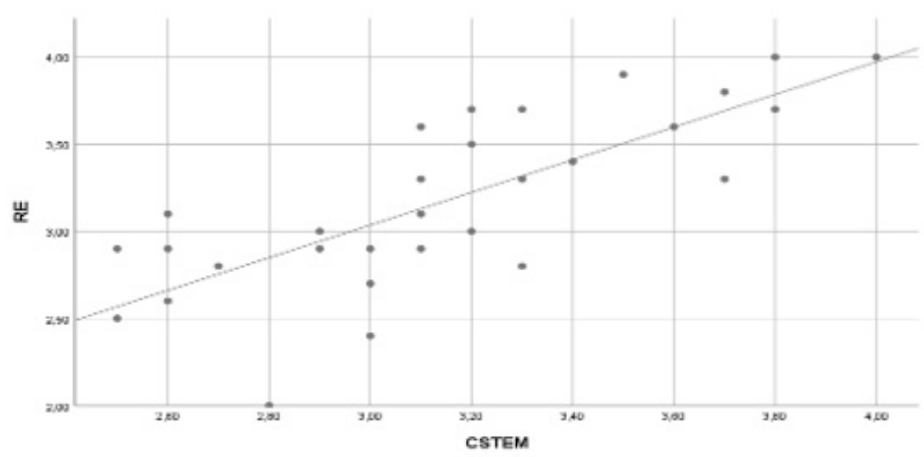


Figure 4: Scatter plot between CSTEM (dependent variable) and RE (independent variable). Interpretation: there is a strong positive correlation between CSTEM and RE, demonstrating that there is indeed a relationship between these variables.

Source: Prepared by the author, 2026.

3.1 General hypothesis

There is a significant improvement in the pedagogical proposal for training in educational robotics to develop STEM skills among teachers.

$\alpha = 0.05 = 5\%$, which is the maximum margin of error.

Decision rule:

$P > \alpha \rightarrow$ The null hypothesis H_0 is not rejected / $P < \alpha \rightarrow$ The null hypothesis H_0 is rejected

Table 7: Regression Model of Competencies in STEM Education as a Function of Educational Robotics
Source: Own elaboration, 2026.

	B	Std. Error	t	Sig.	R squared
(Constant)	1,171	,320	3,664	,001	
RE	,623	,099	6,264	,000	,584

$$\text{CSTEM} = \beta_1 + \beta_2 \text{RE} + \mu_i$$

$$(\text{CSTEM}) \approx 1.171 + 0.623\text{RE}$$

Decision: There is evidence of a statistically significant relationship between RE and CSTEM.

In other words, it is determined that RE has an influence on CSTEM, since the null hypothesis is rejected, i.e., the hypothesis is accepted.

3.2 Specific hypotheses

First specific hypothesis. There is a significant improvement in the educational robotics training proposal for developing teachers' ways of thinking.

H0: There is no significant improvement in the educational robotics training proposal for the development of teachers' ways of thinking.

H1: There is a significant improvement in the educational robotics training proposal for the development of teachers' ways of thinking.

Table 8: Regression model of ways of thinking (MP) as a function of educational robotics (RE)
Source: Own elaboration, 2026.

	B	Std. Error	t	Sig.	R squared
(Constant)	1,649	,428	3,855	,001	
RE	,525	,133	3,946	,000	,357

$$MP = \beta_1 + \beta_2 RE + \mu_i$$

$$(MP) \hat{=} 1.649 + 0.525RE$$

Conclusion: There is evidence of a statistically significant relationship between RE and MP. In other words, it is determined that RE has an influence on MP, since the null hypothesis is rejected.

From the above data, the variance is 0.02, indicating that the dispersion of the census sample data is low.

Second specific hypothesis. There is a significant improvement in the educational robotics training proposal for developing tools for teachers.

H0: There is no significant improvement in the educational robotics training proposal for developing tools for teachers to use.

H1: There is a significant improvement in the pedagogical proposal for training in educational robotics for the development of tools for teachers to work with.

$$HPT = \beta_1 + \beta_2 RE + \mu_i$$

$$(HPT) \hat{=} 0.291 + 0.900RE$$

Decision: There is evidence of a statistically significant relationship between RE and HPT. In other words, it is determined that RE has an influence on HPT, since the null hypothesis is rejected.

From the above data, the variance is 0.09, indicating that the dispersion of the census sample data is low.

Third specific hypothesis. There is a significant improvement in the educational robotics training proposal for the development of working methods

Table 9: Summary statistics Ways of Thinking (MP)
Source: Prepared by the author, 2026.

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	Number of elements
Element means	3,317	3,100	3,533	,433	1,140	,020	20
Element variances	,439	,248	,626	,378	2,523	,010	20

Table 10: Regression Model of Tools for Working (HPT) as a Function of Educational Robotics (RE)
Source: Own elaboration, 2026

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	Number of elements
Element means	3,317	3,100	3,533	,433	1,140	,020	20
Element variances	,439	,248	,626	,378	2,523	,010	20

Table 11: Summary statistics Tools for working (MP)
Source: Own elaboration, 2026.

	Mean	Minimum	Max	Range	Maximum / Minimum	Variance	Number of elements
Element averages	3,150	2,633	3,567	,933	1,354	,090	10
Element variances	,751	,368	1,344	,976	3,653	,114	10

in postgraduate teachers in Bogotá, Colombia, 2020.

H0: There is no significant improvement in the pedagogical proposal for training in educational robotics for the development of working methods in postgraduate teachers.

H1: There is a significant improvement in the pedagogical proposal for training in educational robotics for the development of working methods in postgraduate teachers.

$$\text{MPT} = \beta_1 + \beta_2 \text{RE} + \mu_i$$

$$(\text{MPT}) \hat{=} 0.803 + 0.644 \text{RE}$$

Decision: There is evidence of a statistically significant relationship between RE and MPT. In other words, it is determined that RE has an influence on MPT, since the null hypothesis is rejected.

From the above data, the variance is 0.254, indicating that the dispersion of the census sample data is low.

Fourth specific hypothesis. There is a significant improvement in the pedagogical proposal for training in educational robotics to develop ways of living in the world among teachers.

H0: There is no significant improvement in the pedagogical proposal for training in educational robotics for the development of ways of living in the world among teachers.

H1: There is a significant improvement in the pedagogical proposal for training in educational robotics for the development of ways of living in the world among teachers.

$$\text{MVM} = \beta_1 + \beta_2 \text{RE} + \mu_i$$

$$(\text{MVM}) \hat{=} 1.858 + 0.451 \text{RE}$$

Decision: There is evidence of a statistically significant relationship between RE and MVM. In other words, it is determined that RE has an influence on MVM, since the null hypothesis is rejected.

Tabla 12: Estadísticos de resumen Herramientas para trabajar (MP)
Fuente: Elaboración propia, 2026.

	B	Std. Dev.	t	Sig.	R squared
(Constant)	,803	,454	1,79	,088	
RE	,644	,141	4,56	,000	,427

Table 13: Summary statistics Ways of working (MPT)
Source: Own elaboration, 2026.

	Mean	Minimum	Max	Range	Maximum / Minimum	Variance	Number of elements
Element means	2,850	1,767	3,300	1,533	1,868	,254	10
Element variances	,716	,489	1,082	,593	2,214	,053	10

Table 14: Regression Model of Ways of Living in the World (MVM) as a Function of Educational Robotics (RE).
Source: Own elaboration, 2026.

	B	Std. Error	T	Sig.	R squared
(Constant)	1,858	,477	3,892	001	
RE	,451	,148	3,036	005	,248

From the above data, it can be seen that the variance is 0.031, which shows that the dispersion of the census sample data is low.

Table 15: Summary statistics Ways of Thinking (MP)
Source: Own elaboration, 2026.

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	Number of elements
Element means	3,289	2,900	3,667	,767	1,264	,031	15
Element variances	,468	,230	,645	,415	2,805	,011	15

4. Discussion

The study confirmed that educational robotics strengthens STEM skills across all dimensions, improving motivation, collaboration, and problem-solving among students and teachers. These findings support previous research (Belmonte et al., 2020; Almeida, 2021) that highlights its impact on Creativity, participation, and digital skills. In addition, robotics transformed teachers’ pedagogical practices, aligning with Bagiya’s (2017) call for innovative STEM approaches to complex educational scenarios. However, it is important to clarify that the intervention is not the only cause of the positive results; there is a strong positive correlation and an observed improvement in the intervention group.

Given that robotics explains 58.4% of the variation in STEM development (Anwar et al., 2019), in their systematic review of robotics in K-12 settings, they highlight that integrating robotics not only improves academic performance but is also a significant predictor of interest in STEM careers. Your finding of 58.4% precisely quantifies the “importance” that Anwar mentions in a qualitative, general sense. Kopcha et al. (2017) highlight the impact of robotics on teachers’ professional development (PD). Their results indicate that robotics is an “efficient way” to integrate STEM principles. You can argue

that your coefficient of determination provides quantitative evidence confirming the efficiency suggested by Kopcha et al.

The application of the pedagogical strategy in educational robotics had a significant impact on the appropriation of digital technologies and information management, critical aspects in teacher training in the face of technological challenges and the COVID-19 pandemic (Vigo-Arrazola et al, 2024). Beltrán et al. (2018) corroborated these findings by proposing an ICT (Information and Communication Technologies) course to improve teaching practices in science and mathematics, noting that STEM content develops digital skills, though designing activities based on real-world problems poses challenges.

Pearson’s correlation analysis showed coefficients above 0.70 between educational robotics and various dimensions of STEM skills, suggesting a strong relationship between these variables. This finding is consistent with Vivas-Fernández and Sáez-López (2019), who reported significant improvements in digital and programming skills in primary school students after robotics workshops.

The study also showed that educational robotics promotes the development of communication,

teamwork, and collaboration skills among teachers, which are crucial aspects of current teaching. Quílez et al. (2017) emphasized the importance of collaborative projects for adapting the curriculum to students' learning rhythms, and Campos (2018) indicated that STEM competencies are essential for research.

Compared to previous research, our results highlight the robustness of educational robotics as a tool for improving STEM skills. Venegas et al. (2021) found that robotics in the classroom develops logical and computational thinking

and improves the classroom environment and collaboration among students.

Finally, although the relationship between educational robotics and ways of thinking was the lowest among the evaluated categories due to its subjective nature, it was shown to favor the development of competencies in personal responsibility, social responsibility, and global citizenship. Orcos et al. (2019) showed that educational robotics projects have high motivational value and a significant impact on the development of social skills and group work.

5. Conclusions

The implementation of educational robotics should not be understood merely as a technical update, but as a disruptor of the cognitive structure of teaching. The results confirm that the strategy was effective, not because of the device per se, but because it forced teachers to move from linear teaching to teaching based on uncertainty and problem-solving. The significant impact on the “ways of thinking” dimension suggests that robotics serves as a mirror of mental processes, enabling Creativity and critical thinking to move from abstract concepts to tangible, assessable practices.

There is evidence of high effectiveness in the appropriation of “tools” and “ways of working,” indicating that the curriculum model breaks down the barrier of technological fear. However, from a critical perspective, it is vital to reflect on whether this rapid acquisition of technical skills reflects genuine pedagogical innovation or merely instrumental efficiency. The consolidation of collaborative dynamics under the STEM approach is a significant advance. However, the challenge lies in ensuring that collaboration is not only operational (task distribution) but also

intellectual and constructive, allowing teachers to redefine their role from transmitter to facilitator of learning ecosystems.

The most revealing finding, and one that requires deep reflection, is the modest progress in the dimension of “ways of living in the world.” This technical-social gap warns of the risk of training teachers who are “digitally literate but socially disconnected.” Training that prioritizes how the machine works over what it is used for in a context of global citizenship is incomplete.

Although improvements were observed across all areas, the dimension “ways of living in the world” (related to ethics, citizenship, and social context) showed the least pronounced gains. This gap indicates an area for critical optimization. For the proposal to be considered a replicable model of international excellence, it is essential to intensify the pedagogical component that explicitly connects robotics with socio-scientific and ethical challenges, ensuring that the development of technical skills translates into comprehensive teacher training with a high sense of social responsibility.

6. Recommendations

It is imperative that implementing institutions review the curriculum design to intensify the pedagogical intentionality in the dimension of “ways of living in the world.” Given that this was the least significant area for improvement, it is recommended to integrate mandatory modules and projects that connect educational robotics with the analysis of the Sustainable Development Goals (SDGs), the ethics of artificial intelligence, and digital citizenship. This will ensure that technical training translates into teaching practices that are high in social and ethical awareness.

To achieve a thorough optimization of the proposal, it is recommended that a complementary qualitative research phase be carried out. Through in-depth interviews and focus groups with

teachers, the causal mechanisms and subjective perceptions that explain the ‘how’ and ‘why’ of the observed improvement should be identified. This experiential feedback is crucial for refining the methodology and ensuring the sustainability of changes in classroom practices.

Given the robust statistical validation in the development of cognitive and technical skills, it is recommended that educational authorities and universities institutionalize and standardize the proposal. A roadmap should be designed to enable the controlled replication of the pedagogical model across other faculties and graduate programs at the national and regional levels, consolidating educational robotics as a cross-cutting, strategic axis for teacher training.

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Impacto de la realidad aumentada y la realidad virtual en el aprendizaje matemático de los estudiantes con TEA y TDAH

Impact of augmented reality and virtual reality on mathematical learning in students with ASD and ADHD

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Impacto de la realidad aumentada y la realidad virtual en el aprendizaje matemático de los estudiantes con TEA y TDAH

Impact of augmented reality and virtual reality on mathematical learning in students with ASD and ADHD

Resumen:

En este estudio se analiza el impacto de las tecnologías de Realidad Aumentada (RA) y Realidad Virtual (RV) en el aprendizaje de las matemáticas de alumnos de primaria con Trastorno del Espectro Autista (TEA) y Trastorno por Déficit de Atención e Hiperactividad (TDAH). Mediante un diseño cuasi-experimental de métodos mixtos, se asignó a 60 alumnos de primaria (30 con TEA y 30 con TDAH) a grupos experimentales (RA/RV) y de control (enseñanza tradicional). La intervención, de ocho semanas de duración, incluyó experiencias matemáticas intensivas basadas en las necesidades sensoriales y cognitivas, así como pruebas previas y posteriores para medir la capacidad de cálculo y resolución de problemas. Los resultados indicaron que, en el grupo experimental, los alumnos con TDAH lograron un aumento del 30 % en las calificaciones de matemáticas, así como en la motivación (+30 %) y la atención sostenida (+25 %). Según los docentes, los entornos interactivos y atractivos de RA/RV redujeron la distracción y mejoraron la participación. Los alumnos con TEA mejoraron moderadamente (15-18 %), lo que demostró que se necesitaba una personalización adicional para adaptarse a las sensibilidades sensoriales.

Palabras clave: realidad aumentada (RA), realidad virtual (RV), aprendizaje de las matemáticas, educación neurodiversa, inclusión social.

Abstract:

The impact of Augmented Reality (AR) and Virtual Reality (VR) technologies on primary school students with Autism Spectrum Disorder (ASD) and Attention Deficit Hyperactivity Disorder (ADHD) in math learning is discussed in this study. Using a mixed-methods quasi-experimental design, 60 primary school students (30 ASD, 30 ADHD) were assigned to experimental (AR/VR) and control (traditional instruction) groups. The 8-week intervention had intensive math experiences based on the sensory and cognitive needs, pre- and post-tests measuring the calculation and problem-solving capacity. Outcomes indicated that in the experimental group, ADHD students achieved a 30% increase in math scores and in motivation (+30%) and sustained attention (+25%). Interactive and engaging AR/VR environments reduced distractibility and enhanced engagement, according to teachers. ASD students moderately improved (15–18%), showing that additional customization was needed to accommodate sensory sensitivities.

Keywords: augmented reality (AR), virtual reality (VR), mathematics learning, neurodiverse education, social inclusion.

1. Introducción

El aprendizaje de las matemáticas ha sido un tema complejo dentro del sistema escolar, y se vuelve aún más complejo cuando se enseña a estudiantes con necesidades educativas especiales, específicamente a estudiantes con Trastorno del Espectro Autista (TEA) y Trastorno por Déficit de Atención e Hiperactividad (TDAH) (Ortiz, 2024). Ambos perfiles de estudiantes presentan rasgos cognitivos, conductuales y emocionales que influyen directamente en los procesos de enseñanza y aprendizaje. La rigidez del pensamiento, la hiperreactividad sensorial, la alteración del proceso habitual de establecimiento de relaciones abstractas o simbólicas y la alteración de las funciones de atención selectiva y sostenida son algunas de las variables que dificultan el acceso a los contenidos del currículo normal (Hoyos et al., 2022). El aprendizaje de las matemáticas, dado que se basa en la comprensión de conceptos abstractos, el seguimiento de procedimientos paso a paso y la resolución de problemas ordenados, es, por lo tanto, una materia muy vulnerable para este grupo de estudiantes (García García et al., 2023).

Estos desafíos no son de naturaleza anecdótica, sino sistémica, como lo evidencian las brechas de rendimiento de larga data entre los estudiantes neurodivergentes y neurotípicos, particularmente en los campos de las STEM (Bricio et al., 2024). El contenido de las matemáticas es especialmente propenso a resultar cognitivamente abrumador para estos estudiantes, ya que depende en gran medida de la memoria de trabajo, la atención prolongada y el pensamiento inferencial, aspectos todos ellos afectados tanto en el TEA como en el TDAH (Castro et al., 2024). Además, la práctica pedagógica estándar se basará naturalmente en la instrucción didáctica, la descripción del lenguaje y los sistemas representacionales incompatibles con las rutinas perceptivas y de procesamiento de los estudiantes neurodiversos (Cerdá et al., 2021).

Los hallazgos recientes en neurociencia cognitiva han puesto aún más de relieve los déficits específicos de procesamiento neuronal en los

estudiantes con TEA y TDAH, lo que refuerza la necesidad de intervenciones pedagógicas diferenciadas (Cortez et al., 2025). Por ejemplo, los procedimientos de resonancia magnética funcional muestran patrones de activación anormales de la corteza prefrontal y los lóbulos parietales en participantes con TDAH durante el procesamiento de operaciones aritméticas, lo que indica un déficit de la función ejecutiva y de la memoria de trabajo (Rubia, 2023). De manera similar, los estudios sobre el TEA indican un procesamiento perceptivo intensificado, pero un procesamiento deteriorado de las representaciones simbólicas, lo que hace que la enseñanza tradicional de las matemáticas sea más desafiante (Iuculano et al., 2024). Los estudios también indican la necesidad de implementar otros enfoques de enseñanza más sensibles a los perfiles cognitivos neurodivergentes (Cruz y Lumbreras, 2022).

Para abordar esto, la utilización de nuevas tecnologías como la Realidad Aumentada (RA) y la Realidad Virtual (RV) ha sido una forma innovadora de satisfacer las necesidades de los estudiantes con TEA y TDAH (Rial Costa et al., 2022). Ambas tecnologías poseen la capacidad única de crear contextos de aprendizaje interactivos, inmersivos y visualmente intensos que pueden adaptarse al carácter particular de los alumnos (Cabas-Hoyos et al., 2022). La RA y la RV tienen la capacidad de redefinir datos inmateriales como información sensorial háptica, manipulable y comprensible, mejorando así el proceso de aprendizaje y memorización (Valverde et al., 2024). El grado de personalización que ofrecen, al igual que su valor de entretenimiento, tiene un mayor potencial para facilitar el apoyo a la motivación, la reducción de la frustración y la participación activa en los procesos de aprendizaje (Carmona Serrano et al., 2022).

La razón por la que la RA y la RV son mejores que otras tecnologías de apoyo es que ambas tecnologías son más eficaces en la integración multisensorial, compensando los déficits en el nivel fundamental del TEA y el TDAH

de manera más directa de lo que se intentó originalmente (Concepción y Muñoz, 2024). La RV, por ejemplo, permite crear entornos controlados y libres de distracciones que reducen las intrusiones sensoriales externas para los estudiantes con TEA, al tiempo que ofrece mecanismos de retroalimentación adaptativa que permiten la regulación de la atención para los estudiantes con TDAH. La RA, por otro lado, superpone información virtual sobre entornos del mundo real para ofrecer experiencias híbridas que combinan el aprendizaje abstracto-simbólico y el concreto-perceptivo, con el fin de permitir la internalización de conceptos a través de la cognición incorporada (Nieves et al., 2024).

A pesar de las crecientes tendencias en la implementación de la tecnología de RA y RV en el aprendizaje, la evidencia empírica de sus impactos en el aprendizaje de las matemáticas en estudiantes con TEA y TDAH sigue siendo escasa y dispersa (Zambrano et al., 2025). Gran parte de la investigación existente en los últimos años se centró en aplicaciones más amplias de las dos tecnologías o en la experiencia de los estudiantes basada en consideraciones anecdóticas, en lugar de crear diseños de investigación sistemáticos para recopilar mediciones sistemáticas (López-Bouzas et al., 2023). Además, la literatura existente no logra diferenciar con claridad el efecto identificado en estudiantes con diferentes trastornos del desarrollo neurológico, lo que obstaculiza nuestra capacidad para comprender cómo cada trastorno influye en las respuestas a los entornos de aprendizaje inmersivo (de Souza Malaquias et al., 2024). Esta incapacidad para diferenciarlos entre sí, y la falta de diseños experimentales adecuados, es un área de conocimiento que debe abordarse para poder proceder a la integración basada en la evidencia de estas tecnologías en la educación inclusiva (Díaz et al., 2023).

Una de las principales limitaciones de la investigación actual es la utilización de muestras pequeñas, intervenciones breves y cuasi-experimentos, lo que dificulta la generalización y la replicabilidad (Smith y Jones, 2024). La falta de estudios longitudinales complica aún más el problema, ya que nadie ha podido constatar una retención a largo plazo de las

habilidades matemáticas ni mejoras estables en la motivación (Domene y Rueda, 2024). Además, la mayoría de los estudios utilizan metodologías descriptivas o exploratorias que excluyen las medidas psicométricas estandarizadas o las pruebas neurocognitivas, y pasan por alto los efectos sutiles pero valiosos desde el punto de vista educativo de las intervenciones de RA y RV (García y Calleros, 2021).

Con la llegada de las tecnologías de RV y RA, su aplicación a la pedagogía aún carece de una investigación adecuada. Gran parte de la literatura existente ofrece un asesoramiento empírico muy mínimo a los educadores y no considera adecuadamente las variables mediadoras que afectan a la eficacia entre los alumnos neurodiversos (Ohanna et al., 2023; Lagos San Martín et al., 2024). La calidad del contenido, la usabilidad de la interfaz, el control emocional dentro del espacio virtual y la disponibilidad sensoriomotora son algunas de las variables clave que deben investigarse en detalle (Lledó et al., 2023; López-Belmonte et al., 2024). La falta de estudios interdisciplinarios —que incluyan perspectivas pedagógicas, tecnológicas y clínicas— ha obstaculizado el desarrollo de mejores prácticas en la aplicación de la RA y la RV en la enseñanza de las matemáticas a niños con TEA y TDAH (Sánchez y Sainz, 2021). El potencial de aprendizaje de las tecnologías inmersivas es enorme, pero no está plenamente desarrollado (Muñoz et al., 2024).

Un diseño de aprendizaje eficaz basado en RA/RV requiere un trabajo interdisciplinario que incluya a desarrolladores de software, maestros de educación especial, psicólogos y terapeutas ocupacionales. Por ejemplo, el desarrollo de un módulo de aprendizaje en RV sobre transformaciones geométricas requiere más que una simple animación; se debe prestar atención a la legibilidad visual, la capacidad de respuesta en la interacción, los esquemas de refuerzo y la gestión de la carga cognitiva (Patiño et al., 2024; Pérez Rubio et al., 2023). Del mismo modo, el diseño de la interfaz debe tener en cuenta las sensibilidades sensoriales del TEA y los niveles de tolerancia a la frustración del TDAH para evitar consecuencias perjudiciales (Pérez & López-Bouzas, 2021). Por lo tanto, la eficacia de estas

tecnologías no depende solo de las capacidades tecnológicas, sino también de su utilización pedagógica (Retama et al., 2024; Romero et al., 2022). La metodología de enseñanza de los alumnos neurodiversos necesita un cambio radical mediante el uso de la RA y la RV en el núcleo mismo de la pedagogía de la equidad, no como complementos, sino como el núcleo de una pedagogía equitativa (Romero, 2023).

Para llevar a cabo este cambio, la implementación debe pasar de basarse en la novedad a adoptar modelos basados en la evidencia y fundamentados en los principios del Diseño Universal para el Aprendizaje (UDL) (Saiz & Torrijos, 2022). Estos modelos deben valorar la flexibilidad, la representación multimodal y la autonomía del alumno, de modo que puedan diseñar experiencias inmersivas que sean inclusivas por naturaleza (Rose y Meyer, 2024). Además de la presentación de contenidos, la RA y la RV pueden transformar los sistemas de evaluación. Los entornos virtuales permiten la medición del rendimiento en tiempo real, el monitoreo del comportamiento y la modificación dinámica de los estímulos de aprendizaje, atributos que no están presentes en las evaluaciones convencionales. Los sistemas impulsados por IA pueden modular el nivel de dificultad, ofrecer retroalimentación inmediata y reconocer señales tempranas de desmotivación, además de proporcionar una evaluación formativa adaptativa personalizada según perfiles neurocognitivos únicos (Baker et al., 2024).

Desde una perspectiva neurocientífica, las tecnologías inmersivas forman parte de los enfoques de cognición incorporada y situada. La investigación en neuroimagen sugiere que la RV y la RA activan simultáneamente múltiples regiones del cerebro para apoyar el procesamiento visoespacial, la codificación de la memoria y el aprendizaje basado en recompensas (Kaczmarek et al., 2024). Dichos procesos pueden contrarrestar las deficiencias de la función ejecutiva en el TEA y el TDAH, ofreciendo nuevas vías para la adquisición de habilidades matemáticas. Por lo tanto, investigar la influencia de los mundos inmersivos en el funcionamiento neurocognitivo es importante desde el punto de vista pedagógico y científico (Serrano et al., 2025).

Los estudiantes con TEA y TDAH suelen experimentar ansiedad, falta de autoestima y estrés en los entornos de aprendizaje. Las tecnologías inmersivas bien diseñadas pueden proporcionar espacios seguros y libres de juicios para experimentar, donde se permite la repetición continua y se puede recibir retroalimentación alentadora. Entornos como la iluminación ambiental con luz de ambiente o sonido ajustable pueden incluso reducir el estrés y mejorar la concentración, lo que convierte a los canales de RA y RV en una ayuda tanto cognitiva como emocional para la enseñanza de las matemáticas (Didehbani et al., 2023). Sin embargo, persisten las preocupaciones. Las cuestiones éticas — como la restricción del tiempo frente a la pantalla, la protección de la privacidad y el riesgo de sobreestimulación — deben abordarse mediante directrices sólidas y soluciones de diseño ético. Las disparidades socioeconómicas en el acceso a la tecnología también contribuyen a problemas de equidad, particularmente en las escuelas de bajos ingresos (Warschauer y Matuchniak, 2024). Las investigaciones emergentes no deben limitarse a medir la eficacia, sino también examinar cuidadosamente las condiciones estructurales para una adopción equitativa.

Los años venideros requieren la cooperación entre sectores. Los educadores, los investigadores cognitivos, los desarrolladores y los responsables políticos deben colaborar para garantizar que las tecnologías de realidad virtual y realidad aumentada se creen para todos, se utilicen de manera responsable y se prueben a fondo. Las iniciativas piloto deben incluir la formación sistémica de los docentes, la participación de los padres y mecanismos de retroalimentación de los alumnos. Solo a través de una acción conjunta y sistémica de este tipo se podrá liberar todo el potencial de la RA y la RV como agentes disruptivos de la educación matemática inclusiva. El objetivo general de este estudio es examinar el impacto de las tecnologías de realidad aumentada y realidad virtual en el aprendizaje de contenidos matemáticos en estudiantes con trastorno del espectro autista y trastorno por déficit de atención con hiperactividad, en variables de rendimiento académico, motivación y atención (Ordoñez & Alonso, 2023).

Estos objetivos concretos son: evaluar las diferencias en el rendimiento matemático antes y después de la intervención pedagógica mediada por RA y RV; compararlas con las obtenidas mediante el enfoque convencional; identificar patrones de comportamiento y participación durante la utilización de la tecnología; e investigar las percepciones de los estudiantes, los docentes y las familias hacia el proceso de aprendizaje inmersivo. A partir de estos objetivos, surge un conjunto de preguntas de investigación que guían el estudio: ¿Existe alguna diferencia en la mejora del rendimiento en matemáticas entre los estudiantes con TEA y TDAH tras la implementación de RA y RV? ¿En qué se diferencian los dos grupos en cuanto al impacto de la tecnología? ¿Cómo perciben la experiencia las distintas partes interesadas? ¿Cuáles son los elementos de diseño pedagógico y tecnológico que facilitan o dificultan el aprendizaje en estos entornos? La hipótesis de trabajo es que el uso

de entornos de RA y RV adaptados a los perfiles de los estudiantes con TEA y TDAH provoca una mejora significativa en el aprendizaje de las matemáticas en comparación con los enfoques tradicionales.

Este impulso se manifestará tanto en términos de un mejor rendimiento en pruebas estandarizadas como en términos de una mayor participación en las actividades, un aumento de la motivación intrínseca y una mejora en el mantenimiento de la atención sostenida. También se prevé que el impacto de estas tecnologías varíe entre los dos grupos de pacientes, siendo quizás más pronunciado en los estudiantes con TDAH debido a la estimulación sensorial controlada y la interactividad de las herramientas, mientras que en los estudiantes con TEA, su eficacia dependería del grado de modificación del estímulo visual y de la claridad estructural del entorno.

2. Método

La metodología de la investigación se basa en una metodología mixta, que integra orientaciones cuantitativas y cualitativas. La razón de esta elección es la necesidad de comprender plenamente el impacto de la RA y la RV, no solo en formas medibles en las pruebas de rendimiento, sino también en el seguimiento de los cambios de actitud, comportamiento y motivación por parte de los estudiantes. En esta investigación se aplicó un diseño cuasi-experimental de pre-prueba y post-prueba, lo que permitió determinar con precisión las diferencias entre las condiciones iniciales y finales tras aplicar la intervención educativa con tecnologías inmersivas. Aunque no se utilizó la aleatorización de los participantes, se logró en cierta medida la equivalencia entre los grupos mediante una rigurosa selección de los sujetos y el control de las variables externas.

Este estudio empleó un diseño cuasi-experimental de métodos mixtos, con pruebas previas y posteriores, para evaluar el efecto del uso de tecnologías inmersivas en el aprendizaje de las

matemáticas. El universo de esta investigación incluyó a estudiantes de quinto o sexto grado de escuelas primarias diagnosticados con TEA o TDAH, que asistían a escuelas que siguen una política de inclusión educativa, con instalaciones de apoyo especial. El tamaño total de la muestra, que constituía el universo de estudio de esta investigación, incluyó a 60 estudiantes que fueron seleccionados de manera intencional. En esta muestra, 30 participantes fueron diagnosticados con TEA y 30 participantes fueron diagnosticados con TDAH.

La selección de los participantes se realizó, por lo tanto, teniendo en cuenta criterios de inclusión específicos necesarios para que los participantes interactuaran con la intervención tecnológica. Principalmente, incluía estar matriculado como alumno de quinto o sexto grado de educación primaria, con un diagnóstico de TEA o TDAH. Lo más importante es que la participación estaba vinculada a un buen nivel de funcionamiento cognitivo, lo que permitía a los participantes

manejar las plataformas tecnológicas, incluyendo la Realidad Aumentada y la Realidad Virtual, junto con una comunicación verbal básica que hiciera posible la interacción con los instrumentos de investigación. Aunque el artículo no los enumeraba explícitamente, por implicación, los estudiantes que carecían de la capacidad cognitiva o de la comunicación verbal básica, o cuyos padres o tutores se negaron a dar su consentimiento por escrito, fueron excluidos de participar en la investigación.

La muestra incluyó a 60 estudiantes, la mitad de los cuales habían sido diagnosticados con TEA y la otra mitad con TDAH. Todos los estudiantes cursaban quinto o sexto grado de primaria en escuelas que enfatizaban la inclusión educativa con instalaciones de apoyo especial. Se utilizó un muestreo intencional en la selección de los participantes, dando prioridad a aquellos que tenían un nivel adecuado de funcionamiento cognitivo para poder manejar las plataformas tecnológicas utilizadas, así como la comunicación verbal básica.

La recopilación de datos se llevó a cabo utilizando diversos instrumentos para obtener una visión integral del impacto de la RA y la RV en el aprendizaje de las matemáticas. Los instrumentos iniciales fueron pruebas de rendimiento en matemáticas diseñadas a partir del plan de estudios oficial para el nivel educativo correspondiente. Las pruebas incluían ejercicios de cálculo, resolución de problemas, razonamiento lógico-matemático y comprensión de conceptos abstractos. Fueron desarrolladas por expertos en educación matemática. Las pruebas se administraron tanto antes como después de la intervención para medir los cambios a nivel individual y grupal, así como las diferencias entre los grupos experimental y de control.

Además de esto, se utilizaron cuestionarios estandarizados para evaluar variables como la motivación intrínseca para aprender matemáticas y la atención sostenida en las actividades. Los cuestionarios fueron administrados a los estudiantes por examinadores capacitados que parafrasearon los ítems y emplearon ejemplos concretos y ayudas visuales para facilitar la

comprensión de los estudiantes. Posteriormente, las respuestas a estos cuestionarios se contrastaron con el desempeño en la prueba de matemáticas para facilitar la delineación de correlaciones entre las variables de cambio cognitivo y las medidas de motivación y atención.

La observación sistemática ofreció una fuente secundaria de datos valiosos. Se utilizó la matriz de observación para registrar las características de comportamiento de los estudiantes durante las sesiones de aprendizaje. Los indicios observados fueron el tiempo dedicado a la tarea, el número de contribuciones espontáneas, la expresión de emociones, el nivel de interacción con los objetos virtuales y la reacción a la implementación de RA y RV.

Con el fin de obtener conocimientos pedagógicos enriquecidos desde una perspectiva cualitativa, se realizaron entrevistas semiestructuradas entre estudiantes, docentes y familias. El objetivo de las entrevistas era revelar actitudes sobre la utilidad de las herramientas tecnológicas, la percepción del cambio de actitud hacia las matemáticas, los desafíos durante la intervención y las recomendaciones de aplicación futura. Las entrevistas se grabaron en cinta y posteriormente se transcribieron y codificaron temáticamente utilizando el proceso de análisis cualitativo con el apoyo de un software especial (Atlas.ti).

El proyecto se llevó a cabo en tres fases fundamentales. La primera fase preparatoria consistió en la creación y modificación de contenidos matemáticos para entornos de RA y RV. Se utilizaron programas como CoSpaces Edu y Unity 3D para crear experiencias inmersivas y objetos interactivos en función del nivel de los estudiantes y las necesidades individuales de los estudiantes con TEA y TDAH. Se prestó especial atención a la sobrecarga sensorial de los entornos, evitando diseños que distrajeran y optando, en cambio, por una estética visual con imágenes y tonos relajantes que facilitaran la comprensión de los conceptos matemáticos. Al mismo tiempo, los docentes participantes recibieron una formación rigurosa tanto sobre el uso técnico de las herramientas como sobre las estrategias pedagógicas para incluir a los

estudiantes. Durante el período de intervención de ocho semanas, los estudiantes trabajaron en un horario semanal de 60 minutos.

Los participantes se dividieron en dos grupos: un grupo experimental expuesto a entornos de RA y RV, y un grupo de control que recibió instrucción tradicional basada en materiales impresos, explicaciones en la pizarra y presentaciones orales. Las sesiones se llevaron a cabo en aulas bien equipadas con los recursos tecnológicos necesarios, incluyendo cascos de RV, tabletas equipadas con software de RA, proyectores interactivos y ayudas visuales. Cada lección constaba de tres fases: presentación del contenido, práctica guiada que implicaba la manipulación virtual de objetos matemáticos y situaciones problemáticas, y una fase final centrada en la revisión y la reflexión. La presencia de un profesor de apoyo especializado permitió responder de forma inmediata a las necesidades individuales de los estudiantes, garantizando niveles adecuados de accesibilidad y participación cognitiva. Los instrumentos de evaluación mencionados anteriormente se aplicaron tanto al grupo experimental como al de control al final de la intervención.

El análisis estadístico de los datos cuantitativos recopilados se llevó a cabo mediante pruebas *t* para muestras independientes y relacionadas, así como mediante un análisis de varianza (ANOVA), con el fin de comparar las diferencias significativas entre los grupos y dentro de cada condición. Se gestionaron los errores de tipo I y de tipo II, y se calcularon los tamaños del efecto para proporcionar una estimación de la magnitud de las diferencias identificadas. Paralelamente, se realizó un análisis cualitativo mediante un proceso de codificación abierta, agrupación axial e identificación de temas recurrentes. A través del análisis, se identificaron tendencias significativas en las percepciones de los participantes. Desde el punto de vista ético, se actuó con la debida diligencia para proteger los derechos de los niños participantes. También se solicitó por escrito el permiso de sus padres o tutores en cuanto al propósito, los procedimientos empleados y los riesgos potenciales de esta investigación. Lo mismo se leyó en voz alta a los estudiantes, de quienes se obtuvo el consentimiento verbal. La confidencialidad de los datos se protegió mediante codificación alfanumérica y almacenamiento seguro bajo llave.

3. Resultados

Los resultados cuantitativos de las pruebas de rendimiento en matemáticas realizadas antes y después de la intervención fueron relevantes, ya que tendieron a mostrar un mejor rendimiento entre los estudiantes que habían tomado las sesiones de RA y RV. Los resultados de las pruebas de cálculo y resolución de problemas, tras un análisis minucioso, mostraron un aumento del 25 % en las puntuaciones promedio entre los estudiantes del grupo experimental, en comparación con un mero aumento del 5 % entre el grupo de control. Esta diferencia significa que las tecnologías inmersivas no solo aumentan el rendimiento en el aprendizaje, sino que también permiten comprender mejor los conceptos matemáticos al exponerlos a los estudiantes de forma visual y dinámica. Vale la pena mencionar

aquí que las pruebas de resolución de problemas identificaron un aumento de hasta el 22 % en el grupo experimental, en comparación con solo el 3 % en el grupo de control, lo que pone de manifiesto que las tecnologías inmersivas proporcionan una plataforma increíblemente potente para desarrollar habilidades cognitivas de orden superior.

Los participantes también tuvieron una mejora media del 30 % en su puntuación general en la evaluación posterior a la intervención, lo que indica que las tecnologías inmersivas desempeñan un papel importante en la mejora de la atención, la motivación y la capacidad para realizar tareas académicas. El TDAH se caracteriza por la falta de concentración, la impulsividad y la

incapacidad para mantener la atención durante períodos prolongados en tareas poco interesantes o con una estructura estereotipada. Sin embargo, los alumnos que asistieron a clases de RA y RV experimentaron una mejora considerable en su rendimiento, no solo en los exámenes, sino también en su comportamiento en el aula.

Los informes de los maestros indicaron que los estudiantes con TDAH mostraron una reducción drástica en el comportamiento de distracción hacia la actividad matemática. Los maestros afirmaron que los estudiantes se mantenían en la tarea por más tiempo y eran más resistentes, incluso después de tener que resolver problemas matemáticos muy desafiantes. Esa persistencia e interés se tradujeron incluso en los cuestionarios de motivación, ya que los niños con TDAH tuvieron una mejora del 30 % en la motivación natural para realizar actividades matemáticas, frente a un insignificante 5 % del grupo de control.

También se observó una mayor atención sostenida según los resultados del cuestionario de atención. Los estudiantes con TDAH que participaron en las sesiones de RA y RV mejoraron en un 25 % su capacidad para mantener la atención en las actividades matemáticas. Esto demuestra que las tecnologías inmersivas no solo captan la atención de los estudiantes con TDAH, sino que también ofrecen un entorno en el que pueden controlar mejor su atención, lo que se traduce en mejoras en el aprendizaje.

Aunque los estudiantes con TEA también mostraron mejoras en el rendimiento matemático tras la intervención, estas fueron menores que en el grupo con TDAH. Los estudiantes con TEA demostraron mejoras del 18 % en los cálculos realizados en las pruebas y del 15 % en la resolución de problemas. Estos resultados sugieren que, aunque las condiciones inmersivas fueron útiles en este grupo, las mejoras no fueron tan grandes como las del grupo con TDAH. Esto puede estar relacionado con las características distintivas del TEA, es decir, la dificultad en la interacción social, la dificultad en la comunicación y las sensibilidades sensoriales. Los estudiantes con TEA pueden experimentar dificultades

para procesar de manera eficiente los estímulos visuales y auditivos, lo que podría haber influido en su interacción con las tecnologías inmersivas. A pesar de ello, los docentes informaron que los estudiantes con TEA eran más propensos a interactuar con las matemáticas cuando estas se presentaban de forma visualmente estimulante e interactiva. Esto puede interpretarse en el sentido de que las tecnologías virtuales tienen la capacidad de atraer a los estudiantes con TEA porque ofrecen una vía de acceso menos exigente a los conceptos matemáticos. No obstante, los maestros descubrieron que era necesario adaptar la tarea de manera individualizada para satisfacer los requisitos sensoriales y cognitivos de estos estudiantes, lo que significa que adaptar la tecnología virtual a las características únicas de cada estudiante es de suma importancia.

Los padres de los estudiantes con TEA también afirmaron que las diferencias académicas en esta población no eran tan evidentes como en los estudiantes diagnosticados con TDAH, pero que a los niños les gustaban más las matemáticas. Los padres también ofrecieron observaciones adicionales sobre los niños con TEA, señalando que se sentaban en las aulas con mayor frecuencia y se mantenían concentrados en la tarea sin necesidad de que los adultos les dieran indicaciones, lo cual era un gran logro en lo que respecta a la motivación y la atención.

Además de los resultados de las pruebas de rendimiento en matemáticas, los cuestionarios de motivación y atención previos y posteriores a la intervención también fueron útiles para determinar cómo las tecnologías inmersivas influyen en la motivación y la concentración de los estudiantes. Los resultados indicaron que el aprendizaje con actividades de RA y RV tuvo un impacto positivo en la motivación de los estudiantes, especialmente en el grupo con TDAH. La motivación intrínseca, medida con una escala de interés en las actividades matemáticas, aumentó considerablemente en un 30 % entre los estudiantes del grupo experimental. El grupo de control, sin embargo, mostró un aumento mucho menor, del 5 %.

En cuanto a la atención sostenida, los resultados también fueron positivos para los estudiantes del grupo experimental. Los estudiantes con TDAH mejoraron su concentración en las tareas de matemáticas en un 25 %, según lo indicado por la puntuación en el cuestionario de atención sostenida. El grupo de control mejoró solo en un 5 %.

La observación sistemática durante las sesiones replicó los resultados de los cuestionarios y el rendimiento en las pruebas. Los estudiantes del grupo experimental se mostraron participativos y activos a lo largo de la actividad, ya que el 80 % de ellos fue capaz de completar el trabajo que se les había asignado, en comparación con el mero 50 % del grupo de control.

4. Conclusiones

En general, a partir de esta investigación se puede afirmar que las tecnologías inmersivas son un nuevo instrumento para la enseñanza de las matemáticas a niños con necesidades educativas especiales, especialmente aquellos con Trastorno del Espectro Autista (TEA) y Trastorno por Déficit de Atención e Hiperactividad (TDAH). La evidencia indica que los entornos inmersivos proporcionan un medio tangible e interactivo de los conceptos matemáticos al transformar las abstracciones en conceptos interactivos y basados en los sentidos. Esto concuerda con la teoría cognitiva contemporánea del aprendizaje incorporado, según la cual las interacciones corporales con objetos virtuales potencian la comprensión conceptual y la recuperación de la memoria (Pouw et al., 2024). En el caso de las personas con TDAH, cuya cognición se caracteriza por una atención sostenida y una persistencia en las tareas por debajo de lo óptimo, la naturaleza interactiva y atractiva de la Realidad Aumentada (RA) y la Realidad Virtual (RV) supera la distracción al proporcionar retroalimentación simultánea y desafíos regulados dinámicamente que mantienen el compromiso. De manera similar, para los estudiantes con TEA, que probablemente tienen fortalezas en el procesamiento visual y dificultades en el procesamiento simbólico abstracto, estas tecnologías ofrecen experiencias de aprendizaje estructuradas, predecibles y visualmente enriquecidas, más alineadas con sus perfiles cognitivos (Mintz et al., 2024).

Se observaron los máximos beneficios en los estudiantes con TDAH, quienes demostraron

una notable mejora en el rendimiento académico, la gestión de tareas y la atención. Esto se ve respaldado por evidencia neurocientífica reciente que ha demostrado que los entornos de aprendizaje gamificados e interactivos inducen la liberación de dopamina, que es un mediador central del aprendizaje basado en recompensas y la función ejecutiva en el TDAH (Volpe et al., 2024). El aumento del 30 % en la motivación intrínseca entre el grupo experimental indica el potencial de la RA y la RV para convertir las matemáticas en una tarea atractiva en lugar de tediosa y, por lo tanto, permitir un aprendizaje más profundo y sostenido. Además, la flexibilidad de estas tecnologías permite el ajuste en tiempo real de la dificultad de las tareas y la estimulación sensorial, un componente crítico para garantizar la máxima carga cognitiva y evitar la frustración, una preocupación significativa en los desafíos académicos relacionados con el TDAH (Shaw et al., 2024).

En el caso de los estudiantes con TEA, aunque se observaron mejoras en las habilidades matemáticas, estos avances fueron relativamente modestos en comparación con los de los estudiantes con TDAH. Concretamente, las habilidades de resolución de problemas y de cálculo aumentaron un 15 % y un 18 %, respectivamente. Estos hallazgos sugieren que, si bien las tecnologías inmersivas muestran un potencial considerable, ciertas características relacionadas con el TEA —como la hipersensibilidad sensorial, la inflexibilidad cognitiva o las dificultades con las tareas abiertas— pueden limitar su impacto.

Los docentes que participaron en el estudio hicieron hincapié de manera sistemática en la necesidad de una mayor individualización, incluyendo ajustes sensoriales adaptativos (por ejemplo, reducción del deslumbramiento visual y moderación de los estímulos auditivos) y el uso de narrativas sociales para facilitar la interacción con objetos virtuales. Los resultados ponen de relieve una limitación importante en el diseño actual de la RA/RV: la mayoría de las plataformas existentes no están lo suficientemente adaptadas para dar cabida a la diversidad de perfiles sensoriales y cognitivos dentro de la población con TEA (Fletcher-Watson et al., 2024). Los desarrollos futuros deberían priorizar diseños modulares y personalizables, que permitan a los docentes ajustar variables como el ritmo, la complejidad visual y las exigencias sociales para satisfacer las necesidades específicas de cada alumno.

Las limitaciones del estudio deben interpretarse con cautela. El pequeño tamaño de la muestra, aunque común en los primeros estudios con grupos neurodiversos, restringe la generalización. Además, sin datos longitudinales, uno no puede evitar preguntarse si los beneficios se mantienen. ¿Continúan los estudiantes con sus avances matemáticos después de unos meses o años? ¿Retienen las tecnologías inmersivas cada vez más conceptos, como el pensamiento algebraico o la demostración geométrica? Para responder a estas preguntas, se requiere una investigación longitudinal a largo plazo sobre el rendimiento matemático, combinada con evaluaciones neurocognitivas, como la memoria de trabajo o el control atencional (Giofrè et al., 2024). Una segunda limitación es el enfoque exclusivo en el aprendizaje aislado de una sola tarea matemática y no en planes de estudio integrados. El trabajo futuro debe examinar el uso real en el aula de las herramientas de RA/RV, donde existen distracciones, interacción social y otras exigencias académicas.

Para avanzar en este campo, se requieren varias vías diferentes. En primer lugar, deben realizarse ensayos controlados aleatorios (ECA) con muestras grandes y estratificadas, con controles de factores como la gravedad del TEA, el subtipo de TDAH (p. ej., inatento frente a hiperactivo-

impulsivo) y comorbilidades (p. ej., ansiedad o discalculia), para garantizar la reproducibilidad y determinar el subgrupo de máximo beneficio (Torgerson et al., 2024). En segundo lugar, la creación de sistemas inmersivos «inteligentes» impulsados por la inteligencia artificial (IA) podría revolucionar la personalización. Tomemos, por ejemplo, un sistema dinámico y adaptativo de problemas matemáticos en RV ajustado a los patrones de mirada del estudiante (confuso o interesado) o un adaptador de paleta de colores en RA ajustado a medidas fisiológicas de ansiedad (variabilidad de la frecuencia cardíaca). Ambos tipos de tecnologías aprovecharían los beneficios de la inmersión, así como los paradigmas de precisión en el aprendizaje (Luckin et al., 2024).

La segunda línea de pensamiento atractiva consiste en combinar la tecnología inmersiva con intervenciones conductuales basadas en la evidencia. Para el TDAH, la combinación de entornos matemáticos de RV con estrategias cognitivo-conductuales (por ejemplo, avatares de autocontrol o recordatorios de atención plena dentro de la RV) podría mejorar la autorregulación. En el caso del TEA, la combinación de componentes de aprendizaje socioemocional (SEL), como compañeros virtuales que modelan la resolución colaborativa de problemas, podría abordar simultáneamente los objetivos matemáticos y de comunicación social (Parsons et al., 2024). Este doble enfoque es importante, ya que el rendimiento de un estudiante neurodiverso generalmente depende de abordar requisitos de desarrollo más generalizados más allá de la adquisición de habilidades específicas de la materia.

Las consideraciones éticas y pragmáticas también guiarán el trabajo futuro. Se debe analizar el riesgo de dar demasiada importancia a la tecnología a expensas de la interacción entre personas o del aprendizaje experiencial. Del mismo modo, la desigualdad en el acceso es un problema persistente: el software de RA/RV de alta fidelidad debe ejecutarse con hardware costoso (por ejemplo, cascos, sensores de movimiento), lo que solo puede servir para perpetuar las desigualdades educativas. Las aplicaciones para teléfonos inteligentes que emplean RA y plataformas de código abierto

tienen el potencial de nivelar el campo de juego, pero es necesario evaluar su desempeño en relación con los sistemas de alta fidelidad (Selwyn et al., 2024). Además, la preparación de los docentes es imperativa; los docentes

deben estar preparados no solo para emplear estas tecnologías, sino también para descifrar los abundantes datos que estas generan (por ejemplo, patrones de error, tiempo dedicado a la tarea) de una manera que informe la instrucción.

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Impacto del microaprendizaje «Speaking Corners» en la confianza oral y la motivación de futuros profesores de inglés

Impact of the “Speaking Corners” microlearning on the oral confidence and motivation of future English teachers

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Impacto de la realidad aumentada y la realidad virtual en el aprendizaje matemático de los estudiantes con TEA y TDAH

Impact of augmented reality and virtual reality on mathematical learning in students with ASD and ADHD

Resumen:

Este estudio exploró los efectos de una intervención de microaprendizaje Speaking Corners para comprender en profundidad la confianza oral y la motivación de los profesores de inglés como lengua extranjera en formación mientras se preparaban para realizar el examen B2 First. Se empleó un diseño de métodos mixtos, que consistió en una encuesta cuasi-experimental previa y posterior a la prueba con un análisis temático de las respuestas cualitativas. Los participantes eran estudiantes de sexto semestre matriculados en tres clases universitarias de Pedagogía de Lenguas Nacionales y Extranjeras (PINE) en Ecuador. Cuantitativamente, la confianza mejoró en las tres clases y el conocimiento de la estructura del examen aumentó en dos de ellas. La utilidad percibida del microaprendizaje aumentó notablemente en una clase. Los resultados cualitativos mostraron que los participantes pasaron de tener una comprensión vaga a una comprensión clara, utilizaron más estrategias de examen, se sintieron menos ansiosos y estuvieron más motivados. Los resultados mostraron que las secuencias de microaprendizaje dirigidas por compañeros y respaldadas por recompensas son eficaces para mejorar la preparación para los exámenes y mantener el compromiso. La investigación demuestra un marco pedagógico práctico y rentable para la enseñanza del inglés como lengua extranjera de alto nivel, con ramificaciones para la formación del profesorado y la preparación de exámenes.

Palabras clave: Microaprendizaje, aprendizaje de una segunda lengua, comunicación oral, motivación, métodos de enseñanza.

Abstract:

This study explored the effects of a microlearning Speaking Corners intervention to understand deeply the oral confidence and motivation of pre-service EFL teachers while getting ready for taking the B2 First exam. A mixed-methods design was employed, consisting of a quasi-experimental pre-test-post-test survey with a thematic analysis of qualitative responses. The participants were sixth-semester students enrolled in three university classes of Pedagogy of National and Foreign Languages (PINE) major, in Ecuador. Quantitatively, confidence improved across all three classes, and knowledge of exam structure rose in two classes. Perceived usefulness of microlearning increased notably in one class. Qualitative results showed that participants went from having a vague understanding to a clear understanding, used exam strategies more, felt less anxious, and were more motivated. The findings showed that peer-led and reward-supported microlearning sequences are effective in improving exam preparedness and maintaining engagement. The research proves a practical and cost-effective pedagogical framework for high-stakes EFL speaking instruction, with ramifications for teacher education and exam preparation settings.

Keywords: Microlearning, second language learning, oral communication, motivation, teaching methods.

1. Introducción

El microaprendizaje ha surgido como una potente estrategia pedagógica en los contextos de inglés como lengua extranjera (EFL) y de adquisición de una segunda lengua, debido a la entrega de «cápsulas» de contenido focalizado que reducen las exigencias cognitivas excesivas de los estudiantes. Según la teoría de la carga cognitiva, esta segmentación libera recursos de la memoria de trabajo para el procesamiento relevante; en consecuencia, a los alumnos les resulta más fácil interiorizar estructuras lingüísticas complejas (Susilana et al., 2022). La investigación realizada por Sweller (2008) respalda esta teoría al destacar que la sobrecarga cognitiva puede dificultar el aprendizaje, mientras que una enseñanza diseñada adecuadamente puede ayudar a optimizar los recursos cognitivos, lo que en última instancia conduce a una mejor retención y comprensión del material educativo.

Los profesores de inglés en formación suelen manifestar incertidumbre sobre los requisitos de las tareas del examen oral, un repertorio estratégico limitado bajo presión de tiempo y poca confianza a la hora de trasladar la expresión oral del aula a condiciones similares a las del examen. La ansiedad ante la expresión oral y los exámenes sigue siendo una barrera importante para el rendimiento en el aprendizaje de idiomas adicionales, y recientes trabajos metaanalíticos confirman la relación negativa entre la ansiedad y el rendimiento (Chen, 2025). Dado que el examen oral Cambridge B2 First especifica formatos de tareas y criterios analíticos fijos, familiarizarse explícitamente con estas exigencias es un objetivo preparatorio razonable (Cambridge English, 2025). Además, la práctica en pequeñas dosis y rica en retroalimentación es defendible: las comparaciones cuasi experimentales entre la retroalimentación inmediata y la diferida muestran ventajas en cuanto al compromiso, la disposición a participar y los resultados en comparación con condiciones sin retroalimentación (Mai, 2025; Qun, 2025). Por último, revisiones recientes indican que los formatos de microaprendizaje pueden mejorar los resultados en la expresión oral en inglés en contextos de educación superior,

lo que respalda tareas breves y específicas como los «Speaking Corners» (Monib et al., 2025; Prasittichok y Smithsarakarn, 2024).

Además, como afirma Fitria (2022), las aplicaciones recientes que se centran únicamente en puntos gramaticales críticos, elementos de vocabulario y estrategias para realizar exámenes han demostrado la capacidad del microaprendizaje para optimizar el tiempo de estudio y evitar abrumar a los alumnos. Este enfoque centrado coincide con las conclusiones de Sathiyaseelan et al. (2024), quienes señalaron que los módulos de microaprendizaje específicos mejoran el compromiso de los estudiantes y hacen que la adquisición del idioma sea más eficiente.

Asimismo, la incorporación de los principios del aprendizaje multimedia de Mayer, como la alineación de canales verbales y visuales coherentes y la segmentación del contenido en fragmentos manejables, permite mejorar la comprensión y la retención de los alumnos (Nie, 2023). Esta alineación también está respaldada por estudios que demuestran que los elementos multimedia pueden mejorar significativamente el rendimiento del aprendizaje en diversos contextos educativos (Zhu et al., 2020). En conjunto, estas consideraciones de diseño tienen por objeto garantizar que los módulos de microaprendizaje se ajusten a las limitaciones cognitivas, al tiempo que fomentan entornos de aprendizaje flexibles en los que los alumnos puedan estudiar y revisar el material a su propio ritmo.

Como complemento de las estrategias cognitivas, cabe mencionar que la dinámica motivacional también desempeña un papel fundamental en la eficacia del microaprendizaje. Basándose en la teoría de la autodeterminación (SDT), Laksanasut (2025) ha demostrado que los módulos de microaprendizaje que apoyan la autonomía, la competencia y la relación aumentan significativamente la motivación intrínseca. El impacto de la autonomía en la motivación ha sido ampliamente documentado en diversos entornos educativos, lo que indica que, cuando los

estudiantes sienten que controlan su aprendizaje, son más propensos a comprometerse y persistir (Ryan y Deci, 2000).

Por consiguiente, en la práctica, la inclusión de mecánicas de juego como los sistemas de puntos, los bucles de retroalimentación inmediata y las recompensas con insignias funciona tanto como refuerzo conductista como promotor de la participación sostenida (Gorham et al., 2023; Laksanasut, 2025). La investigación de Qudsi (2024) respalda esta idea al mostrar que los elementos gamificados en las herramientas educativas mejoran significativamente la motivación y el compromiso de los alumnos. Esto permite suponer que las tareas simuladas del Cambridge B2 First, antes conocido como First Certificate in English (FCE), dentro de estas cápsulas no solo fomentan la sensación de dominio, sino que, según Barus y Bontisesari (2023), también refuerzan la comprensión de los alumnos a través de experiencias compartidas de desafío.

En relación con esto, otra ventaja clave del microaprendizaje es su capacidad para aumentar la familiaridad con los formatos de los exámenes y reducir sus efectos negativos. Al utilizar sesiones diseñadas en torno a consignas al estilo del B2 First con retroalimentación instantánea, los alumnos pueden comprender mejor la estructura del examen, reducir su ansiedad y familiarizarse con las pruebas, lo que se traduce en una mejora notable del rendimiento (Sankaranarayanan et al., 2023). Esta reducción de la ansiedad ante los exámenes es especialmente relevante, ya que los estudios han demostrado que un mayor nivel de ansiedad puede afectar negativamente al rendimiento, impidiendo que los alumnos demuestren sus verdaderas capacidades (Myers et al., 2021). Gagné y Casademont (2024) destacan que, al centrarse en la conciencia metalingüística y la práctica reflexiva, estos módulos ayudan a los alumnos a reconocer y corregir sus propios errores, lo que se traduce en respuestas orales más precisas y fluidas.

Del mismo modo, Prasittichok y Smithsarakarn (2024) enfatizan que proporcionar un andamiaje explícito dentro de estas cápsulas de microaprendizaje mantiene a los alumnos

activamente comprometidos. Dicho andamiaje es crucial, ya que la zona de desarrollo próximo de Vygotsky sugiere que los alumnos logran una mayor comprensión con el apoyo adecuado (Gauvain, 2008). Todo ello puede guiarlos para producir respuestas de mayor calidad, acordes con lo que se espera en un examen oral de B2 First.

Por último, la accesibilidad bajo demanda del microaprendizaje a través de plataformas móviles se adapta a diversos ritmos de estudio y aprovecha la repetición espaciada, lo que puede ser clave para garantizar la retención a largo plazo (Zamata-Aguirre et al., 2023). Por eso, Luo (2022) afirma que este modelo, disponible en cualquier momento y lugar, permite a los estudiantes reforzar sus habilidades precisamente cuando lo necesitan, lo que subraya la relevancia del microaprendizaje en los entornos educativos actuales, caracterizados por su rapidez. Además, Viberg et al. (2020) destacaron las estrategias asistidas por la tecnología destinadas a promover el aprendizaje autorregulado entre los estudiantes de idiomas, posicionando el microaprendizaje móvil como una herramienta eficaz para desarrollar habilidades lingüísticas esenciales. El marco conceptual que proporcionaron sugiere que el aprendizaje móvil puede mejorar eficazmente la autorregulación de los estudiantes, lo cual es crucial en los contextos de adquisición de idiomas.

Al combinar estos aspectos cognitivos, motivacionales y prácticos, una intervención de microaprendizaje denominada «Speaking Corners» (rincones de conversación), que ofrece recompensas inmediatas y una puesta en escena al estilo del examen B2 First, propone un enfoque con base teórica para mejorar el rendimiento, la confianza y la participación de los estudiantes de inglés como lengua extranjera.

Los profesores de inglés en formación de nuestro entorno manifiestan poca confianza en los exámenes orales, un conocimiento limitado de los formatos de las tareas y los criterios de evaluación del B2 First, y una asimilación desigual de las estrategias específicas para cada tarea, factores que socavan la preparación para el examen. Los cursos locales hacen hincapié en la fluidez

oral general, pero ofrecen una práctica limitada y restringida en el tiempo, bajo condiciones semejantes a las del examen. Dado que se ha demostrado que la práctica breve, centrada y rica en retroalimentación puede reducir la carga cognitiva y la ansiedad, al tiempo que mejora el uso de estrategias, se puso a prueba un enfoque de microaprendizaje denominado «Speaking Corners» para abordar estas barreras y examinar su impacto a corto plazo en las percepciones y la preparación para el examen.

En este estudio, exploramos cómo un enfoque de microaprendizaje basado en «Speaking Corners», con recompensas instantáneas y etapas al estilo del B2 First, influye en las habilidades orales, la confianza y la preparación para el examen de los estudiantes. Nuestro objetivo es mostrar cómo dividir la práctica en pasos pequeños, incorporar bucles de retroalimentación lúdicos y ofrecer acceso móvil en cualquier momento puede hacer que el aprendizaje de idiomas resulte más motivador y manejable. Al probar esta intervención en clases reales de inglés como

lengua extranjera en la universidad, buscamos demostrar su potencial como solución flexible y escalable que apoya tanto a los docentes como a los alumnos en diversos contextos.

Este estudio aborda el persistente reto que supone el rendimiento oral orientado a los exámenes entre los profesores de inglés en formación, incluyendo la baja confianza comunicativa, el conocimiento limitado de la estructura de los exámenes y la adopción irregular de estrategias eficaces para las tareas. El objetivo principal fue evaluar el impacto de la intervención de microaprendizaje «Speaking Corners» en la percepción de confianza, disfrute y utilidad de los estudiantes de sexto semestre de la carrera de Pedagogía de Lenguas Nacionales y Extranjeras. Utilizando un diseño pretest-postest complementado con un análisis temático de las respuestas abiertas, nos preguntamos: ¿Cómo influye la intervención «Speaking Corners» en la confianza oral, el disfrute y la utilidad percibida, y qué temas surgen en las reflexiones de los estudiantes sobre su experiencia en la preparación del examen?

2. Materiales y métodos

En esta sección se describe el marco metodológico utilizado para evaluar el impacto de la intervención pedagógica de los rincones de conversación en el rendimiento oral y las percepciones de los estudiantes universitarios en relación con el examen B2 First. Se describe el diseño general, la población participante, el entorno educativo y los procedimientos de intervención, así como los instrumentos empleados para la recopilación de datos y las técnicas analíticas aplicadas tanto a la vertiente cuantitativa como a la cualitativa. El objetivo es proporcionar transparencia en cuanto a los procesos seguidos y garantizar la replicabilidad de los resultados.

2.1. Diseño metodológico

Este estudio empleó un diseño de métodos mixtos que combina enfoques cuantitativos y cualitativos para examinar el impacto de la intervención pedagógica Speaking Corners en el

rendimiento oral del B2 First y las percepciones relacionadas de los estudiantes. El componente cuantitativo siguió un diseño cuasi-experimental de pretest/postest sin grupo de control, mientras que el componente cualitativo adoptó un enfoque de análisis temático para explorar en profundidad las experiencias de los estudiantes. Ambos componentes se integran durante la fase de interpretación para permitir la triangulación de los resultados.

2.2. Población y muestreo

La población estaba formada por estudiantes universitarios matriculados en el programa PINE de una universidad pública de Ecuador. Los participantes se distribuyeron en tres clases separadas (Clase 1, Clase 2 y Clase 3), todas ellas con un nivel de competencia B2.1 según el Marco Común Europeo de Referencia para las Lenguas (MCER).

Se utilizó un método de muestreo no probabilístico por conveniencia, ya que se invitó a participar a todos los estudiantes presentes en las clases objetivo durante el periodo de intervención. La muestra final incluyó a estudiantes de las Clases 1, 2 y 3, respectivamente, con datos coincidentes de las pruebas previas y posteriores.

Los estudiantes eran elegibles si estaban matriculados en el semestre objetivo, asistían a la intervención, daban su consentimiento informado y completaban cuestionarios previos y posteriores emparejados utilizando el mismo código anónimo; para la parte cualitativa, se requería al menos una respuesta abierta después de la intervención. Las puntuaciones de las subescalas se eliminaron antes del análisis cuando los registros mostraban discrepancias en los códigos, ausencias o bajas de los estudiantes. Por lo tanto, la muestra analítica final fue: Clase 1 = 18, Clase 2 = 15, Clase 3 = 18.

2.3. Entorno

La intervención se llevó a cabo durante el horario lectivo habitual en aulas universitarias equipadas con proyectores multimedia, pizarras blancas y pupitres móviles para facilitar las actividades en grupo. La actividad Speaking Corners se integró en el programa de estudios existente como parte del componente de desarrollo de la comunicación oral.

2.4. Intervención

La intervención Speaking Corners se diseñó para simular las condiciones del examen B2 First Speaking en un entorno colaborativo e interactivo. Cada clase participó en tareas de expresión oral estructuradas y alineadas con los formatos oficiales del examen, rotando por diferentes «rincones» que se centraban en diversas partes del examen. La intervención también incorporó principios de microaprendizaje, proporcionando segmentos instructivos breves y específicos seguidos de una práctica inmediata. No se utilizaron materiales comerciales ni específicos de ninguna marca; en su lugar, los investigadores crearon tareas y consignas que se ajustaban a los descriptores del MCER B2 y a las especificaciones del B2 First.

2.5. Instrumentos y mediciones

El instrumento cuantitativo fue un cuestionario ad hoc con escala Likert (1-5) que se administró antes y después de la intervención. Este instrumento fue creado por los investigadores y dos especialistas en inglés como lengua extranjera revisaron los ítems para garantizar su claridad y la adecuación de su contenido antes de su administración. Este instrumento midió cinco constructos:

1. Conocimiento de la estructura del examen (Conocer la estructura)
2. Confianza al hablar durante los exámenes (Confianza al hablar en los exámenes)
3. Utilidad percibida del microaprendizaje (Microaprendizaje)
4. Eficacia percibida del aprendizaje (aprendizaje eficaz)
5. Percepción de la inmediatez de los beneficios (recompensa inmediata)

Dado que los cinco resultados eran medidas Likert de un solo ítem, no se pueden aplicar coeficientes de consistencia interna (por ejemplo, α de Cronbach), ya que estos índices requieren múltiples ítems por constructo. Por lo tanto, todos los análisis inferenciales se centraron en pruebas no paramétricas adecuadas a la distribución del cambio previo y posterior y de las diferencias entre clases. Las respuestas se registraron de forma anónima, y los participantes utilizaron apodos únicos para permitir la correspondencia entre las pruebas previas y posteriores. Inicialmente, estos datos se organizaron y limpiaron utilizando Microsoft Excel y, posteriormente, se utilizó JASP v0.95.4.0 para la codificación.

El componente cualitativo se diseñó para captar las experiencias subjetivas de los estudiantes, los cambios percibidos en el aprendizaje y los mecanismos a través de los cuales la intervención de microaprendizaje influyó en su participación. Consistió en cuatro preguntas abiertas de retroalimentación antes de la intervención, que sirvieron como percepciones de referencia, y reflexiones inmediatas después de la intervención. Todas las respuestas se recopilaron mediante una encuesta digital y se exportaron a Microsoft Excel para su organización inicial y a Microsoft Word para su análisis temático manual.

2.6. Análisis de datos

Adoptamos un enfoque convergente de métodos mixtos para examinar los cambios y las experiencias de aprendizaje durante la intervención. Se utilizaron datos cuantitativos (ítems Likert previos y posteriores para cinco constructos en tres clases) para estimar el cambio dentro de la clase y el tamaño del efecto, mientras que los datos cualitativos (breves reflexiones abiertas/notas de enfoque) captaron las percepciones de los estudiantes sobre qué cambió, por qué y cómo las actividades apoyaron ese cambio. Ambas vertientes se analizaron por separado utilizando métodos adecuados a su naturaleza y luego se integraron para triangular los resultados y explicar los patrones observados en las cifras.

Procedimiento cuantitativo

Los datos se examinaron para verificar la integridad de los emparejamientos (coincidencia de ID), el rango válido (Likert 1-5) y los empates/ceros en las diferencias previas y posteriores. Para cada clase, resumimos las medianas [Q1, Q3] en Pre y Post y calculamos las puntuaciones de cambio ($\Delta = \text{Post} - \text{Pre}$) para la presentación de informes descriptivos. De manera inferencial, realizamos pruebas de rangos con signo de Wilcoxon (bilaterales) dentro de cada clase e informamos la estadística de la prueba (W), la p exacta y la correlación biserial de rangos emparejados (r_{rb}) como el tamaño del efecto. Dado que la prueba de Wilcoxon excluye las diferencias cero, n se refiere al número de pares distintos de cero utilizados en cada prueba. Los análisis se realizaron en Microsoft Excel y JASP v0.95.4.0.

Procedimiento cualitativo

Los datos cualitativos también se organizaron, limpiaron y visualizaron en Microsoft Excel; esta vez se clasificaron por preguntas en su conjunto para obtener una perspectiva diferente sobre la implementación de la estrategia. Los datos se codificaron manualmente con Microsoft Word y, posteriormente, los códigos y temas resultantes se cargaron en el sistema OpenAI a través de la interfaz ChatGPT 5o para triangular la interpretación con los datos obtenidos manualmente. Al final, se obtuvieron y analizaron cinco códigos, que se contrastaron con los resultados cuantitativos para identificar aspectos destacados significativos del estudio a partir de las respuestas de los estudiantes. Por último, se utilizó un análisis temático basado en un libro de códigos, de modo que las discrepancias se resolvieron mediante consenso negociado y la decisión de codificación se documentó en un registro de auditoría.

Por último, ambas líneas de análisis se diseñaron para abordar los mismos objetivos de investigación desde perspectivas complementarias. Los resultados cuantitativos proporcionaron cambios medibles en las percepciones de los alumnos antes y después de la intervención, mientras que los resultados cualitativos ofrecieron una visión más profunda de las experiencias de los estudiantes y los factores que influyen en su participación. En la siguiente sección se presentan estos resultados en una estructura integrada, comenzando por el análisis cuantitativo, seguido de los temas cualitativos y concluyendo con una síntesis que sirve de base para el debate.

3. Resultados

Esta sección presenta los resultados del estudio en dos partes. En primer lugar, se presentan los resultados cuantitativos derivados de los datos de las encuestas previas y posteriores a la intervención, destacando los cambios en las percepciones de los estudiantes sobre las tareas

breves y específicas, el aprendizaje dirigido por compañeros y la sensación de recompensa inmediata tras la actividad de preparación para el examen B2 First Speaking. Las figuras y tablas resumen los resultados estadísticos más relevantes para facilitar su interpretación.

La segunda parte de esta sección presenta los temas que surgen de las respuestas abiertas de los estudiantes, ilustrando cómo experimentaron e interpretaron el enfoque de microaprendizaje basado en el rincón de aprendizaje. Esta doble presentación tiene como objetivo proporcionar tanto una descripción cuantificable del cambio como una comprensión más rica y contextualizada del impacto de la intervención.

3.1. Resumen del análisis cuantitativo de los datos

El análisis cuantitativo se basó en tres conjuntos de datos emparejados correspondientes a la clase 1, la clase 2 y la clase 3. Cada clase completó una prueba previa y una prueba posterior que medían cinco constructos:

1. Conocer la estructura
2. Confianza al hablar en los exámenes
3. Microaprendizaje
4. Aprendizaje efectivo
5. Recompensa inmediata

Para cada clase, informamos la mediana [Q1, Q3] en Pre y Post, la mediana de Δ individual (Post – Pre) [Q1, Q3] y los resultados de Wilcoxon con rangos con signo (W, p exacto, correlación biserial de rangos emparejados r_{rb}). Dado que Wilcoxon excluye los empates, n denota los pares distintos de cero utilizados por la prueba. Los análisis se realizaron en Microsoft Excel y JASP v0.18.x; la redacción y el código se realizaron con la ayuda de ChatGPT-5o.

3.2. Resultados por clase

Tabla 1. Clase 1: Wilcoxon antes vs. después (medianas)
Fuente: Elaboración propia, 2026.

Variable	Pre Mediana [Q1,Q3]	Post Mediana [Q1,Q3]	Mediana Δ [Q1,Q3]	n	W	p (exacto)	r_{rb}
Conocimiento de la estructura	4,00 [3,00, 4,00]	4,50 [4,00, 5,00]	1,00 [0,00, 1,00]	12	0	.001	1,00
Seguridad al hablar en los exámenes	3,00 [3,00, 3,00]	4,00 [4,00, 4,00]	1,00 [0,00, 1,75]	12	0	.002	1,000
Microaprendizaje	4,00 [4,00, 5,00]	4,00 [4,00, 4,00]	0,00 [0,00, 0,00]	7	14	1,000	0,00
Recompensa inmediata	4,00 [3,00, 5,00]	4,00 [4,00, 4,75]	0,50 [0,00, 1,00]	12	18	0,078	0,538
Aprendizaje efectivo	5,00 [4,00, 5,00]	4,50 [4,00, 5,00]	0,00 [0,00, 0,00]	8	18	1,000	0,00

Resumen de la clase 1. Aumento del conocimiento de la estructura y la confianza (W = 0, p = 0,001 y p = 0,002; r_{rb} = 1,00). El microaprendizaje y el aprendizaje eficaz no mostraron cambios; la recompensa inmediata solo mostró una tendencia no significativa.

Tabla 2: Clase 2 — Wilcoxon antes y después (medianas)
Fuente: Elaboración propia, 2026.

Variable	Pre Mediana [Q1,Q3]	Mediana posterior [Q1,Q3]	Mediana Δ [Q1,Q3]	n	W	p (exacto)	r_{rb}
Estructura conocida	4,00 [4,00, 5,00]	5,00 [4,00, 5,00]	0,00 [0,00, 1,00]	6	3,5	.129	0,667
Seguridad al hablar en los exámenes	3,00 [2,00, 3,50]	4,00 [4,00, 4,00]	1,00 [0,00, 1,50]	10	0	.005	1,000
Microaprendizaje	4,00 [3,50, 5,00]	4,00 [4,00, 5,00]	0,00 [0,00, 1,00]	9	15	.390	0,333
Recompensa inmediata	4,00 [3,50, 5,00]	4,00 [4,00, 5,00]	0,00 [0,00, 0,50]	6	7	.520	0,333
Aprendizaje efectivo	5,00 [4,00, 5,00]	4,00 [4,00, 5,00]	0,00 [-0,50, 0,00]	7	15,5	.860	0,107

Class 2 summary. Only Confidence improved (W=0, p=.005; r_{rb} =1.00). The other constructs were not significant.

Tabla 3: Clase 3 — Wilcoxon antes y después (medianas)
Fuente: Elaboración propia, 2026.

Variable	Pre Mediana [Q1,Q3]	Mediana posterior [Q1, Q3]	Mediana Δ [Q1,Q3]	n	W	p (exact)	r_{rb}
Estructura conocida	4,00 [3,00, 4,00]	5,00 [4,00, 5,00]	1,00 [0,00, 2,00]	12	0	.002	1,000
Seguridad al hablar en los exámenes	3,00 [2,00, 3,75]	4,00 [4,00, 4,00]	1,00 [0,00, 1,75]	11	3,5	.009	0,894
Microaprendizaje	4,00 [4,00, 4,00]	4,50 [4,00, 5,00]	0,00 [0,00, 1,00]	9	4	.025	0,822
Recompensa inmediata	4,00 [4,00, 5,00]	4,50 [4,00, 5,00]	0,00 [0,00, 0,75]	9	18	.608	0,200
Aprendizaje efectivo	4,00 [3,00, 5,00]	5,00 [4,00, 5,00]	0,00 [0,00, 1,00]	10	8	.044	0,709

Resumen de la clase 3. Mejoraron el conocimiento de la estructura y la confianza (p = 0,002, p = 0,009), aumentó el microaprendizaje (p = 0,025) y el aprendizaje efectivo mostró una pequeña mejora (p = 0,044). La recompensa inmediata no cambió.

3.3. Tendencias generales

En todas las clases, las mejoras más consistentes se observaron en la confianza al hablar en los exámenes (significativa en las tres clases). El conocimiento de la estructura aumentó en la clase 1 y la clase 3, pero no en la clase 2, lo que indica heterogeneidad en la rapidez con la que se consolidó la comprensión del formato del examen. Las mejoras en el microaprendizaje se concentraron en la clase 3, mientras que el aprendizaje efectivo mostró una pequeña mejora localizada solo en esa clase. La recompensa inmediata se mantuvo alta con un cambio mínimo antes y después, en consonancia con un efecto techo.

En conjunto, los resultados no paramétricos indican avances significativos y específicos en línea con la intervención: los estudiantes informaron de manera consistente de una mayor confianza para hablar en condiciones de examen; el conocimiento de la estructura del examen aumentó en dos clases; y los avances en microaprendizaje/aprendizaje efectivo fueron más evidentes en la clase 3, donde los indicadores de fidelidad de implementación y compromiso fueron más altos. La estabilidad de la recompensa inmediata sugiere un techo en el aumento de la motivación percibida, lo que es coherente con las altas medianas previas.

En la siguiente sección se integrarán estos resultados cuantitativos con datos cualitativos, explorando cómo las percepciones y experiencias de los estudiantes se alinean con las tendencias numéricas observadas.

3.4. Resumen del análisis de datos cualitativos

Por otra parte, el análisis cualitativo se organizó por preguntas. Esto responde a la esencia de los instrumentos utilizados en el momento de la recopilación de datos y, dado que esto puede enriquecer los resultados de las respuestas recopiladas. Posteriormente, todo este conjunto de datos se trianguló para obtener una visión más amplia de los resultados.

Los códigos resultantes de este análisis fueron:

1. Conocimiento del examen
2. Estrategias y recursos
3. Conciencia del rendimiento
4. Preocupaciones y barreras
5. Factores motivacionales

Inicialmente, esto presenta un conjunto de códigos diferente al definido originalmente, por lo que es necesario realizar una triangulación adicional. No obstante, antes de cotejarlos con los datos cuantitativos,

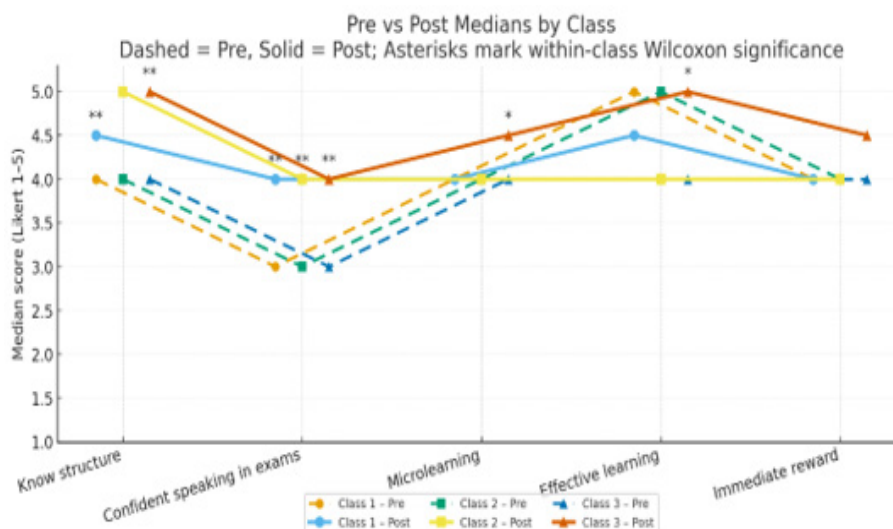


Figura 1: Vista agregada de los cambios medianos en todas las clases.

Fuente: Elaboración propia, 2026.

los investigadores analizaron los códigos obtenidos para obtener una visión más amplia de las conclusiones que los estudiantes pudieron haber extraído tras la intervención. El resultado fue la siguiente tabla, en la que se explican los códigos, el número de veces que los estudiantes mencionaron algo relacionado con ellos y el cambio que se evidencia según las respuestas que escribieron en la sección de preguntas abiertas.

La pregunta 1 corresponde a la pregunta número 1 de la encuesta, tanto en la prueba previa como en la posterior, y los números correspondientes a las siguientes preguntas. Los números que aparecen después de cada código son el número de veces que los estudiantes mencionaron la palabra, la frase representativa o las expresiones en sus respuestas.

3.5. Conocimiento del examen

En la prueba previa, muchos participantes tenían una idea superficial sobre la estructura del examen, limitando sus respuestas a «cuatro partes» o expresando literalmente su desconocimiento «en realidad, casi nada». Tras la intervención, las respuestas resultaron

ser más precisas, lo que reflejaba una clara comprensión de cada parte del examen. Un estudiante dijo: «La parte 2 consiste en comparar, no en describir», mientras que otro mencionó: «Aprendí cómo está estructurada cada parte del examen FCE B2 y consejos útiles sobre cómo responder». Este cambio en sus respuestas en la prueba posterior muestra cómo la intervención ayudó a los estudiantes a pasar de una idea vaga de la estructura del examen a un conocimiento más explícito de la misma.

3.6. Estrategias y recursos

Antes de la intervención, las referencias a las estrategias eran limitadas y genéricas, y solían centrarse en aspectos generales como la «fluidez» o la «interacción». Después de participar en la actividad Speaking Corners, los estudiantes comenzaron a destacar recursos lingüísticos específicos y expresiones útiles. Un estudiante respondió: «Tenemos que usar frases más avanzadas para demostrar que tenemos un nivel B2». Otros valoraron los consejos concisos, sencillos y fáciles de recordar: «Resume la idea de la forma más breve posible, manteniéndola breve y concisa». Estos comentarios reflejan un aumento significativo en la apropiación,

Tabla 4: Análisis cualitativo
Fuente: Elaboración propia, 2026.

Categoría	Prueba previa (Preguntas 1-3)	Prueba posterior (Preguntas 1-4)	Cambio
Conocimiento del examen	Conocimiento de la estructura: 24	Conocimiento de la estructura y las tareas: 29 (más detallado y preciso)	Evolución de una vaga descripción de «4 partes» a descripciones detalladas de cada tarea
Estrategias y recursos	Conocimiento de las tareas: 12	Frases y vocabulario útiles: 21 Estrategias/consejos: 20	Gran aumento en el uso de estrategias y vocabulario, vinculado al rendimiento en los exámenes
Conciencia del rendimiento	Enfoque de la evaluación (fluidez, vocabulario, interacción): 9	Confianza/fluidez: 3 Reflexión metacognitiva: 3	Nueva dimensión reflexiva (vinculación del aprendizaje con los errores/el progreso)
Preocupaciones y obstáculos	Estrategias/consejos: 6	Se han comunicado muy pocas preocupaciones	Cambio del enfoque en el miedo y la ansiedad → a una valoración positiva de las estrategias y la claridad
Factores motivacionales	Menciones sobre la confianza: 3	Disfrute y compromiso: 8 (P3), 20 (P4) Recompensas e incentivos: 21 (Q3) Conocimientos adquiridos/progreso: 13 (Q3), 15 (Q4) Aprendizaje entre compañeros/colaboración: 8 (Q2), 2 (Q4)	Aumento claro de la motivación intrínseca y extrínseca

por parte de los estudiantes, de herramientas prácticas para mejorar su rendimiento.

3.7. Conciencia del rendimiento

En la prueba previa, casi no se mencionó la confianza o la reflexión metacognitiva, sino que se mencionó el miedo a cometer errores y la frágil autoeficacia (véase Preocupaciones y barreras). Sin embargo, después de la intervención, algunos estudiantes comenzaron a relacionar su progreso con el reconocimiento de los errores y la percepción de la mejora personal. Un participante comentó: «... en comparación con el examen que tuve a mitad de semestre, ahora tengo una visión global de mis errores y de lo que puedo mejorar». Estas respuestas demuestran una conciencia emergente de sus propios procesos de aprendizaje y rendimiento.

3.8. Preocupaciones y barreras

Antes de la intervención, las preocupaciones se centraban principalmente en las barreras lingüísticas y afectivas. Los estudiantes expresaban con frecuencia su ansiedad: «Me pongo muy nervioso y tiendo a olvidar lo que sé, a veces palabras muy sencillas». Otros expresaban: «Para ser sincero, creo que si no te sientes cómodo contigo mismo durante el examen oral del FCE, puedes suspender». También les preocupaba la interacción y el tiempo: «Tengo algunas preocupaciones, como quedarme sin cosas que decir o titubear mientras hablo y que mis compañeros tarden demasiado». Por el contrario, en la prueba posterior, estas preocupaciones habían

desaparecido en gran medida, dando paso a valoraciones más positivas que se centraban en las estrategias aprendidas durante las actividades: «Sí, había motivación, ya que después de la presentación me sentí muy orgulloso de mí mismo, ya que pude comprender cómo funcionan las diferentes partes de la prueba, por lo que tengo una idea clara de cómo mejorar mi expresión oral». Otros mencionaron el aumento del nivel de confianza: «Fue gratificante aprender consejos útiles y ver mi progreso al hablar con más confianza».

3.9. Factores motivacionales

Si bien los aspectos motivacionales estaban casi ausentes en la prueba previa, la prueba posterior reveló que tanto la motivación intrínseca como la extrínseca estaban muy presentes después de la intervención. Los estudiantes destacaron las recompensas extrínsecas, como «los dulces» y «los premios eran buenos», y los motivadores intrínsecos relacionados con el aprendizaje y la colaboración: «Fue gratificante por los conocimientos que adquirí al hacer mi parte y los conocimientos presentados por mis compañeros de clase». También hicieron hincapié en el aprendizaje entre compañeros: «Cada uno era un experto en su presentación. Fueron capaces de explicar muy bien cada tema». La mayoría de los estudiantes expresaron una clara voluntad de repetir la experiencia: «Sí, me gustaría tener más lecciones como esta porque son interactivas, útiles y se centran en las habilidades reales para el examen».

3. Resultados

4.1. Qué indican los datos en relación con los objetivos

Los análisis no paramétricos dentro de la clase muestran un aumento constante de la confianza en las tres clases, junto con

mejoras en el conocimiento de la estructura en las clases 1 y 3. El microaprendizaje y el aprendizaje eficaz mejoraron principalmente en la clase 3, mientras que la recompensa inmediata se mantuvo alta con cambios mínimos, lo que sugiere un efecto techo.

Estos patrones reflejan los cambios medianos que se muestran en la figura 1 y los resultados de Wilcoxon en las tablas 1-3, lo que indica que la intervención mejoró de manera más sólida la preparación de los estudiantes para hablar en condiciones de examen y su comprensión del formato del examen, con mejoras adicionales específicas de cada clase en el aprendizaje orientado a la práctica.

Las reflexiones cualitativas coinciden con estos resultados. Los estudiantes describen una conciencia más clara de lo que requieren las tareas del examen (por ejemplo, «comparar, no describir» en la parte 2), un mayor uso de frases concisas de nivel B2 y consejos, y una mayor sensación de preparación a la hora de realizar las tareas de expresión oral. También atribuyen su progreso a actividades breves y específicas que podían aplicar de inmediato, en consonancia con el énfasis en el microaprendizaje, al tiempo que señalan que la motivación y la recompensa ya eran elevadas desde el principio. En conjunto, los avances cuantitativos y los relatos cualitativos cumplen los objetivos del estudio al evidenciar mejoras cuantificables en la confianza y el conocimiento de la estructura relevantes para el examen, y al explicar cómo la intervención apoyó esos cambios mediante una orientación práctica y específica.

4.2. Comparación con investigaciones anteriores

Los resultados también respaldan los principios de la teoría de la carga cognitiva. Los estudiantes describieron a menudo los Speaking Corners como «breves y agradables» o «menos abrumadores», lo que confirma la idea de que dividir las tareas en segmentos más pequeños reduce la carga innecesaria y permite que la memoria de trabajo se centre en el procesamiento esencial (Sweller, 2008; Susilana et al., 2022). Sus referencias a una mayor concentración, una comprensión más rápida y una mejor memoria reflejan estudios previos sobre microaprendizaje que demuestran cómo las

cápsulas de aprendizaje concisas aumentan el compromiso y la eficacia en la adquisición de idiomas (Fitria, 2022; Sathiyaseelan et al., 2024).

Además, la preferencia por una entrada multimodal breve seguida inmediatamente de la práctica refleja los principios del aprendizaje multimedia. Se ha demostrado que la separación y coordinación de los canales verbales y visuales, tal y como describe Mayer, mejora la comprensión y la retención (Nie, 2023; Zhu et al., 2020).

En este estudio, estas decisiones de diseño no solo favorecieron la participación general, sino que también prepararon a los estudiantes de forma más directa para las tareas del examen, ayudándoles a ser más estratégicos en su redacción, en las transiciones entre partes y en la forma de abordar los debates interactivos.

El formato dirigido por compañeros también se ajusta a las ideas socioculturales sobre cómo aprenden las personas. Los estudiantes consideran a sus compañeros como «expertos» que hacen que las estrategias sean memorables, lo que se ajusta a los principios de la mediación escalonada en la zona de desarrollo próximo (Gauvain, 2008) y se corrobora con los resultados de un compromiso sostenido cuando el microaprendizaje integra un andamiaje explícito (Prasittichok y Smithsarakarn, 2024). Además, el desarrollo de la conciencia del rendimiento (identificar errores y correlacionar estrategias con el progreso) se corresponde con la investigación sobre la autorregulación mejorada por la tecnología en entornos móviles y de microaprendizaje (Viberg et al., 2020; Luo, 2022; Zamata-Aguirre et al., 2023).

Por último, el perfil motivacional que surge tras la intervención, caracterizado por la satisfacción intrínseca (orgullo, progreso) y sutiles señales extrínsecas (fichas, reconocimiento), se ajusta a la SDT: el diseño promueve la autonomía (rincones dirigidos por los estudiantes), la

competencia (señales de éxito inmediatas) y la relación (colaboración entre compañeros) (Ryan y Deci, 2000; Laksanasut, 2025). Los informes que indican que los ciclos de recompensa cortos mantienen el compromiso concuerdan con investigaciones recientes sobre elementos gamificados en contextos educativos (Gorham et al., 2023; Qudsi, 2024). Estas comparaciones indican que la intervención concuerda teóricamente con la bibliografía comentada en la introducción.

4.3. Novedades de este estudio

El estudio demuestra que el microaprendizaje mapeado 1:1 a las partes de expresión oral del B2 First produce mejoras en la preparación específica para el examen, y no solo en el compromiso general, lo que amplía los resultados del microaprendizaje a un ámbito de alta exigencia y vinculado a tareas (Fitria, 2022; Sathiyaseelan et al., 2024; Nie, 2023; Zhu et al., 2020).

Asimismo, documentó cómo un microformato dirigido por compañeros funciona como un andamiaje distribuido, convirtiendo las exigencias del examen en estrategias y frases memorables y reutilizables, en consonancia con Gauvain (2008) y Prasittichok y Smithsarakarn (2024).

Además, caracteriza un doble cambio motivacional, orgullo intrínseco y progreso junto con incentivos extrínsecos mínimos, en consonancia con la SDT y de relevancia práctica para la preparación de exámenes de inglés como lengua extranjera de bajo costo y escalable (Ryan y Deci, 2000; Laksanasut, 2025; Gorham et al., 2023; Qudsi, 2024).

4.4. Anomalías y confianza desigual

Las diferentes clases tienen diferentes tasas de crecimiento de la confianza. Los datos sugieren que la confianza es un constructo que evoluciona gradualmente y que probablemente requiere ciclos adicionales y retroalimentación orientada al rendimiento

para consolidarse, mientras que los conocimientos y las estrategias experimentan cambios rápidos. La detectabilidad puede verse comprometida por muestras pequeñas y emparejadas, fluctuaciones en la dispersión de la línea de base y ajustes menores en la dosis o la cadencia (tiempo por esquina, composición del grupo). Este patrón concuerda con las investigaciones que indican que las mejoras en el conocimiento procedimental (por ejemplo, la familiaridad con las pruebas y la práctica reflexiva; Sankaranarayanan et al., 2023; Myers et al., 2021; Gagné y Casademont, 2024) a menudo superan los avances en el alivio de la ansiedad ante las pruebas y la estabilización de la confianza en uno mismo. Por último, el uso de indicadores de un solo ítem impidió el cálculo de las métricas de consistencia interna (α/ω). En futuros trabajos se deberían considerar subescalas de varios ítems para permitir la estimación de la fiabilidad y el modelado a nivel latente.

4.5. Implicaciones pedagógicas

Para la enseñanza del habla orientada a los exámenes, los datos respaldan la incorporación de «rincones» de microaprendizaje que:

- Aclaren los movimientos de cada parte (por ejemplo, «comparar» frente a «describir» en la parte 2) y proporcionen frases modelo B2 relacionadas con la rúbrica.
- Utilicen explicaciones entre compañeros para que las conversaciones sobre estrategias sean más habituales y se compartan formas útiles de expresarse.
- Ofrecen comentarios inmediatos sobre cada minitarea y una reflexión de 30 segundos para ayudar a los estudiantes a ser más conscientes de su rendimiento.
- Utilizar pequeñas recompensas para que las cosas avancen sin interferir en lo que los alumnos quieren hacer.
- Si se quiere fomentar la confianza, lo mejor es repetir los ciclos una y otra vez.

4.6. Requisitos para futuras investigaciones

Los estudios futuros deberían complementar los autoinformes con evaluaciones independientes del rendimiento (por ejemplo, rúbricas de tipo examinador para B2 First Speaking) para determinar si las mejoras perceptivas conducen a avances cuantificables en la competencia. Las comparaciones sistemáticas entre el microaprendizaje y la preparación tradicional aclararían las ventajas adicionales. Los diseños longitudinales pueden investigar el mantenimiento y la transferencia, mientras que los estudios de dosificación pueden evaluar la cantidad y la duración de las intervenciones necesarias para estabilizar la confianza. El uso de software especializado (como MAXQDA) con acuerdo entre codificadores puede hacer que el aspecto

cualitativo sea más fiable a la hora de relacionar la charla sobre estrategias con el rendimiento posterior.

4.7. Conclusión

En resumen, los datos indican que los Speaking Corners basados en el microaprendizaje aclaran las exigencias del examen, comprimen la adquisición de estrategias y estimulan la motivación en la preparación del examen B2 First Speaking. El enfoque es viable y escalable en contextos de formación del profesorado; con ciclos repetidos y comentarios centrados en el rendimiento, tiene un gran potencial para transformar las ganancias perceptivas en mejoras sólidas y demostrables en el rendimiento oral.

5. Conclusiones

Este estudio logró sus objetivos al demostrar que una intervención de microaprendizaje Speaking Corners, basada en marcos teóricos establecidos, mejoró la preparación para el examen, la motivación y la utilización estratégica de los alumnos. La integración de la teoría de la carga cognitiva, el aprendizaje multimedia, la teoría de la autodeterminación y los principios de andamiaje creó un marco sólido para diseñar tareas breves, centradas y atractivas que mejoraron la comprensión y el rendimiento. Los resultados cuantitativos demostraron una notable mejora en la comprensión de los alumnos de la estructura del examen y sus actitudes hacia el microaprendizaje. Los resultados cualitativos indicaron que los alumnos pasaron de una comprensión difusa de la materia a una comprensión más explícita, utilizando estrategias específicas y demostrando una mayor motivación para aprender.

Se trata de un proyecto novedoso porque utiliza el microaprendizaje para ayudar a

los estudiantes a prepararse para el examen B2 First Speaking, ya que demuestra que los formatos segmentados, dirigidos por compañeros y basados en recompensas pueden ayudarles a prepararse para determinadas tareas. Esta contribución mejora la investigación actual al esclarecer los mecanismos mediante los cuales el andamiaje distribuido y el refuerzo inmediato cultivan la competencia estratégica y el compromiso sostenido en contextos de EFL orientados a los exámenes.

Los resultados tienen importantes repercusiones en el ámbito, ya que ilustran una metodología escalable y económica para las iniciativas de formación del profesorado y los cursos de preparación de exámenes. Las investigaciones futuras deberían incluir métricas de rendimiento independientes para validar las mejoras perceptivas, así como metodologías longitudinales y comparativas para evaluar la sostenibilidad, la transferibilidad y las ventajas relativas del microaprendizaje en comparación con

los métodos de preparación tradicionales. El modelo Speaking Corners es una forma buena y teóricamente sólida de enseñar

la expresión oral de alto nivel y realizar investigaciones en inglés como lengua extranjera.

6. Recomendaciones

Aunque no es obligatorio, es recomendable que las investigaciones futuras incluyan evaluaciones del rendimiento basadas en examinadores para determinar si las mejoras perceptivas se traducen en una competencia medible. Los diseños longitudinales podrían aclarar aún más la durabilidad de los beneficios motivacionales y estratégicos, así como su transferencia a otros contextos de alto riesgo. Los estudios comparativos

con métodos de preparación tradicionales ayudarían a establecer la eficacia y eficiencia relativas de las intervenciones de microaprendizaje, mientras que se recomienda el uso de software cualitativo con acuerdo entre codificadores para mejorar la fiabilidad del análisis temático y profundizar en la conexión entre el uso de estrategias y el rendimiento.

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Efecto del aprendizaje interactivo basado en escenarios sobre el conocimiento, la autoeficacia y la competencia en el traspaso clínico entre estudiantes de enfermería

Effect of Scenario Based Interactive Learning on Knowledge, Self Efficacy and Competency on Clinical Handover Among Student Nurses

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Effect of Scenario Based Interactive Learning on Knowledge, Self Efficacy and Competency on Clinical Handover Among Student Nurses

Resumen:

El traspaso clínico es fundamental para la atención del paciente. Este estudio examinó la efectividad del aprendizaje interactivo basado en escenarios para mejorar el conocimiento, la autoeficacia y la competencia de los estudiantes de enfermería en el traspaso clínico. Se llevó a cabo un diseño experimental verdadero entre 80 estudiantes de enfermería de último año, quienes fueron asignados aleatoriamente en dos grupos. El grupo experimental recibió una clase magistral seguida de aprendizaje basado en escenarios y una sesión de debriefing, mientras que el grupo de control recibió solo una clase magistral. Se utilizaron instrumentos validados para medir la competencia, la autoeficacia y el conocimiento. Se emplearon estadísticas descriptivas, pruebas t pareadas e independientes, ANCOVA y correlación de Pearson para analizar los datos. Los resultados mostraron que el conocimiento y la competencia del grupo experimental mejoraron significativamente en comparación con el grupo de control ($p < 0.001$). Los niveles de autoeficacia aumentaron dentro de los grupos, pero después de controlar los valores basales, no se observó una diferencia significativa entre los grupos. El conocimiento y la competencia ($r = 0.476$) y el conocimiento y la autoeficacia ($r =$

Abstract:

Clinical handover is vital for patient care. This study examined the effectiveness of scenario-based interactive learning in improving student nurses' knowledge, self-efficacy, and competency in handover. A true experimental design was conducted among 80 final-year nursing students who were randomly divided into two groups. The experimental group received a lecture followed by scenario-based learning and debriefing, whereas the control group received only a lecture. Validated tools were used to measure competency, self-efficacy, and knowledge. Descriptive statistics, paired and independent t-tests, ANCOVA, and Pearson correlation were used to analyze the data. The experimental group's knowledge and competency significantly improved compared to the control group ($p < 0.001$). Self-efficacy levels increased within groups, but after controlling for baseline values, there was no discernible difference across the groups. Knowledge and competency ($r = 0.476$) and knowledge and self-efficacy ($r = 0.362$) showed positive associations. Scenario-based interactive learning improved clinical handover knowledge and proficiency in student nurses, which may also contribute to

0.362) mostraron asociaciones. El aprendizaje interactivo basado en escenarios es un método de enseñanza eficaz para mejorar el conocimiento y la competencia de los estudiantes de enfermería en el traspaso clínico, lo que también puede contribuir a mejorar la seguridad del paciente y los procesos de comunicación.

Palabras clave: ISBAR, traspaso de enfermería, transferencia de información clínica, aprendizaje simulado, basado en escenarios.

enhancing patient safety and communication processes.

Keywords: ISBAR, nursing handover, handoff, simulated learning, scenario-based interactive learning.

1. Introducción

El traspaso clínico se define como «el intercambio de información entre profesionales sanitarios sobre un paciente, que va acompañado de una transferencia del control o de la responsabilidad sobre el paciente» (Burgess et al., 2020). Un traspaso preciso y exhaustivo, cuando se realiza correctamente, mejora la estabilidad; ayuda a evitar errores y lagunas en la atención al paciente; contribuye a la comprensión adecuada de las necesidades de los pacientes; y aumenta la satisfacción laboral y la experiencia de las enfermeras (Lee y Lim, 2021). Los trasposos clínicos tienen lugar en diversos entornos sanitarios, desde trasposos en las salas hasta interfaces de urgencias de alto riesgo. Los entornos difieren en complejidad debido a variaciones en el ritmo, la gravedad y la composición del equipo. Los trasposos en enfermería adoptan la forma de comunicación a pie de cama con participación del paciente, mientras que los trasposos médicos son multidisciplinarios y se centran en detalles clínicos exhaustivos (Fealy et al., 2018). Fuera del ámbito hospitalario, los trasposos del personal de urgencias prehospitalarias a los equipos hospitalarios son esenciales para la transferencia de información urgente. Estos suelen tener lugar en condiciones dinámicas y ruidosas, como en ambulancias o servicios de urgencias, donde las limitaciones de tiempo, las distracciones y las diversas relaciones profesionales pueden obstaculizar una buena comunicación y transferencia de información (Wood et al., 2014). La comunicación imprecisa

entre el personal sanitario y el intercambio de información inexacto durante el traspaso son causas importantes de errores médicos y resultados desfavorables en entornos sanitarios de todo el mundo (Toumi et al., 2024). Numerosos estudios respaldan que, durante los trasposos entre profesionales sanitarios, la información compartida era inadecuada, lo que afectaba a la atención al paciente (Pilcher et al., 2022).

A lo largo de los años, se han desarrollado varios formatos estructurados para mejorar el proceso de traspaso. I-PASS es un formato de sistema creado para pediatría, que consiste en «gravedad de la enfermedad, resumen del paciente, lista de acciones, conciencia de la situación, planificación de contingencias y síntesis por parte del receptor». Otros formatos comúnmente utilizados y estudiados incluyen ISBAR, que se desglosa en «Introducción, Situación, Antecedentes, Evaluación, Recomendación». ISBAR se basó en SBAR, un sistema de comunicación para submarinos nucleares desarrollado por la Marina de los Estados Unidos. El marco ISBAR, que ha sido promovido por la OMS, es una herramienta de comunicación estándar consolidada que puede utilizarse fácilmente en diversas situaciones clínicas, como los cambios de turno, los traslados de pacientes para diagnósticos, los traslados entre hospitales y la escalada de pacientes que lo necesitan (Burgess et al., 2020). El marco ISBAR comprende cinco elementos centrados en la comunicación. La «I» denota la introducción,

que incluye presentarse indicando el cargo y el área de trabajo, identificar al paciente y a la persona de guardia, y comunicar el motivo de la llamada. La «S» significa situación, y se centra en el estado clínico actual del paciente. «B» se refiere a los antecedentes, que exponen los problemas que han dado lugar a la situación. «A» denota una evaluación que sugiere cuál cree la enfermera que es el problema. «R» se refiere a las recomendaciones que indican los pasos esenciales que deben darse para abordar el problema, incluyendo el examen del estado clínico del paciente para una comprensión precisa de la situación (Burgess et al., 2020).

Participar en los traspasos clínicos antes de asumir responsabilidades en la atención al paciente prepara a los estudiantes para la profesión (Malone et al., 2016). El Instituto de Educación en Calidad y Seguridad para Enfermeras (2020) respalda la necesidad de contar con habilidades de comunicación eficaces en los traspasos como una competencia necesaria para que las enfermeras en formación preserven la seguridad del paciente y eviten eventos imprevistos (Le et al., 2023). Las investigaciones que examinan las experiencias de enfermeras noveles en situaciones de cuasi-accidentes y eventos adversos revelaron que las fallas de comunicación durante los traspasos estaban relacionadas con siete de cada ocho casos. Este hallazgo destaca la necesidad de incorporar la formación en traspasos en los programas de educación de enfermería antes de la obtención de la licencia (Ebright et al., 2004). A pesar de su importancia, se ha prestado poca atención a la enseñanza de habilidades de comunicación en los traspasos a través de la instrucción en el aula en diversos programas de enfermería. En consecuencia, los estudiantes de enfermería suelen basarse en sus experiencias en los centros clínicos para practicar los traspasos. Este método plantea dificultades debido a la variabilidad de los procedimientos de traspaso en los distintos entornos clínicos, lo que, en última instancia, deja a los recién graduados insuficientemente preparados para este aspecto esencial de la práctica de la enfermería (Le et al., 2023). A menudo, un traspaso clínico satisfactorio no solo implica el conocimiento del procedimiento, sino también la autoeficacia, es decir, la creencia de que uno tiene la capacidad de realizar las comunicaciones

necesarias en un entorno estresante. Se ha asociado a los estudiantes con baja autoeficacia con un aumento de la ansiedad, fallos en la comunicación y una menor competencia en el entorno clínico. Estos hallazgos subrayan el potencial de las intervenciones educativas específicas e interactivas para cerrar la brecha entre la teoría y la práctica y preparar a la próxima generación de profesionales de enfermería con las competencias clave necesarias para llevar a cabo traspasos de pacientes seguros, eficaces y competentes.

Dado el papel fundamental que desempeña una comunicación eficaz en el traspaso para la seguridad del paciente y la limitada formación estructurada que se imparte en muchos programas de enfermería, existe una necesidad creciente de estrategias educativas que desarrollen activamente la competencia comunicativa y la autoeficacia de los estudiantes. Los enfoques de enseñanza experienciales e interactivos se recomiendan cada vez más para salvar la brecha entre el conocimiento teórico y la práctica clínica, al proporcionar oportunidades para el ensayo, la retroalimentación y la reflexión (Le et al., 2023). Entre estos enfoques, el aprendizaje basado en escenarios y el aprendizaje basado en la simulación han cobrado protagonismo como métodos pedagógicos. Tanto el aprendizaje basado en escenarios (SBL) como el aprendizaje basado en la simulación se fundamentan en la teoría del aprendizaje experiencial, pero difieren en su enfoque pedagógico para la formación en comunicación estructurada. La simulación de alta fidelidad es eficaz para mejorar el rendimiento psicomotor y la autoeficacia a corto plazo en tareas clínicas (Cant y Cooper, 2017), pero a menudo hace hincapié en el manejo clínico agudo y las habilidades técnicas, lo que puede limitar la práctica centrada en marcos de comunicación estandarizados. Por el contrario, el SBL hace hincapié en la secuenciación cognitiva, el razonamiento contextual y el diálogo estructurado dentro de narrativas realistas, lo que facilita una comprensión más profunda de los protocolos de comunicación como el ISBAR (Yilmaz et al., 2020; Lavanya et al., 2024).

El aprendizaje interactivo basado en escenarios, también denominado aprendizaje basado en

escenarios, es un enfoque pedagógico que permite a los estudiantes de enfermería participar en debates específicos. El SBL se clasifica en cuatro tipos de escenarios: escenarios de debate profesional, escenarios hipotéticos profesionales, escenarios para la enseñanza de habilidades e información, y escenarios para la investigación de problemas. Los escenarios bien elaborados proporcionan una base para que los educadores aborden los objetivos de aprendizaje y ofrezcan una experiencia de aprendizaje significativa a los estudiantes de enfermería a la hora de prestar una atención más segura a los pacientes en entornos hospitalarios (Ahmed, 2019). La bibliografía previa afirma que los escenarios de simulación ayudaron a los estudiantes de enfermería a mejorar sus habilidades de comunicación en áreas como la elaboración de informes, la documentación, la instrucción de los pacientes y el trabajo en equipo (Wang et al., 2015). Además,

el SBL fomenta el análisis reflexivo y la práctica verbal repetida, lo que favorece el desarrollo de la autoeficacia y la integración de conocimientos (Ahmed, 2019; Safdar et al., 2020). Es importante destacar que el SBL también es más escalable y viable en entornos con recursos limitados, ya que requiere menos recursos de simulación sin dejar de proporcionar un aprendizaje experiencial significativo.

Los resultados del estudio podrían contribuir al corpus de conocimientos ya establecido y utilizarse como parte de la estrategia docente en entornos de simulación o de laboratorio para lograr un traspaso clínico eficaz. Por lo tanto, el investigador se propone examinar la eficacia del uso del enfoque de aprendizaje basado en escenarios para el desarrollo de conocimientos, autoeficacia y competencia en el traspaso clínico.

2. Materiales y métodos

Diseño: El presente estudio adoptó un enfoque cuantitativo y un diseño experimental verdadero.

Consideraciones éticas: El comité de ética de la institución otorgó la autorización ética antes de iniciar el procedimiento y se obtuvo un permiso formal de la institución. Se recabó el consentimiento informado tras explicar los objetivos y el procedimiento del estudio. Se informó a los participantes de que podían abandonar el estudio voluntariamente en cualquier momento durante el periodo de estudio.

Muestra y entorno: Para determinar el tamaño exacto de la muestra, se realizó un cálculo utilizando G*Power versión 3.1, que reveló que se necesitaba una muestra de 35 participantes en cada grupo para detectar un tamaño del efecto de 0,80 con una potencia del 95 % ($1 - \beta = 0,95$) a un nivel de significación de 0,05. Sin embargo, por precaución, se reclutó a un total de 40 participantes en cada grupo. Los participantes del estudio fueron reclutados de entre un total de 120 estudiantes del cuarto curso de la Licenciatura

en Enfermería y del tercer curso del Diploma en Enfermería. De ellos, un total de 80 participantes que cumplieran todos los criterios de elegibilidad, estaban interesados en participar en el estudio y podían asistir a todo el proceso de intervención fueron asignados aleatoriamente al grupo experimental o al grupo de control mediante un método de sorteo. Cada grupo contaba con un total de 20 estudiantes de la licenciatura y 20 del curso de diplomatura en enfermería.

Instrumentos: Los datos demográficos de los participantes en la investigación se obtuvieron mediante el uso de un formulario Performa. El investigador elaboró un cuestionario estructurado de opción múltiple sobre el traspaso clínico y el enfoque ISBAR para evaluar los conocimientos de los estudiantes, compuesto por diez ítems en los que se puntuaba con «0» las respuestas incorrectas y con «1» las correctas. La validación del cuestionario corrió a cargo de formadores de enfermería y expertos profesionales del ámbito, y se realizaron las modificaciones recomendadas. Se adoptó una escala de autoeficacia para evaluar

la confianza del individuo en la realización del traspaso clínico, procedente de un estudio de Lee y Lim (2021). La herramienta constaba de 17 ítems calificados en una escala Likert de 5 puntos. La escala iba de «Totalmente de acuerdo» a «Totalmente en desacuerdo». La puntuación oscila entre 17 y 85 puntos. Las puntuaciones más altas indican una mayor autoeficacia. La fiabilidad de la herramienta se verificó utilizando el alfa de Cronbach en el estudio de Lee y Lim, que fue de 0,958 (Lee y Lim, 2021). El investigador desarrolló una lista de verificación estandarizada para medir la capacidad de los estudiantes para aplicar el método ISBAR durante el traspaso clínico. Constaba de un total de 12 ítems: 3 ítems sobre la introducción, 2 sobre la situación, 3 sobre los antecedentes, 1 sobre la evaluación y 3 sobre la repetición/recomendaciones. La puntuación «0» indicaba que no se había realizado y «1» indicaba que sí se había realizado. Expertos en práctica y formación de enfermería validaron la lista de verificación y se incorporaron las correcciones necesarias. Antes del estudio principal, se llevó a cabo un estudio piloto para evaluar la fiabilidad de los instrumentos de investigación. El cuestionario

arrojó un coeficiente de fiabilidad de 0,71. La consistencia interna de la escala de autoeficacia se estableció utilizando el alfa de Cronbach ($\alpha = 0,85$), y la lista de verificación mostró un valor del alfa de Cronbach de 0,75, lo que indica una fiabilidad aceptable.

Escenarios: Se desarrollaron tres escenarios basados en diversas situaciones de traspaso clínico. Los escenarios abarcaban el traspaso de turno, el traslado a una sala y la derivación a otro hospital, y se desarrollaron tomando como referencia casos clínicos reales. También se elaboraron directrices de traspaso basadas en ISBAR y un plan de debriefing. Los escenarios fueron revisados por un panel de expertos, que incluía formadores de enfermería y profesionales clínicos con experiencia en la formación basada en la simulación y la comunicación sobre seguridad del paciente. Revisaron los escenarios en cuanto a su relevancia, claridad, realismo y adecuación basándose en el marco ISBAR. Se realizaron modificaciones menores en los escenarios a partir de los comentarios de los expertos para mejorar la claridad. La validez de contenido se determinó basándose en el método del Índice de Validez de

Ejemplo del escenario 1:

Componente	Descripción
Título del escenario	Uso de la comunicación estructurada ISBAR para la derivación de un niño con diarrea aguda
Objetivos de aprendizaje	1. Identificar los componentes de la herramienta de comunicación ISBAR. 2. Aplicar ISBAR para el traspaso estructurado de pacientes. 3. Comunicar la información del paciente de forma clara y concisa durante la derivación.
Destinatarios	Estudiantes de enfermería
Escenario	Centro de salud comunitario en una zona remota
Contexto clínico	Niño de 15 años que presenta diarrea persistente y deshidratación que empeora, lo que requiere su derivación a un centro de referencia
Duración del escenario	Sesión informativa previa (5 min), escenario de simulación (15 min), sesión de análisis posterior (20 min)
Estado del paciente	Diarrea aguda con signos de deshidratación moderada e inestabilidad hemodinámica
Información clínica clave	Signos vitales iniciales: PA 90/60 mmHg, pulso 118 lpm, FR 26 lpm, temperatura 98,6 °F, SpO ₂ 98 %. Tras 3 horas: PA 88/58 mmHg, pulso 124 lpm, FR 28 lpm.
Intervenciones iniciadas	Solución salina normal por vía intravenosa, 500 ml durante 90 minutos; terapia de rehidratación oral (SRO); suplementos de zinc; sobre de Ecobion
Actividad de simulación	Los participantes realizan una derivación telefónica a un centro superior utilizando el marco de comunicación ISBAR
Acciones esperadas de los alumnos	Evaluar el estado del paciente, reconocer el empeoramiento de la deshidratación, preparar la derivación y comunicar la información del paciente utilizando el formato ISBAR
Método de evaluación	Lista de verificación del desempeño que evalúa los componentes de ISBAR, la claridad de la comunicación y la precisión de la información del paciente
Enfoque de la sesión de reflexión	Reflexión sobre la claridad de la comunicación, la precisión en la transmisión de la información y la toma de decisiones clínicas durante la derivación

Contenido (CVI). La validez de contenido de los escenarios fue satisfactoria, con un CVI de 0,75, lo que indica la idoneidad de los escenarios para formar a los participantes en el uso del marco ISBAR para traspasos clínicos eficaces.

2.1 Procedimiento de recopilación de datos

El estudio se llevó a cabo del 4 de septiembre de 2023 al 30 de septiembre de 2023. El primer día, se informó a los participantes de los objetivos y los procedimientos del estudio. Las mediciones iniciales del estudio consistieron en la administración del cuestionario de conocimientos y la escala de autoeficacia (escala de Likert) a los participantes, tanto del grupo experimental como del grupo de control. La herramienta de evaluación de competencias utilizada en el estudio fue el Examen Clínico Objetivo Estructurado (OSCE), basado en escenarios y utilizando una lista de verificación estructurada, llevado a cabo por el evaluador, que desconocía la distribución de los grupos.

Intervención:

Al grupo de control se le impartió la clase magistral estándar sobre el traspaso clínico y los componentes del sistema ISBAR. Al grupo experimental se le impartió una enseñanza interactiva en el laboratorio de habilidades durante 3 horas utilizando los escenarios previamente desarrollados. La intervención consistió en la clase magistral y los escenarios mediante juegos de rol.

Fase 1: Sesión de clase

La sesión comenzó con una clase interactiva de una hora impartida por el equipo de investigación. La clase abarcó la importancia de un traspaso clínico eficaz para la seguridad del paciente, los errores de comunicación habituales durante el traspaso y los principios y componentes de la herramienta de comunicación ISBAR. Se mostraron ejemplos de traspasos estructurados utilizando ISBAR para familiarizar a los participantes con el marco. Fase 2: Demostración de escenarios (20 minutos) Tras la clase, el equipo de investigación llevó a cabo un juego de roles basado en escenarios

clínicos previamente elaborados relacionados con situaciones de atención al paciente que requerían comunicación de traspaso. Estas demostraciones ilustraron la aplicación práctica de la estructura ISBAR en la comunicación clínica.

Fase 3: Práctica en grupos reducidos (20 minutos)

Se organizó a los participantes en pequeños grupos de cuatro personas, formando un total de diez grupos, para realizar ejercicios de traspaso basados en situaciones hipotéticas. Cada grupo recibió situaciones clínicas y se le indicó que llevara a cabo los traspasos utilizando el marco ISBAR. Dentro de cada situación, se asignaron roles específicos a los participantes: uno como enfermero, otro como miembro del equipo sanitario de la unidad de destino y dos como observadores, con el fin de facilitar una práctica estructurada basada en roles.

Fase 4: Sesión de reflexión (1 h 20 min)

Tras la práctica en grupos reducidos, se llevó a cabo una sesión de análisis estructurada para todos los participantes. En ese momento, los participantes pudieron revisar los escenarios, reflexionar sobre sus prácticas de comunicación y examinar la aplicación de cada componente del marco ISBAR. Esto garantizó que se reforzaran las técnicas adecuadas de traspaso entre los participantes. Para minimizar la contaminación, la recopilación de datos del grupo de control se completó antes que la del grupo experimental, y se indicó a los participantes que no comentaran la intervención con sus compañeros del grupo de control.

Medición posterior a la prueba: La medición posterior a la prueba se llevó a cabo tanto para el grupo experimental como para el de control tras la intervención, de la misma manera y con las mismas herramientas.

Análisis estadístico: Los datos se recopilaban, codificaban en Excel y analizaban utilizando SPSS versión 26.0. Se utilizaron estadísticas descriptivas, como el porcentaje y la media, para describir los datos demográficos. Las características iniciales de los grupos experimental y de control se compararon mediante la prueba

de chi cuadrado y la prueba de independencia. La distribución de las variables de resultado se evaluó mediante la prueba de Shapiro-Wilk. Las puntuaciones de conocimientos se distribuyeron normalmente tanto en el grupo de control como en el experimental ($p > 0,05$). Las puntuaciones de autoeficacia se distribuyeron normalmente en el grupo de control, pero no en el experimental, mientras que las puntuaciones de competencia no se distribuyeron normalmente en ninguno de los dos grupos ($p < 0,05$). A pesar de estas desviaciones de la normalidad, el ANCOVA y las pruebas t suelen ser robustas ante violaciones

moderadas, especialmente con tamaños de muestra ≥ 30 ; por lo tanto, se consideró apropiado el uso del ANCOVA. Se emplearon pruebas t pareadas para examinar las diferencias intragrupal entre las puntuaciones de la prueba previa y la prueba posterior, mientras que se utilizó el análisis de covarianza (ANCOVA) para comparar las puntuaciones de la prueba posterior entre los grupos experimental y de control. Se aplicó el coeficiente de correlación de Pearson para evaluar las relaciones entre las variables del estudio.

3. Resultados

Tabla 1: Análisis de los datos sociodemográficos del grupo experimental y del grupo de control.
Fuente: Elaboración propia, 2025.

Variables	Categoría	Control (n=40) n (%)	Experimental (n=40) n (%)	Valor χ^2	Valor p
Sexo*	Hombres	7 (17.5%)	12 (30.0%)	1.10	0.29
	Mujeres	33 (82.5%)	28 (70.0%)		
Asistió al traspaso clínico durante las prácticas*	Sí	13 (32.5%)	11 (27.5%)	0.06	0.80
	No	27 (67.5%)	29 (72.5%)		
Variable		Control (n=40) M(SD)	Experimental (n=40) M(SD)	Valor t	Valor p
Edad (años)+		20.55 (1.43)	20.93 (2.29)	-0.88	0.38

Nota:

*- Chi cuadrado de Pearson

+ - Prueba t independiente

La tabla 1 muestra las características demográficas del grupo experimental y del grupo de control. Entre los participantes del grupo experimental, el 70 % (n = 28) eran mujeres y el 30 % (n = 12) eran hombres, mientras que entre los participantes del grupo de control, el 82,5 % (n = 33) eran mujeres y el 17,5 % (n = 7) eran hombres. Ninguno de los participantes de ninguno de los dos grupos declaró haber recibido ningún programa de formación específico sobre el traspaso clínico. La mayoría de los participantes del grupo experimental (75 %, n = 30) y del grupo de control (70 %, n = 28) declararon no haber presenciado el traspaso durante la práctica clínica.

Para evaluar la homogeneidad de las variables demográficas en los grupos experimental y de control, se aplicó una prueba de chi-cuadrado. Se

reveló que no existían diferencias estadísticamente significativas en la composición por sexos ($\chi^2 = 1,10$, $p = 0,29$) ni en haber presenciado un traspaso de turno ($\chi^2 = 0,06$, $p = 0,80$) entre los dos grupos. Dado que todos los participantes de ambos grupos declararon carecer de formación previa en trasposos clínicos, no es posible aplicar una prueba de chi-cuadrado en este caso debido a la falta de variabilidad en los datos. En general, se podría concluir que los grupos experimental y de control eran homogéneos en su composición.

La edad media de los participantes del grupo de control fue de $20,55 \pm 1,43$ años, mientras que en el grupo experimental fue de $20,93 \pm 2,29$ años. La homogeneidad de la edad entre los grupos de control y experimental se evaluó mediante una prueba t independiente. El valor t calculado fue

de -0,88 con un valor p de 0,38, que es superior a 0,05, lo que indica que no existe una diferencia estadísticamente significativa en la edad entre los dos grupos. Por lo tanto, los grupos de control y experimental eran homogéneos en cuanto a la edad.

3.1 Efectos intrasujetos

La tabla 2 presenta el análisis intragrupal mediante pruebas t pareadas, que reveló mejoras significativas en el grupo experimental en todas las variables de resultado. Las puntuaciones de conocimiento aumentaron significativamente de $4,05 \pm 1,82$ a $5,55 \pm 2,79$ ($t(39) = -2,89$, $p = 0,006$), lo que demuestra un tamaño del efecto moderado ($d = 0,46$). La autoeficacia mostró un aumento sustancial de $55,00 \pm 8,32$ a $66,10 \pm 5,73$ ($t(39) = -9,60$, $p < 0,001$), con un tamaño del efecto grande ($d = 1,52$). De manera similar, las puntuaciones de competencia mejoraron notablemente de $4,85 \pm 1,16$ a $10,27 \pm 2,28$ ($t(39) = -13,50$, $p < 0,001$), lo que indica un efecto muy grande ($d = 2,13$).

En el grupo de control, las puntuaciones de autoeficacia y competencia mostraron mejoras estadísticamente significativas, aunque los tamaños del efecto fueron menores. Las puntuaciones de conocimientos no mostraron un cambio estadísticamente significativo ($p = 0,47$). En general, la intervención produjo

mejoras de moderadas a muy grandes en el grupo experimental, especialmente en los resultados de competencia y autoeficacia.

3.2 Efectos entre sujetos

La tabla 3 muestra que el análisis ANCOVA reveló una comparación de las puntuaciones de conocimiento, autoeficacia y competencia en la prueba posterior de ambos grupos, controlando los valores de la prueba previa. Tras ajustar los valores de la prueba previa, se encontró un efecto significativo de la diferencia entre grupos en cuanto a conocimientos ($F(1,77) = 13,49$, $p < 0,001$, $\eta^2 = 0,149$) y competencia ($F(1,77) = 46,97$, $p < 0,001$, $\eta^2 = 0,379$). La potencia observada de estos análisis fue alta (0,95 y 1,00 respectivamente), lo que indica una alta capacidad de este estudio para detectar diferencias. Por el contrario, no se encontró ninguna diferencia estadísticamente significativa en las puntuaciones de autoeficacia entre ambos grupos tras ajustar los valores de la prueba previa ($F(1,77) = 0,17$, $p = 0,681$, $\eta^2 = 0,002$); además, se observó que la potencia de este análisis era baja (0,07). La autoeficacia previa a la prueba contribuyó significativamente a la autoeficacia posterior a la prueba ($F(1,77) = 6,45$, $p = 0,013$).

Se observó un tamaño del efecto elevado de esta intervención sobre el conocimiento (0,149) y un tamaño del efecto muy elevado (0,379), mientras

Tabla 2. Comparación intragrupal de las puntuaciones de la prueba previa y la prueba posterior en cuanto a conocimientos, autoeficacia y competencia mediante la prueba t para datos emparejados, $n1=40$, $n2=40$.

Fuente: Elaboración propia, 2025.

Variable	Grupo	Media $\pm$ DE de la prueba previa	Media de la prueba posterior $\pm$ DE	t (df)	Valor p	Tamaño del efecto (d de Cohen)
Conocimientos	Grupo experimental (n = 40)	4.05 ± 1.82	5.55 ± 2.79	-2.89 (39)	0.006*	0.46
	Control (n = 40)	3.25 ± 1.12	3.45 ± 1.70	-0.72 (39)	0.470	0.11
Autoeficacia	Grupo experimental (n = 40)	55.00 ± 8.32	66.10 ± 5.73	-9.60 (39)	<0.001**	1.52
	Control (n = 40)	54.80 ± 7.35	58.25 ± 7.59	-3.01 (39)	0.004*	0.48
Competencia	Experimental (n = 40)	4.85 ± 1.16	10.27 ± 2.28	-13.50 (39)	<0.001**	2.13
	Control (n = 40)	5.92 ± 1.67	7.37 ± 1.14	-4.80 (39)	<0.001**	0.76

Nota: *nivel de significación $p < 0,05$; **nivel de significación $p < 0,001$
df = grados de libertad.

Tabla 3. Efectos entre sujetos de la intervención sobre el conocimiento, la autoeficacia y la competencia en la prueba posterior utilizando ANCOVA, (N = 80)
Fuente: Elaboración propia, 2025.

DV	IV y COV	Control (n = 40) M (DE)	Experimental (n = 40) M (DE)	ANCOVA F	p	η^2 parcial	R ² (R ² ajustado)	Potencia
Knowledge	Grupo	3.45 (1.70)	5.55 (2.79)	F(1,77) = 13.49	<.001	0.149	0.182 (0.162)	0.95
	T ₁ (Pre-prueba)	3.25 (1.12)	4.05 (1.82)	F(1,77) = 0.90	.346	—	—	0.16
Self-Efficacy	Grupo	58.25 (7.59)	66.10 (5.73)	F(1,77) = 0.17	.681	0.002	0.075 (0.051)	0.07
	T ₁ (Pre-prueba)	54.80 (7.35)	55.00 (8.32)	F(1,77) = 6.45	.013	—	—	0.71
Competency	Grupo	7.37 (1.14)	10.27 (2.28)	F(1,77) = 46.97	<.001	0.379	0.402 (0.387)	1.00
	T ₁ (Pre-prueba)	5.92 (1.67)	4.85 (1.16)	F(1,77) = 0.26	.612	—	—	0.08

Nota:

DV = variable dependiente; IV = variable independiente; COV = covariable; T₁ = puntuación en la prueba previa.

ANCOVA = análisis de covarianza.

η^2 = eta cuadrado parcial (tamaño del efecto).

La potencia representa la potencia estadística observada de la prueba.

que se observó un tamaño del efecto insignificante (0,002) sobre la autoeficacia.

Tabla 4. Medias ajustadas de la prueba posterior e intervalos de confianza del 95 % tras el ANCOVA.
Fuente: Elaboración propia, 2025.

Variable de resultado	Grupo	Media ajustada	Intervalo de confianza del 95 %
Conocimiento	Grupo de control	3.52	2.77 – 4.26
	Experimental	5.48	4.74 – 6.23
Autoeficacia	Control	56.41	53.10 – 59.72
	Experimental	57.39	54.08 – 60.70
Competencia	Control	7.34	6.74 – 7.93
	Experimental	10.31	9.72 – 10.91

La tabla 4 muestra que las medias ajustadas de la prueba posterior, calculadas mediante ANCOVA, revelaron que el grupo experimental obtuvo puntuaciones más altas que el grupo de control en cuanto a conocimientos y competencias tras controlar los datos de referencia. En cuanto al conocimiento, la puntuación media ajustada del grupo experimental fue de 5,48 (IC del 95 %: 4,74-6,23), mientras que la del grupo de control fue de 3,52 (IC del 95 %: 2,77-4,26).

Del mismo modo, las puntuaciones de competencia fueron más altas en el grupo experimental que en el grupo de control. En este caso, la puntuación media ajustada del grupo experimental fue de 10,31 (IC del 95 %: 9,72-10,91), mientras que la puntuación media

ajustada del grupo de control fue de 7,34 (IC del 95 %: 6,74-7,93). Esto demostró un efecto de intervención elevado.

Sin embargo, las puntuaciones de autoeficacia no mostraron diferencias significativas entre los dos grupos. En este caso, la puntuación media ajustada del grupo experimental fue de 57,39 (IC del 95 %: 54,08-60,70), mientras que la puntuación media ajustada del grupo de control fue de 56,41 (IC del 95 %: 53,10-59,72).

3.3 Correlación entre las puntuaciones de conocimientos, autoeficacia y competencia

La tabla 5 muestra el análisis de correlación realizado para investigar la relación entre el conocimiento, la autoeficacia y la competencia. El análisis de correlación de Pearson mostró una correlación positiva moderada entre el

Tabla 5: Relación entre las puntuaciones de conocimientos, autoeficacia y competencia, n = 80
Fuente: Elaboración propia, 2025.

Correlación de Karl Pearson	1	2	3
Conocimiento	-		
Autoeficacia	0.362* (0.022)	-	
Competency	0.476** (0.0002)	0.053 (0.745)	-

Nota:

*Nivel de significación p<0,05

**Nivel de significación p < 0,001.

conocimiento y la autoeficacia ($r = 0,362$, $p = 0,022$). Esto implica que un aumento en el nivel de conocimiento se corresponde con un aumento en el nivel de autoeficacia. Además, una correlación positiva entre el conocimiento y la competencia ($r = 0,476$, $p = 0,0002$) sugiere que un aumento en el nivel de conocimiento

se corresponde con un aumento en el nivel de competencia. Sin embargo, no se encontró una relación estadísticamente significativa entre la autoeficacia y la competencia ($r = 0,053$, $p = 0,745$), lo que indica que la confianza percibida puede no traducirse necesariamente en resultados de competencia medibles.

4. Discusión

El presente estudio examinó la eficacia del enfoque de aprendizaje interactivo basado en escenarios en el desarrollo del conocimiento, la autoeficacia y la competencia. Los resultados mostraron que los participantes que se sometieron al enfoque de aprendizaje interactivo basado en escenarios mostraron una mejora significativa en sus conocimientos y competencias en comparación con los participantes del grupo de control. Sin embargo, los resultados mostraron que no hubo un impacto significativo del enfoque de aprendizaje interactivo basado en escenarios en la autoeficacia de los participantes tras ajustar los resultados. Estos hallazgos ponen de relieve el potencial de las estrategias de aprendizaje basadas en escenarios para mejorar las competencias cognitivas y prácticas entre los alumnos.

La mejora en la adquisición de conocimientos en el grupo experimental podría atribuirse al entorno de aprendizaje activo proporcionado a través de estrategias de aprendizaje basadas en escenarios. Las estrategias de aprendizaje basadas en escenarios y las estrategias de aprendizaje basadas en la simulación ofrecen a los alumnos oportunidades para aplicar los conocimientos teóricos en situaciones de la vida real, lo que fomenta una mejor comprensión y retención de los conocimientos. Estudios recientes han demostrado que las estrategias de aprendizaje basadas en la simulación son un enfoque viable en la formación en enfermería para mejorar la adquisición de conocimientos y el desarrollo de habilidades en los estudiantes de enfermería (Alharbi et al., 2024). Las estrategias de aprendizaje basadas en escenarios también ofrecen oportunidades para el aprendizaje

experiencial a través de estrategias de resolución de problemas en situaciones de la vida real, lo que fomenta la comprensión cognitiva de situaciones clínicas complejas (Baek et al., 2022). Las estrategias de aprendizaje basadas en escenarios también ofrecen oportunidades para promover el aprendizaje experiencial a través de estrategias de resolución de problemas en situaciones de la vida real, lo que fomenta la comprensión cognitiva de situaciones clínicas complejas (Baek et al., 2022).

Además, los resultados del presente estudio revelaron un avance significativo en la competencia de los participantes del grupo experimental. El desarrollo de la competencia es una parte esencial de la formación de las enfermeras, ya que supone la integración de conocimientos, habilidades psicomotoras y toma de decisiones. El aprendizaje basado en escenarios es un enfoque educativo que permite a los alumnos ejercitar sus habilidades de toma de decisiones clínicas en un entorno de aprendizaje controlado. El aprendizaje basado en escenarios tiende un puente entre el aula y el entorno clínico. Estudios previos han demostrado que la formación basada en escenarios es eficaz para mejorar las competencias clínicas de los estudiantes de enfermería. La formación basada en escenarios es eficaz para mejorar las competencias clínicas de los estudiantes de enfermería en las siguientes áreas: habilidades de comunicación, habilidades de trabajo en equipo y habilidades prácticas para la atención segura de los pacientes (Sadeghi et al., 2023). Además, los estudios han demostrado que la educación basada en la simulación es eficaz para mejorar

las habilidades clínicas, la capacidad de toma de decisiones y la competencia profesional de los estudiantes de enfermería (Görücü et al., 2024).

A pesar de los avances en conocimientos y competencias, los resultados no demostraron un impacto estadísticamente significativo en la autoeficacia tras ajustar las puntuaciones. Una posible explicación de esto podría ser que la autoeficacia puede verse influida por diversos factores psicológicos. Por ejemplo, la autoeficacia puede verse moldeada por experiencias previas, niveles de confianza y experiencias de dominio. Si bien las intervenciones educativas pueden ser eficaces para mejorar los niveles de conocimientos y habilidades a corto plazo, el desarrollo de la autoeficacia puede ser un proceso a largo plazo que implica una exposición repetida al contenido de aprendizaje. Estudios anteriores también han indicado que el aprendizaje basado en la simulación puede ser eficaz para mejorar la confianza y la competencia de los alumnos. Sin

embargo, el nivel de mejora en la autoeficacia puede variar en función de la duración de la intervención educativa. Por ejemplo, Saragih et al. (2024) indicaron que la mejora en la autoeficacia puede variar en función de la duración de la intervención educativa.

En general, los resultados del presente estudio respaldan el creciente conjunto de pruebas que indican que el aprendizaje interactivo basado en escenarios es un enfoque eficaz para mejorar los conocimientos y las competencias de los alumnos. Esto se debe a que el aprendizaje basado en escenarios proporciona a los alumnos situaciones de la vida real que les permiten aprender a través de la experiencia, lo que puede mejorar su comprensión y sus habilidades como futuros profesionales sanitarios. El aprendizaje basado en escenarios puede mejorar el plan de estudios utilizado para formar a los profesionales sanitarios, haciéndolos más eficaces y competentes.

5. Puntos fuertes y limitaciones

El presente estudio presenta varios puntos fuertes. En primer lugar, el estudio contó con un diseño controlado que permitió la comparación entre los grupos experimental y de control. Esto contribuyó a aumentar la validez interna del estudio. En segundo lugar, el estudio contó con más de una variable de resultado, incluyendo el conocimiento, la autoeficacia y la competencia. Esto ayudó a proporcionar una evaluación más completa de la eficacia de la intervención de aprendizaje interactivo basado en escenarios. En tercer lugar, el estudio contó con un análisis estadístico más sólido, con la inclusión tanto de un análisis intragrupal mediante la prueba t pareada como de un análisis intergrupar mediante ANCOVA para controlar las diferencias iniciales en las puntuaciones de la prueba previa entre los grupos. Además, la inclusión de medidas del tamaño del efecto ayudó a proporcionar una mayor comprensión de los resultados del estudio.

A pesar de los puntos fuertes del estudio mencionados anteriormente, es necesario señalar algunas limitaciones. En primer lugar, el tamaño de la muestra de participantes fue relativamente pequeño y el entorno del estudio se limitó a una única ubicación. En segundo lugar, la duración del periodo de intervención fue relativamente corta. Esto podría ser la razón de la falta de mejora en las puntuaciones de autoeficacia de los participantes. Por lo general, los cambios en los constructos psicológicos tardan más tiempo en producirse. En tercer lugar, el estudio utilizó métodos de autoinforme para recopilar datos sobre la autoeficacia, lo que pudo haber dado lugar a un sesgo de respuesta. Es necesario realizar estudios futuros con una muestra de mayor tamaño, un periodo de intervención más prolongado y un diseño multicéntrico para confirmar los hallazgos del presente estudio.

6. Conclusiones

Se ha observado que el aprendizaje interactivo basado en escenarios es eficaz para mejorar el nivel de conocimientos y competencias de los estudiantes de enfermería. Se ha señalado que la intervención tiene un efecto positivo en el pensamiento crítico, el aprendizaje reflexivo y las habilidades de resolución de problemas de los estudiantes. Aunque la intervención tiene un efecto positivo en el nivel de autoeficacia de los

estudiantes, los resultados no son significativos, ya que los estados psicológicos requieren una intervención a largo plazo. Se ha observado que la aplicación del aprendizaje interactivo basado en escenarios ofrece una forma viable y creativa de abordar la brecha entre la teoría y la práctica en la mejora del nivel de resultados educativos en la formación en enfermería.

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Analysis of Scientific Competencies in the Use of Smart Notebooks in Primary Education

Análisis de las competencias científicas en el uso de los cuadernos inteligentes en Educación Primaria

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Analysis of Scientific Competencies in the Use of Smart Notebooks in Primary Education

Análisis de las competencias científicas en el uso de los cuadernos inteligentes en Educación Primaria

Abstract:

This study analyses the contribution of smart notebooks, as a methodological tool, to the development of students' scientific competence within the context of the bilingual model of science education in Primary Education. A descriptive study based on content analysis was conducted using a sample of 17 smart notebooks implemented in the third cycle of Primary Education in bilingual schools in Spain. The analysis instruments, grounded in the PISA 2025 theoretical framework and the CLIL approach, allow for the assessment of the development of scientific competencies, knowledge, contexts, and scientific practices. The results show that smart notebooks particularly foster the development of scientific knowledge, model representation, and inquiry. However, areas for improvement were identified in relation to scientific argumentation and research design. Overall, the findings confirm their potential to promote competency-based learning in bilingual contexts.

Keywords: primary education, scientific competence, bilingualism, Sciences, intelligent notebook

Resumen:

En este estudio se analiza la contribución de los cuadernos inteligentes, como instrumento metodológico, al desarrollo de las competencias científica del alumnado en el contexto del modelo bilingüe de enseñanza de las ciencias en Educación Primaria. Se llevó a cabo una investigación descriptiva basada en análisis de contenido, aplicada a una muestra de 17 cuadernos inteligentes utilizados en el tercer ciclo de Educación Primaria en centros bilingües en España. Los instrumentos de análisis, fundamentados en el marco teórico de PISA 2025 y en el enfoque AICLE, permiten evaluar el desarrollo de las competencias científicas, los conocimientos, los contextos y las prácticas científicas. Los resultados muestran que los cuadernos inteligentes favorecen especialmente el desarrollo del conocimiento científico, la representación de modelos y la indagación. No obstante, se identifican áreas de mejora relacionadas con la argumentación científica y el diseño de investigaciones. En conjunto, se confirma su potencial para promover un aprendizaje competencial en contextos bilingües.

Palabras clave: educación primaria, competencia científica, bilingüismo, Ciencias de la Naturaleza, cuaderno inteligente.

1. Introduction

Educational systems strive to integrate foreign language instruction across subject areas through approaches such as Content and Language Integrated Learning (CLIL). One of the most in-demand subjects and the focus of this study is Natural Sciences in Primary Education (Aragón, 2007; Order ECD/1112/2022). Setting aside the advantages offered by a CLIL approach, such as its positive impact on content learning (Coyle et al., 2010) or its effect on students' cognitive flexibility (Ball, 2016), the growing interest in this approach has often coincided with the need to adapt teaching methodologies for bilingual content to the introduction of global comparative assessments, the most representative of which is the Programme for International Student Assessment (PISA) (OECD, 2023). It was within this context of global educational comparisons and methodological change that “smart notebooks” emerged in 2014 (Embid, 2018). The smart notebook is an educational tool that documents a student's work throughout the academic year, capturing both the content learned (right-hand page of the notebook or “input”) and the reflective knowledge (left-hand page or “output”) acquired and produced by the student (Ruber Andrés et al., 2025).

To date, publications on this tool have demonstrated that smart notebooks in science offer abundant and varied benefits to the classroom for both students and teachers. They have been shown to improve students' learning and academic performance in science (Mallozi, 2013); develop their scientific skills and abilities (Bravo-Torija et al., 2016); foster active and personalized learning by developing critical thinking and metacognition, and promoting effective learning strategies (Marcarelli, 2010); improve their communication and organizational skills (Young, 2003; Embid, 2018); support differentiated and inclusive learning (Gilbert & Kotelman, 2005); and serve as a formative assessment tool (Marcarelli, 2010). Furthermore, several studies highlight that smart notebooks improve teachers' planning and preparation (Marcarelli, 2010); provide a wealth of

assessment information (Young, 2003); and affect classroom management and communication and collaboration between teachers and families (Gilbert & Kotelman, 2005). These benefits lead to smart notebooks being considered an appropriate and effective educational tool (Marcarelli, 2010; Young, 2003). However, research to date has analyzed smart notebooks from the perspectives of various educational stakeholders—such as students, families, teachers, and researchers—while overlooking insights that an analysis of the educational tool itself can offer. How can we analyze the scientific competencies that students develop through the use of the smart notebook?

This study proposes the design and application of several tools that allow for the analysis of the evidence collected in smart notebooks, in order to study the development of scientific competencies through the use of the smart notebook in the context of current science education in Primary Education in the Autonomous Community of (anonymous for review), adapted to the bilingual model and the educational legislation that regulates it, which is the objective of this study.

1.1 Smart Notebook. Definition and Characteristics

Smart workbooks emerged from “interactive workbooks,” which originated in California (United States) in the 1970s. Interactive workbooks are characterized by their specific focus on developing scientific skills, providing students with the opportunity to connect their thinking and experiences with scientific concepts, deepen and refine their scientific ideas, and reflect on their learning (Bravo-Torija et al., 2016; Marcarelli, 2010). In 2013, Floria Mallozi (2013) investigated whether the use of interactive notebooks would affect the scientific skills of 194 students in two schools in the northeastern United States. The results revealed that students who used this methodology achieved significantly higher scores. Similar results were obtained with students in Algebra (Drew, 2018) and Physics (Fajardo et

al., 2019). However, interactive notebooks aim not only to promote the acquisition of scientific knowledge but also the skills and abilities that characterize the work of scientists (Marcarelli, 2010). Scientists use lab notebooks to record data and observations, to draw models that represent their ideas, to formulate questions, and to draw conclusions (Nesbit et al., 2004). Interactive notebooks engage students in authentic scientific language and processes, such as data recording or analysis (Fulton, 2017; Mallozzi, 2013; Mason & Bohl, 2017; Young, 2003).

Furthermore, these notebooks have been shown to foster active and personal learning. They provide students with autonomy in their learning, a space in which they can creatively and independently construct the meaning of information conveyed in class (Gilbert & Kotelman, 2005; Jaladanki & Bhattacharyya, 2014). Over the years, interactive workbooks have been used in numerous classrooms across the United States for social studies instruction and have recently spread worldwide to other disciplines, such as mathematics and the experimental sciences, the subject of this research. It was not until 2014 that the term “smart notebooks” was adopted in Spain, when it was incorporated into the CLIL approach within the Spanish bilingual model (Embid, 2018). According to Yaylak (2020) and Young (2003), science smart notebooks are a tool used to strengthen curriculum learning (“input”) through greater student participation (“output”). Marcarelli (2010) adds that a smart notebook provides a space where students can make connections before new learning, review their thinking, apply it, and share it with their peers; in other words, it is a tool that fosters students’ metacognition (Ruber Andrés et al., 2025). In their first year of implementation in Spain, smart notebooks substantially improved student outcomes, particularly in formulating questions, identifying similarities and differences, and designing a research project (Bravo et al., 2016).

1.2 Scientific competence. Definition, development, and assessment

Several authors define scientific literacy as the ability to apply, in an integrated manner and across diverse contexts and situations, the knowledge,

skills, and attitudes developed through learning (Cañal, 2012; Ferrés-Gurt et al., 2015; Pedrinaci et al., 2012). However, the most recent version, with respect to the theoretical framework of scientific competence, is the definition provided by PISA 2025 (OECD, 2023). The main objective of PISA is to measure students’ ability to apply their knowledge and demonstrate a specific set of competencies.

If science teaching focuses on developing scientific competence, two fundamental questions immediately arise for teachers: How can we assess whether classroom practices are effectively advancing this competence? Moreover, how should we assess this competence among students? (Cañal, 2012; Pozuelo and Cascarosa, 2023).

PISA is based on a vision of scientific knowledge consisting of three distinct yet interrelated elements. The first of these is understanding the theories, ideas, and concepts that form the basis of current scientific knowledge and provide explanations of the natural world (Pozuelo & Cascarosa, 2023). This type of knowledge is referred to as “content knowledge” (OECD, 2023). Furthermore, the construction of scientific knowledge depends on a set of procedures and methods known as “procedural knowledge” (OECD, 2023). It focuses on knowledge of the practices that underpin scientific research, such as asking questions about the material world; developing models; analyzing and interpreting data; and evaluating and communicating valid and reliable results (National Research Council, 2012). Consequently, over the years, emphasis has been placed on the need to teach “the nature of science” (Lederman, 2006), “ideas about science” (Millar & Osborne, 1998), or “scientific practices” (National Research Council, 2012).

Furthermore, understanding science also requires “epistemic knowledge,” which encompasses the essential characteristics of scientific knowledge construction (Duschl, 2007). It includes an understanding of the goals of science, the justification of its practices, and the importance of consensus and the relevance of scientific knowledge (Rosales Ortega et al., 2020). In conclusion, students need all three forms

of scientific knowledge to develop the key competencies of this framework (OECD, 2023).

Assessment of scientific competence. Cognitive demands

As shown in Figure 1, the assessment of scientific competence in PISA 2025 is based on four fundamental aspects: scientific competencies; scientific knowledge (content, procedural, and epistemic); contexts (personal, local, national, and global); and scientific practices (inquiry, argumentation, and modeling).

A key feature of the PISA 2025 framework (OECD, 2023) is the definition of cognitive demand levels. It is important not to confuse cognitive demand with the difficulty of a question (Pozuelo & Cascarosa, 2023). Difficulty is assessed based on a population's scientific knowledge as reflected in correct answers. In contrast, cognitive demand considers the type of mental process required to answer questions, using verbs such as “recognize,” “interpret,” or “evaluate” (Rosales Ortega et al., 2020).

Bloom's revised taxonomy (Anderson & Krathwohl, 2001) identifies four categories of knowledge: factual, conceptual, procedural, and metacognitive, which are hierarchical and distinct from the six categories used in Bloom's original taxonomy: recall, understand, apply, analyze, evaluate, and create (Bloom, 1956).

Another model is the “Depth of Knowledge” model developed by Webb (1997). His framework consists of four main categories: Level 1 (recall), Level 2 (use of skills and/or content knowledge), Level 3 (strategic thinking), and Level 4 (extended thinking). Each category establishes a set of verbs that can be used to describe cognitive performance. More recently, Tekkumru-Kisa et al. (2020) published a framework that analyzes task difficulty levels and distinguishes the levels of thinking required for different types of scientific practices.

The approach adopted for the PISA 2025 Framework (OECD, 2023) focuses on developing the definition of cognitive demand. Webb's (1997) levels of depth of knowledge provide a taxonomy that requires items to identify both the cognitive demand (analyze, organize, compare...) and the expected depth of knowledge required. Furthermore, each item can also be mapped using a third dimension, as each item can be categorized as a demand that may be:

- Low: carrying out a single-step procedure (recalling and using a concept or locating information from a graph or table) (OECD, 2023).
- Medium: requires the use of two or more steps in reasoning using an idea, or relating two ideas in a single step, such as constructing an argument.
- High: requires the ability to make

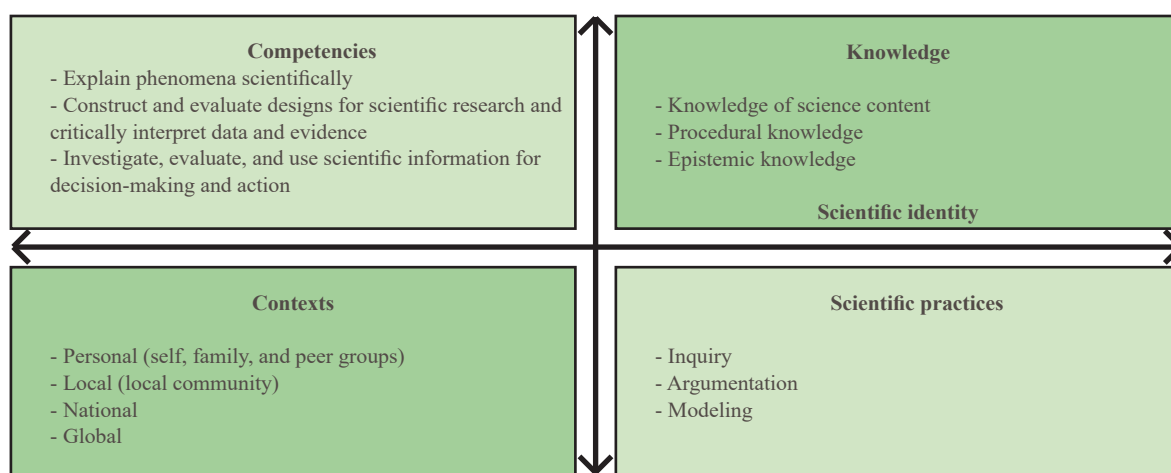


Figure 1: Summary of the aspects of scientific competence to be assessed in PISA 2025 [OECD, 2023]

Source: Author's own work, (2025).

connections between two or more pieces of evidence to develop an explanation (developing or evaluating a research plan).

The difficulty of any item, therefore, is a combination of the number and degree of complexity of the knowledge required, the level of prior knowledge, the cognitive operation required by the item (recall, analysis, evaluation), and the extent to which the response depends on abstract scientific models or ideas (OECD, 2023).

More specifically, Martín-Páez et al. (2019) propose a categorization of the skills that elementary school students must use to solve everyday situations and problems, identifying four types of skills:

- Type I Skills: the student's ability to recall, recognize, and describe the facts, concepts, and procedures necessary for scientific foundations.
- Type II skills: the use of scientific knowledge to generate explanations.
- Type III skills: scientific processes necessary to approach the study of situations (observing, searching for information, formulating hypotheses, and designing strategies).
- Type IV skills: associated with the use of scientific evidence (analyzing data, drawing evidence-based conclusions, and arguing) (Laya Iglesias and Martínez Losada, 2019).

2. Materials and Methods

To achieve the objectives outlined in this research, a descriptive content analysis methodology was employed, involving the identification and categorization of the empirical reality of texts or documents (the smart notebooks themselves) (as done in other studies such as that by Banegas and Tavella, 2021, and that of (Ornia Noriega et al., 2024), using various analysis tools adapted for this purpose. This methodological choice is justified by the aim of analyzing specific components of written documents through indicators and/or criteria already established by the prior theoretical framework. The content analysis presented in this research is of a descriptive-documentary nature because its objective, within a given study framework, is to describe and catalog the reality of the documents through the definition of categories (Piñuel, 2002). Conducting content analysis as a scientific process requires following a series of elements or stages, which will be detailed below (Andréu Abela, 2002).

2.1. Sample

The object of analysis in this research is the smart notebooks, as a methodological tool implemented throughout a school year, used in

the third cycle of Primary Education (5th and 6th grades) in bilingual instruction (Natural and Social Sciences) by Ruber Andrés et al. (2025). The selection of the objects of analysis was based on criteria of accessibility and interest: schools and/or teachers with proven experience in the prolonged use of the workbooks, and with accessibility for sample collection. From these, a selection was made, resulting in 17 workbooks collected from two schools across the two grades under study (5th and 6th).

The smart notebooks were collected during the first half of 2025. Together with the teachers who had used these notebooks, a preliminary analysis and discussion of how they implemented the tool in the classroom was conducted to understand the characteristics of each tool within its educational context. Subsequently, the coding process—known as the analysis phase proper—was carried out, which consists of transforming the raw text data into a system that represents it. This transformation, through decomposition, enumeration, and aggregation, results in a numerical representation of the analyzed content (Espín, 2002; Fernández, 2002).

The coding of the smart notebook analysis involved selecting the units of analysis (categories previously determined in distinct analysis tools) and selecting the counting rules, that is, the method for recording the units of analysis (Espín, 2002). In this study, the following were taken as indicators for these counting rules: the presence or absence of certain elements; the frequency or percentage of occurrence; and their contingency (the simultaneous presence of two or more units). Finally, the quantification process—or the assignment of numbers to variables—was carried out by either counting records for each category or assigning descriptive terms (Fernández, 2002). The analysis process is summarized in Figure 2.

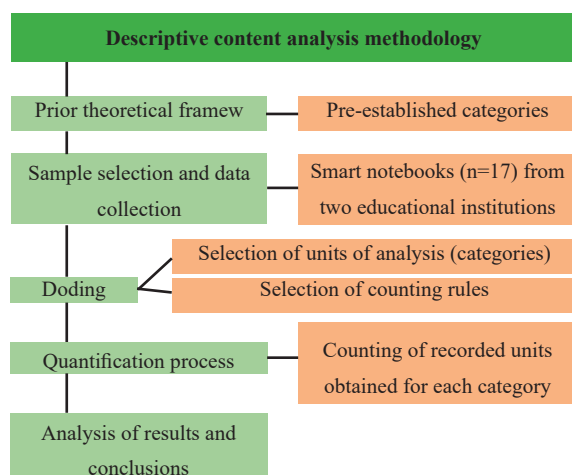


Figure 2: Diagram of the analysis process.
Source: Author's own work, (2025).

This final phase involves analyzing the data obtained and the conclusions of this study in the following sections. It should be noted that the results shown are the average data from the notebooks of the two schools in each grade level; thus, L 2 represents the average values of the notebooks collected at School L in 6th grade, and L 1 in 5th grade, and the same applies to School F (F1 are the average values at School F in 5th grade and F2 are the average values in 6th grade).

Once the “what” to be analyzed (smart notebooks) and the “why” and “for what purpose” (objectives) have been clarified, it is necessary to establish a plan for “how” to do it. This plan involves determining: instruments, units of analysis, and the category system to be used (Espín, 2002).

The units of analysis are the elements of the document that will be considered in the analysis and subject to categorization. To analyze these units, it is necessary to develop a system of categories.

For the development of the analytical tools, it was decided to work with a system of categories already established “a priori,” which were developed in other studies and derived from a theoretical framework. Specifically, the units of analysis are distributed across the different categories as they are encountered in the text. These categories were established to meet the minimum requirements set forth by Fernández (2002): homogeneity (categories must respond to a single classification criterion); exhaustiveness (the content must be fully classifiable); exclusivity (the same elements cannot belong to multiple categories); and adequacy and relevance (consistent with the objective).

The instrument designed and adapted for the analysis of the smart notebooks consists of three distinct tables:

1. The first table (Table 1 in Appendix A) is a tool for evaluating the three scientific sub-competencies according to cognitive demand, adapted from Pozuelo and Cascarosa (2023) and supplemented with the taxonomy of cognitive demand defined in the “PISA 2025 Framework” (OECD, 2023).
2. The second table (Table 2 in Appendix B) is a tool for simultaneously assessing the scientific knowledge and contexts of the smart notebooks, adapted from Pozuelo and Cascarosa (2023), incorporating the changes from the “PISA 2025 Framework” (OECD, 2023).
3. The third table (Table 3 in Appendix C) is a tool for assessing the scientific practices (inquiry, argumentation, and modeling) in the smart workbooks. The units of analysis are categorized according to scientific practice (adapted from similar instruments presented by Ferrés-Gurt et al. (2014) and Uskola et al. (2021)) and the cognitive demands required (OECD, 2023).

3. Results

The analysis of the data collected through the review of the smart workbooks was conducted by exhaustively recording the presence of scientific competencies, knowledge, contexts, and practices, and measuring the frequency of occurrence for each item in each analysis tool.

First, Figure 3 shows how the digital notebooks analyzed develop the three scientific sub-competencies proposed by the PISA Framework (OECD, 2023), highlighting Competency 1 (explaining phenomena scientifically) as the most developed, followed by Competency 3 (investigating, evaluating, and using scientific information [...]) with an average presence of

20–30%; and, finally, competency 2 (constructing and evaluating designs for scientific inquiry [...]) with varying results across the different workbooks (between 7.5% and 20%).

Looking at each of the scientific sub-competencies, Figure 4 shows how the smart workbooks excel in the development of scientific knowledge of the problem (40.2% presence); models or explanatory representations of knowledge (14.7%); and the search for, evaluation of, and communication of information sources (15.3%). Conversely, they show low values in constructing arguments based on a dataset (4.2%), decision-making regarding current problems (3.9%), and data validity.

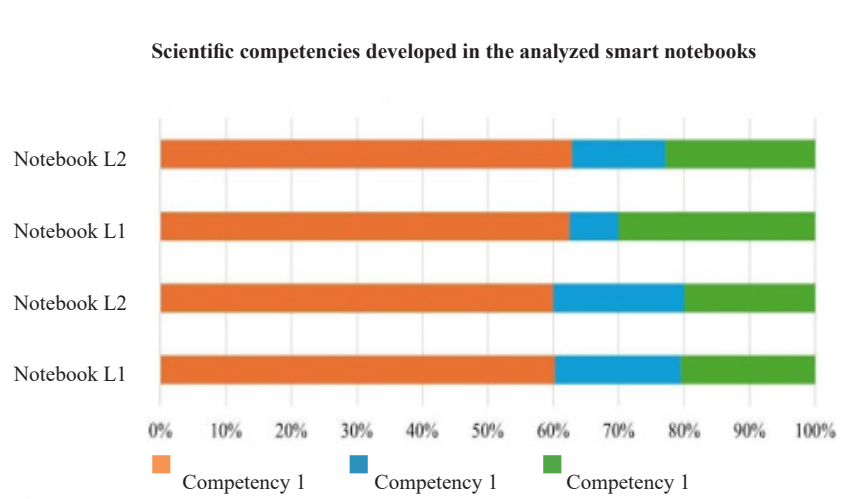


Figure 3: Graph of scientific competencies developed in the smart workbooks (see Table 1 in Appendix A).
Source: Author's own work (2025).

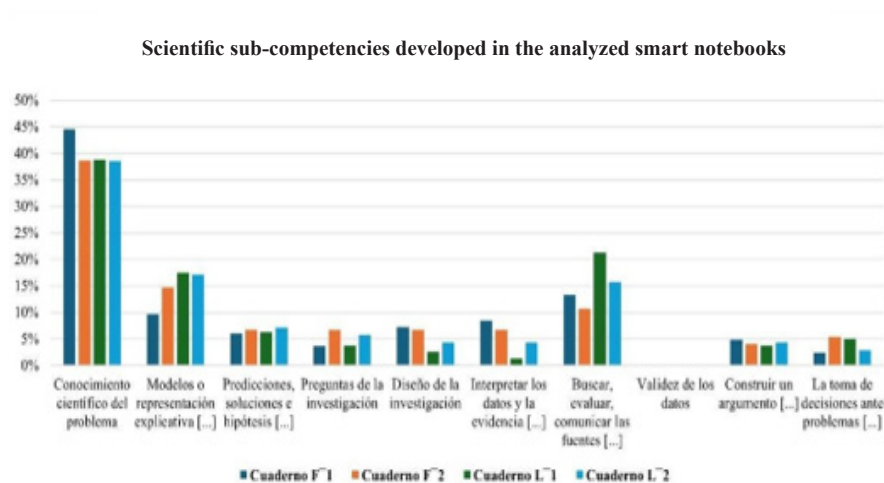


Figure 4: Graph of the scientific sub-competencies developed in the smart notebooks (Table 1 in Appendix A).
Source: Author's own work (2025).

As mentioned above, a key feature of the PISA 2025 framework (OECD, 2023) is cognitive demand. As can be seen in Figure 5, in the workbooks from School “F,” the cognitive tasks most frequently required of students are recalling (36.1% and 34.7%) and applying (26.5% and 30.7%); whereas in the workbooks from School “L,” the most frequently required cognitive tasks are creating (33.8% and 30%) and understanding (20% and 22.9%). Both models agree that the least frequently required cognitive tasks are analyzing (average of 4.9%) and evaluating (average of 0.3%).

Cognitive demand of the scientific competencies developed in the analyzed smart notebooks

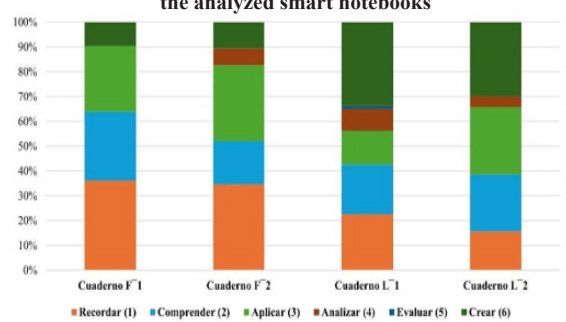


Figure 5: Graph of the cognitive demands of the scientific competencies developed (see Table 1 in Appendix A).
Source: Author's own work (2025).

As stated in the PISA 2025 framework (OECD, 2023), all the competencies analyzed above require scientific knowledge. For students to explain phenomena scientifically, for example,

content knowledge is necessary; to conduct research, procedural and epistemic knowledge is required. The workbooks analyzed stand out in the development of scientific concepts associated with the tasks (36% average presence) [content knowledge]; the formulation of questions about the material world (17%) [procedural]; and the use of science and technology in real-world problems (8%) [epistemic] (Figure 6). All three types of knowledge are represented in the tool, with content and procedural knowledge appearing most frequently. In contrast, the least developed areas of knowledge are scientific laws and theories, the nature of science (objectives, commitments), and the validity of data.

The presence of scientific contexts is another variable to analyze (Figure 7). Smart notebooks are an effective tool for working on concepts in a contextualized manner, as they address all types of scientific contexts, in line with findings from previous studies (Caamaño, 2012; Muñoz Campos et al., 2020). Specifically, the most frequently used contexts are global (51% on average), followed by personal (26%), while the least used are national (13%) and local (10%).

Regarding the scientific practices developed, the smart notebooks analyzed demonstrate that the notebooks address the three scientific practices identified in previous studies (Muñoz Campos et al., 2020; NRC, 2012). Inquiry accounts for over 60% of the content in the four models analyzed,

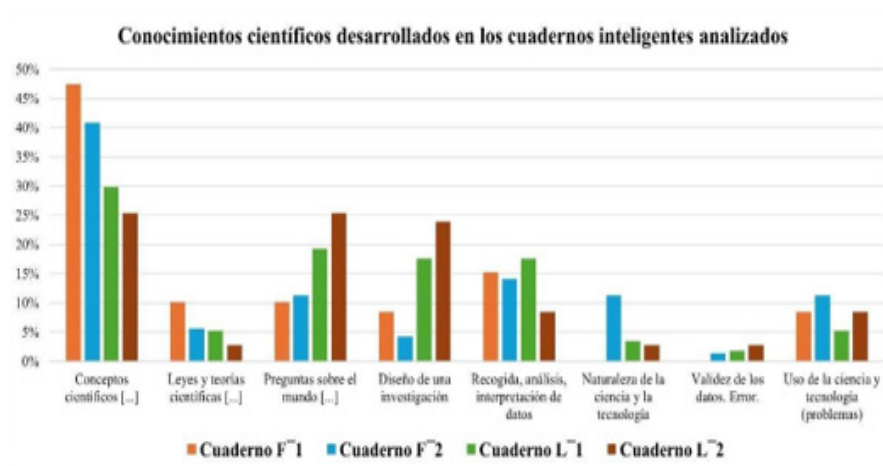


Figure 6: Graph of scientific knowledge developed in the smart workbooks (Table 2 in Appendix B).
Source: Author's own work (2025).

making it the most developed practice, followed by modeling, which accounts for an average of 30.5%, and argumentation, which is present in 6.4% of cases (Figure 8).

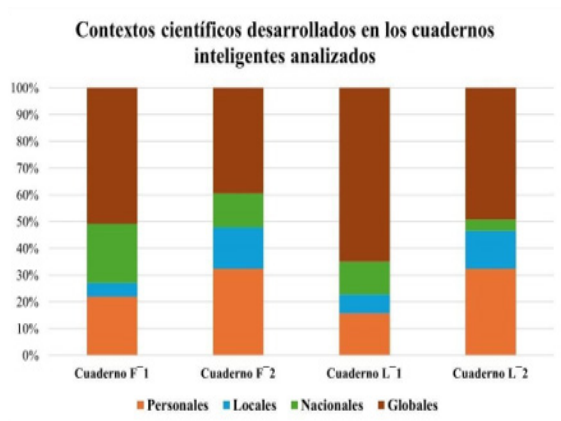


Figure 7: Chart of the scientific contexts developed in the smart workbooks (Table 2 in Appendix B).
Source: Author's own work (2025).

Specifically, in Table 4, it can be observed that the most developed scientific practices with this tool are pictorial representations (25.4%) [modeling], information search (19.5%), problem or question identification (11%), hypothesis formulation (10.9%), and metareflection (10.5%) [inquiry]. In contrast, the least developed scientific practices are those related to argumentation (justification, disadvantages, and opposing viewpoints) and the use of experiments (3%), scale models (2.1%), and computer-based simulations or role-playing (0%).

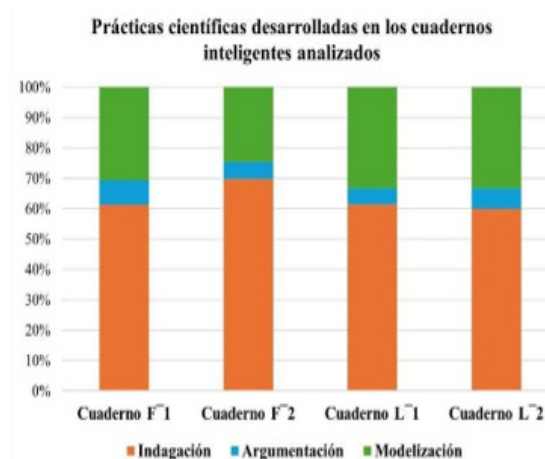


Figure 8: Graph of scientific practices developed in the smart workbooks (Table 3 in Appendix C).
Source: Author's own work (2025).

Regarding the cognitive demands of these practices (Figure 9), following the classification by Caamaño (2012) and Windschitl (2003), the smart notebooks analyzed reveal the presence of structured (45.9%), guided (31.5%), and open-ended (22.6%) scientific practices. However, differences are observed between the models from School 'L', where there is a slight balance among the three types of practices, and the models from School 'F', where structured and guided practices predominate over open ones. Figure 10 shows images of some of the notebooks analyzed.

Table 4: Table of scientific practices developed in the smart notebooks (Table 3 in Appendix C).
Source: Author's own work (2025).

	F , Workbook 1	F , Book 2	L , Book 1	L Workbook 2	MEDIA
Problem Identification	14,5%	13,2%	5,3%	11,1%	11%
Searching for information	12,9%	15,1%	29,8%	20,0%	19,5%
Formulation of hypotheses	16,1%	9,4%	7,0%	11,1%	10,9%
Research planning	0%	7,5%	3,5%	8,9%	5%
Data Analysis and Conclusions	4,8%	9,4%	1,8%	8,9%	6,2%
Metareflection	12,9%	15,1%	14,0%	0%	10,5%
Justification	4,8%	3,8%	5,3%	6,7%	5,1%
Disadvantages	3,2%	1,9%	0%	0%	1,3%
Short position	0%	0%	0%	0%	0%
Pictorial representations	22,6%	20,8%	31,6%	26,7%	25,4%
Scale models	6,5%	1,9%	0%	0%	2,1%
Experiments	1,6%	1,9%	1,8%	6,7%	3%
Role-playing or simulations	0%	0%	0%	0%	0%

Cognitive demand of the analyzed scientific practices (Table 3)

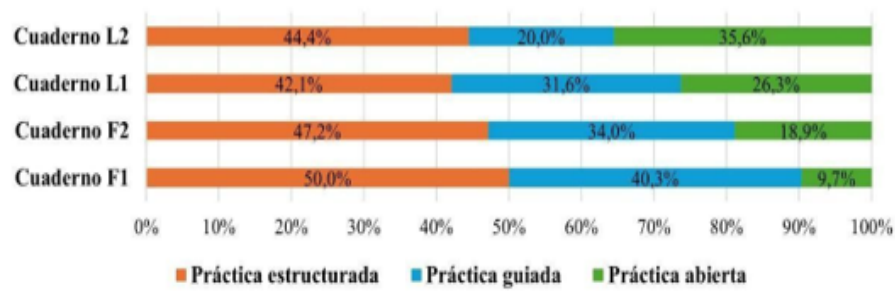


Figure 9: Graph of the cognitive demands of the analyzed scientific practices (Table 3 in Appendix C).
Source: Author's own work (2025).

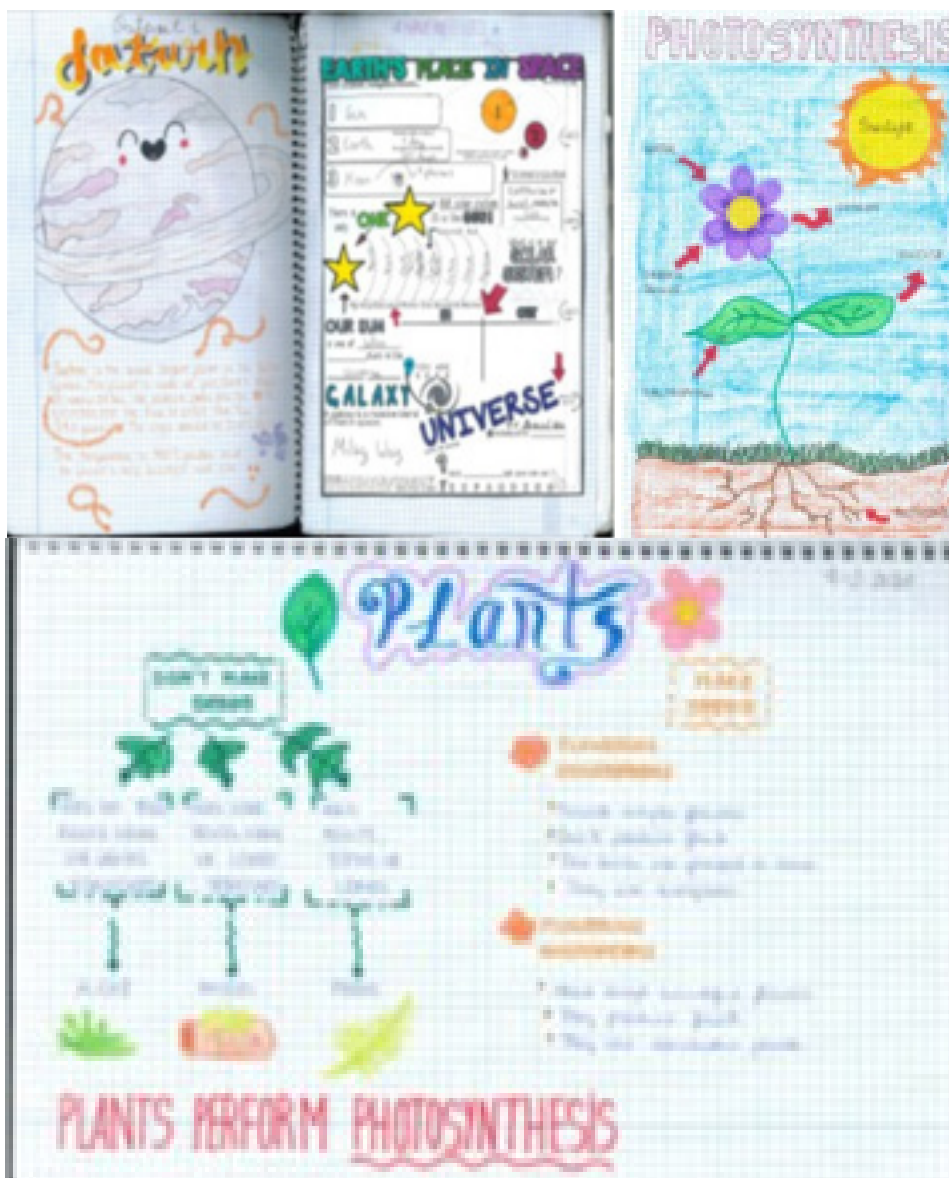


Figure 10: Excerpts from analyzed notebooks.
Source: student notebooks (2025).

4. Discussion and Conclusions

After analyzing the content of the 17 smart workbooks, this study concludes that they are a suitable and effective methodological tool for developing scientific competence in the science-teaching and learning process within English-language bilingual education. These data support previous studies demonstrating that smart notebooks improve the acquisition of scientific knowledge (Mallozi, 2013) and develop scientific skills and abilities, particularly in model representation and information retrieval (Bravo-Torija et al., 2016). Regarding scientific competence, first, it should be noted that the tools designed to analyze scientific competencies have proven effective for the objective set forth in this research. Through their application, the necessary evidence has been gathered to conclude that the smart notebooks analyzed demonstrate a comprehensive development of scientific competence, addressing each of the three sub-competencies that comprise it and preparing students to explain phenomena scientifically, construct and evaluate designs for scientific research, or use scientific information for decision-making. This methodological tool aligns with the current benchmark for assessing this competency: the PISA 2025 framework (OECD, 2023). The workbooks excel in several sub-competencies, such as the development of scientific knowledge, model building, and information retrieval. In addition, it requires students to perform tasks that involve low cognitive demands, such as “remembering” or “understanding,” alongside others that involve high cognitive demands, such as “applying” or “creating.”

The smart workbooks also stand out for their inclusion of three types of scientific knowledge (content, procedural, and epistemic) and four types of scientific contexts (personal, local, national, and global). The results align with previous studies on the concept of learning in context, allowing for the observation of a wide variety of scientific concepts and theories in everyday situations (Chamizo & Izquierdo, 2005) and the establishment of connections between

what is learned in the classroom and what occurs outside of it (Sanmartí & Márquez, 2017).

Another aspect worth highlighting is the development of the three scientific practices, with inquiry and modeling being more prevalent than argumentation. The most developed practices are pictorial representations and information seeking, as was already evident in previous studies on improving smart notebooks for scientific skills and processes (Bravo-Torija et al., 2016; Marcarelli, 2010). The low level of argumentation may be due, in large part, to the difficulty of constructing arguments in a foreign language and to the lack of the necessary vocabulary to formulate positions for or against an argument. Furthermore, the scientific practices addressed present the three levels of cognitive demand proposed by Windschitl (2003) and Caamaño (2012) in a balanced manner. The smart workbooks include: structured activities that present the question and the procedure; guided activities that allow students to decide how to solve the tasks; and open-ended activities that let students decide what to investigate, argue, or model and how to do so.

Regarding cognitive demands, while the workbooks analyzed encourage information-seeking, they also contain few tasks requiring students to analyze or evaluate this information or scientific data. This result could be attributed to the lack of experiments and scientific investigations, as noted earlier. When analyzing the cognitive demands of scientific activities, there is a limited number of tasks requiring open-ended inquiry, modeling, or argumentation—in which the teacher allows students to decide what and how to investigate—most are structured and guided.

Based on the results regarding scientific knowledge and contexts, there is a clear need to introduce a greater presence of scientific laws and theories, with greater depth than scientific concepts, and to include tasks contextualized within students’ local and national environments.

5. Limitations

This study has some limitations that should be considered when interpreting the results. First, the sample size is small, as the analysis was conducted on only 17 smart notebooks from two schools. Furthermore, the selection was based on criteria of accessibility and teachers' prior experience using this tool, which may introduce some bias into the sample. Therefore, the results obtained cannot be generalized to all educational contexts or to all bilingual elementary schools; future research should expand the sample and include schools with diverse organizational and methodological characteristics.

Second, the research is based exclusively on a documentary analysis of the content of the smart notebooks, which allows for identifying evidence

of the development of scientific competencies but does not directly evaluate students' learning processes or the actual impact of this tool on their academic performance. Furthermore, as the study was conducted in a bilingual education context, the use of a foreign language may influence how students express their scientific ideas and the development of certain practices, especially those related to scientific argumentation. This linguistic factor has not been specifically analyzed in the present study; therefore, future research could delve deeper into the interaction between the development of scientific competence and linguistic competence in CLIL contexts, while also incorporating other sources of information, such as classroom observations or interviews with teachers and students.

6. Acknowledgments

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Appendix A. Table 1. Tool for assessing scientific competencies based on the cognitive demands of smart notebooks [adapted from Pozuelo and Cascarosa (2023); and OECD (2023)].
Source: Prepared by the author, 2025.

		ASSESSMENT OF SCIENTIFIC COMPETENCIES					
		Cognitive Demand					
		Low	Medium			High	
		Recall (1)	Comprehend (2)	Apply (3)	Analyze (4)	Evaluate (5)	Create (6)
Explain scientific phenomena	Scientific understanding of the problem	Recall the scientific knowledge associated with the problem	Understands the scientific knowledge associated with the problem	Applies the acquired scientific knowledge to the problem acquired	Analyze the relevance of your scientific knowledge to the	Assess whether your knowledge is sufficient to address the problem	Expand your knowledge to address the problem
	Models or explanatory representations of knowledge and their implications for society	Understand the explanatory models (ideas, frameworks, theories, etc.) associated with your problem	Understand the role of explanatory models (ideas, frameworks, theories, etc.) associated with your problem and their implications for society	Apply explanatory models (ideas, frameworks, theories, etc.) to solving your problem	Analyze the role of explanatory models (ideas, frameworks, theories, etc.) in your problem and their social implications	Assess the adequacy of explanatory knowledge (ideas, frameworks, theories...) to address your problem	Combines their explanatory model (ideas, frameworks, theories, etc.) with other models that may help address the problem
	Predictions, solutions, and explanatory hypotheses	Understands the foundations of scientific methods and the need to propose explanatory hypotheses or solutions	Understands the role of predictions and hypothesis formulation in a problem	Proposes appropriate predictions or hypotheses for a problem but without justifying them	Analyze the feasibility of a hypothesis using some form of evidence (e.g., comparison with other hypotheses)	Evaluates scientific predictions, solutions, and hypotheses based on evidence	Generates arguments to defend or refute explanatory hypotheses
Skills	CDDevelop and evaluate designs for scientific research and critically interpret data and scientific evidence						
	Research questions	Identifies scientifically investigable questions	Understands the role of questions in scientific research	Applies scientifically investigable questions to their research or assignments	Analyze whether or not research questions are scientifically investigable	Evaluates whether the formulated question is the most appropriate for scientific research	Designs a research project based on their own scientifically investigable question justifying its formulation
	Research Design	Understands different ways of conducting scientific research	Identify the research method [design] in a given study	Apply a research method [design] to answer a question or solve a scientific problem	Analyze different ways to answer questions scientifically	Evaluate whether the research method is appropriate given the objectives to be achieved or the question that needs to be	Design the research or the steps to follow, justifying your decisions and meeting the proposed objectives
	Interpret data and scientific evidence	Identifies data and scientific evidence in a scientific investigation	Understand and interpret the data and scientific evidence in a scientific investigation	Applies the data and scientific evidence obtained in a study without drawing conclusions from the data	Analyze the data and scientific evidence obtained in a research study to draw appropriate conclusions from the data	Evaluates and assesses the data and scientific evidence obtained in a research study	Generates solid arguments based on the data and scientific evidence obtained in a research study, drawing their own conclusions
Research, evaluate, and use information	Search for, evaluate, and communicate sources of information	Recalls data collection processes and representations	Understand data collection processes and representations	Collects data and represents it within a scientific investigation scientific	Analyzes data without drawing conclusions	Evaluates data by comparing it with data from other studies	Draws conclusions based on the data obtained
	Data validity	Understands the methods scientists use to validate data	Understands the value of data validation as a sign of consistency in a scientific investigation	Apply a data validation method in a research scientific	Analyze the results of data validation in a research	Evaluate the validity of the data, distinguishing between claims	Draw conclusions about the validity of a information or data within a scientific investigation
	Build an argument based on a set of data	Understands and recalls the meaning and value of arguments and data in a scientific	Identifies data and arguments in scientific research	Uses arguments, but without relying on evidence or data	Analyze the data and arguments presented in a scientific investigation	Evaluate the data and arguments found or presented in a scientific study	Formulates their own arguments based on scientific data and evidence
	Decision-making regarding current issues [sustainable development]	Knows and recalls current issues related to the environment and sustainable development [Agency in the Anthropocene]	Understand current issues related to the environment and sustainable development [Agency in the Anthropocene]	Applies their knowledge to decision-making regarding current issues [Agency in the Anthropocene]	Analyze decisions made regarding current issues related to the environment and sustainable development [Agency in the Anthropocene]	Evaluates and compares possible decisions regarding current issues related to the environment and sustainable development [Agency in the Anthropocene]	Makes well-reasoned decisions regarding current issues related to the environment and sustainable development [Agency in the Anthropocene]

Appendix B. Table 2. Tool for evaluating the scientific knowledge and contexts in smart notebooks [adapted from Pozuelo and Cascarosa (2023); and OECD (2023)].

Source: Prepared by the author, 2025.

		ASSESSMENT OF SCIENTIFIC KNOWLEDGE AND CONTEXTS			
		Scientific contexts			
		Personal (with oneself, the family, and peer groups)	Local (with the local community)	National	Global
Scientific knowledge	Understanding of scientific content	Scientific concepts related to the task			
		Scientific laws and theories related to the task			
	Procedural knowledge	Questions about the material world			
		Research design			
		Data collection, analysis, and interpretation of data			
	Epistemic knowledge	Nature of science and technology (objectives, commitments...)			
		Validity of data. Error.			
		Use of science and technology to address real-world problems			

Appendix C. Table 3. Tool for evaluating scientific practices in smart notebooks [adapted from Ferrés-Gurt et al. [2014]; Uskola et al. [2021]; and OECD (2023)].

Source: Author's own work

		EVALUATION OF SCIENTIFIC PRACTICES		
		Levels based on scientific practice and cognitive demand		
		Structured inquiry (the teacher generates the question and proposes the procedure)	Guided inquiry (the teacher proposes the questions and the students decide how to solve them)	Open inquiry (students decide what to investigate and how to do it)
Scientific Practices	Investigation	Identification of problems or questions that can be investigated		
		Information search		
		Formulation of hypotheses		
		Research planning (data collection)		
		Data analysis and drawing conclusions		
		Metareflection		
	Argumentation	Structured Argumentation (the teacher presents the argument and suggests various options for supporting it)	Guided Argumentation (the teacher presents an argument, and the students decide how to support or refute it)	Open Argumentation (students develop their own argument, along with its justification and/or refutation)
		Justification		
		Disadvantages		
		Opposing position		
	Modeling	Structured modeling (the teacher creates the assignment and provides the model to be replicated)	Guided modeling (the teacher assigns the task, and the students decide how to develop the model)	Open modeling (students decide what to model and how to do it)
		Pictorial representations		
		Scale models (miniatures)		
		Experiments		
		Live-action reenactments or computer simulations		

Transformation of the Natural Landscape and Urban Effects in the Cumbaza River Basin, Morales District (Peru)

Transformación del paisaje natural y los efectos urbanos en la cuenca del Río Cumbaza, Distrito de Morales (Perú)

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Transformation of the Natural Landscape and Urban Effects in the Cumbaza River Basin, Morales District (Peru)

Transformación del paisaje natural y los efectos urbanos en la cuenca del Río Cumbaza, Distrito de Morales (Perú)

Abstract:

The rapid growth of cities poses a significant threat to environmental balance due to the transformations it causes in the natural landscape and the Cumbaza River basin. The purpose of this research is to evaluate land-use changes and their ecological effects through a multitemporal analysis of aerial images from 1969, 1985, 2005, and 2024. Additionally, field verifications were conducted in 2024 to confirm the interpretation of land cover, vegetation, and changes in the physical environment. The results show a progressive replacement of natural and agricultural areas by residential, industrial, and recreational zones, which has led to biodiversity loss, habitat fragmentation, and alterations in water dynamics. It is concluded that these processes continuously transform the natural environment, highlighting the urgency of strengthening sustainable territorial planning through the integration of ecological criteria.

Keywords: urban space, watersheds, ecology, land use, territorial planning.

Resumen:

El crecimiento acelerado de las ciudades representa una amenaza significativa para el equilibrio ambiental, debido a las transformaciones que provoca en el paisaje natural y la cuenca del río Cumbaza. Esta investigación tiene como propósito evaluar los cambios territoriales y sus efectos ecológicos mediante un análisis multitemporal de imágenes aéreas correspondientes a los años 1969, 1985, 2005 y 2024. Asimismo, se realizaron verificaciones de campo en 2024 con el fin de confirmar la interpretación de las coberturas del suelo, la vegetación y las modificaciones del entorno físico. Los resultados evidencian una sustitución progresiva de áreas naturales y agrícolas por zonas residenciales, industriales y recreativas, lo que ha generado pérdida de biodiversidad, fragmentación del hábitat y alteraciones en la dinámica del agua. Se concluye que estos procesos transforman de manera continua el entorno natural, resaltando la urgencia de fortalecer la planificación territorial sostenible mediante la integración de criterios ecológicos.

Palabras clave: espacio urbano, cuencas hídricas, ecología, uso del suelo, planificación territorial.

1. Introduction

The rapid urbanization of cities in Peru has led to significant transformations in recent years (Hevia Milián, 2020); this phenomenon has drastically altered landscapes, affecting natural reserves, increasing the consumption of natural resources such as water, and exerting pressure on biodiversity (Rojas et al., 2015).

As a consequence of this expansion and, in many cases, inadequate planning, the occupation of urban space and residential informality became evident (Hernández-Linares et al., 2018). Therefore, these areas are significant in territorial planning and social welfare (Meléndez et al., 2017), providing the population with space for settlement and contributing to regional development. However, this dynamic has also generated disorderly population growth, reducing areas that could function as urban lungs for present and future generations.

Land occupation has spread toward peripheral areas, generating dispersed growth that contrasts with new sectors that are becoming increasingly organized and dense. In this process, patterns can be observed in lot sizes, occupancy density, land value, and the social distribution of the territory (Desmaison et al., 2018). Analysis of the urban structure reveals a trend toward the reduction of forested areas near rivers (Zucchetti, 2020), indicating an encroachment into fragile and poorly consolidated sectors from an urban planning perspective (Gálvez Paredes, 2019). This dynamic has a direct impact on local ecology, affecting both biodiversity and ecosystem services.

The purpose of the research was to examine landscape transformation and the impacts resulting from urban growth in the Cumbaza River basin, located in the district of Morales, province and department of San Martín, Peru. The study addresses the relationship between the physical-spatial components of the urban environment within the framework of water resource management overseen by the ANA (National Water Authority, 2018), an entity created by

Legislative Decree No. 997 (Presidency of the Council of Ministers, 2008), which is responsible for the administration and conservation of water resources in the country. Landscape biodiversity, defined as the variety and presence of organisms in the ecosystem, is affected by anthropogenic factors associated with urban growth, which alter the structure and functionality of the natural environment (Chen et al., 2022). Thus, this research aims to identify the most significant changes that have occurred in the landscape over the past decades and to understand their causes and effects on the ecological structure of the watershed, so that, in the medium and long term, guidelines can be proposed that promote sustainable urban development and balanced environmental management of the territory.

1.1. Negative Impacts of Urbanization

Urbanization drives territorial transformation by organizing both urban and rural spaces, consolidating land for residential use (Rojas et al., 2017). In Peru, this process is governed by various legal frameworks for urban development (Surrallés, 2020). According to the Ministry of Housing, Construction, and Sanitation (2021), these developments must be properly consolidated and meet basic requirements, including the provision of public services, water and sewer networks, and adequate road infrastructure.

The impact of urban developments in the Cumbaza River basin is evident in the transformation of natural land into artificial surfaces. This process, driven by urban expansion, has been extending built-up areas toward the riverbed, prioritizing economic interests over social and cultural criteria that benefit the population (Franco Muentes & Escobar García, 2019). From this perspective, natural resources are increasingly perceived as tradable goods in the market (Cornejo Guerrero, 2017), offered to investors as opportunities for profit. Consequently, land values have experienced a sustained increase due to urbanization around the river, driving up land prices despite lax compliance with

regulations governing its use (Menacho Sánchez, 2018). This phenomenon has driven speculative appreciation of areas adjacent to the riverbed, even incorporating restricted zones—such as riparian strips—into the real estate market (Rafael & Díaz, 2020), which is interpreted, from the perspective of capitalist urbanization proposed by Harvey (2007), as a process in which land becomes a financial asset subject to dynamics of accumulation.

Established developments have altered the functioning and structure of the watershed's ecosystem, reducing vegetation cover, fragmenting natural habitats, and reducing the landscape's ecological connectivity. These changes directly affect ecosystem processes, including soil stability, water regulation, and biodiversity conservation, thereby compromising the watershed's ecology and existing vegetation. The water that supplies the province, primarily for agricultural purposes, originates in the upper part of the Cordillera Escalera Regional Conservation Area (ACR) via the Cumbaza River; it is this river that preserves primary forests. Likewise,

many mountains and waterfalls originate here, along with their rich biodiversity.

Therefore, the vegetation is a true natural paradise that we must protect, as reflected in its forests; consequently, monitoring and surveillance of these areas are necessary (Alto Huallaga Special Project, 2010). This important watershed has come under pressure from urban expansion over time, impacting not only land use but also the natural environment—the latter being the most fragile and distinctive feature not only of the city but also of the province.

On the other hand, the failure to enforce environmental regulations and their practical guidelines leaves many activities unregulated, and the impact of urban development (Rojas et al., 2017) threatens existing animal life, such as fish and microorganisms. Finally, water pollution from waste and sediment is clearly visible in some sections of the Cumbaza River. This issue is a nationwide reality: 200,000 hectares of forest are deforested annually in Peru (Amazonian Forests, 2023), and many rivers across the country are polluted by solid waste and wastewater.

2. Materials and Methods

To obtain the final analysis of urban sprawl and vegetation fragmentation in the watershed, we digitized satellite images from 1969, 1985, 2005, and 2024, enabling analysis of land use and vegetation cover in the study area over time. To gain a better understanding and obtain more accurate values, field visits were conducted to closely observe and interpret the types of cover present to date, focusing on: (i) areas with visible changes in the satellite images, (ii) transition zones of natural vegetation, (iii) areas of high anthropogenic pressure, and (iv) key points of typical housing.

To complement the satellite analysis, aerial surveys were conducted during the 2024 dry season using a DJI Phantom 4 Pro drone equipped with a 20-megapixel camera and high-precision GPS. The flights were conducted in the morning at an approximate altitude of 120

meters, achieving uniform coverage of the urban and peri-urban areas of the Cumbaza River basin. Flight planning was carried out using the DJI GS Pro application, with an 80% longitudinal and 70% transverse overlap, ensuring the spatial continuity and sharpness of the images obtained. The images obtained were used as high-resolution inputs for validating and updating land cover classifications derived from satellite imagery. Based on this, georeferenced orthomosaics were generated, providing greater precision to the analysis of urban expansion, land-use changes, and fragmentation. All this information was integrated into the multitemporal comparative analysis, facilitating the verification of details and reducing interpretation errors stemming from the low spatial resolution of historical images.

The selection of 1969, 1985, 2005, and 2024 responds to the need to analyze the most

representative stages of the transformation of the natural landscape in the Cumbaza River basin. The initial period of 1969 corresponds to a scenario prior to urban growth and was based on aerial photographs from the National Geographic Institute (IGN). For 1985 and 2005, images from the United States Geological Survey's (USGS) Landsat 5 TM and Landsat 7 ETM+ satellites were reviewed, with a resolution of 30 meters and cloud cover of less than 10%. The selection of these time periods was based on criteria of satellite data availability and continuity, with complete, comparable records and adequate radiometric quality within the historical Landsat series. Furthermore, these dates represent intermediate points that enabled the analysis of the progressive evolution of urban expansion and land cover changes, thereby ensuring the validity of the multitemporal analysis methodology. In 2024, records from the Copernicus program's Sentinel-2A satellite and Google Earth Pro were used, selected for their visual clarity and optimal lighting conditions. The selection criteria considered temporal representativeness, image quality, and availability, and their utility for highlighting urbanization processes and environmental change in the watershed. The Sentinel-2A images, with a spatial resolution of 10 meters, were integrated into a GIS environment for interpretation and comparative historical analysis. The minimum mapping unit was set at approximately 900 m², and the images were georeferenced and visually analyzed, enabling the identification and characterization of more recent periods.

Based on field data and aerial photographs, the analysis was classified into two levels (Table 1). The first level focuses on urbanized areas. The Ministry of Housing, Construction, and Sanitation (2021) defines urbanized territories as areas occupied by urban space, which may or may not be formal and may or may not have access to basic services. The second level focuses on built housing, artificial green spaces, croplands, grasslands, and forests. It incorporates the category of natural landscape, defined as areas with a predominance of vegetation cover and minimal human intervention. Each classification primarily encompasses urban and peri-urban

green areas, data that are highlighted graphically on the digitized maps.

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Subsequently, the maps derived from the land cover data for each year were integrated into the GIS environment to perform a multitemporal comparison through spatial overlay and analysis

Table 1. Land Use Classification (2024).
Source: Author's own work (2024).

Item	Category	Code	Description
1	Urbanized area	1.1	Built-up areas
		1.2	Landscaped green areas
2	Agricultural areas	2.1	Temporary crops
		2.2	Permanent crops
		2.3	Pastures
3	Forested and semi-natural areas	3.1	Forests
		3.2	Shrub and herbaceous areas

of land cover change. This process allowed us to examine transitions between categories—for example, from natural or agricultural landscapes to urbanized areas—by quantifying urban expansion, landscape fragmentation, and vegetation loss, thereby enabling interpretation of transformations in the Cumbaza River basin over the study period.

2.1. Case Study

River pollution in Peru has been an environmental problem that today affects both watersheds and the people who depend on this vital resource. The spread of urban areas also plays an important role in the degradation of natural resources (Sabogal et al., 2019). The city's growth and the lack of adequate equipment to treat wastewater contribute negatively to river pollution; sewage from sewer systems that is not channeled to wastewater treatment plants (WWTPs) is discharged into water bodies (Ministry of the Environment, 2018), as is the case with the Cumbaza and Shilcayo rivers, where these discharges directly affect the watersheds and their ecosystems (García Sinti, 2016).

For this study, we analyzed the Cumbaza River watershed (Figure 1), defined as the territorial unit comprising a network of surface watercourses that converge into the river, which is a major water source in the San Martín region. These waters are used in large quantities for agriculture, an activity that drives the province of San Martín's economy. Consequently, landscape degradation and pollution affect the watershed due to human activities and domestic wastewater discharges, thereby impacting land use and the water quality of the Cumbaza River.

Furthermore, this watershed is a destination for migratory birds, various insects, and tourists and swimmers from the area, who often visit during regional festivals to spend time with family and friends and to cool off amid the intense climate of this part of the Peruvian jungle. It is also important to consider this watershed, which is a tributary of the Mayo River, which flows into the Huallaga River, one of the most important navigable rivers in the Peruvian Amazon.

2.2. Landscapes within the study area

The landscape analysis evaluated the different areas within the study area, taking into account their visual perception (Morlans, n.d.). This research analyzes changes in land use and environmental conditions in the Cumbaza River basin, incorporating criteria such as urban land use, vegetation cover, and landscape fragmentation to determine visual quality and fragility (Table 2).

Regarding visual fragility, we refer to landscape sectors that are more susceptible to land-use changes. This tool is fundamental in urban planning, as the information it provides enables the identification of the most vulnerable areas and the prioritization of actions in response to the current situation. Three observation points were defined from which images were recorded to facilitate the identification of areas in conflict with urban expansion (Figure 2). Furthermore, the research was supplemented by 10 semi-structured interviews with residents, selected through convenience sampling and snowball sampling. These informants have lived in the Morales study area for more than 15 years, which allowed for a precise understanding of the changes and deterioration that have occurred in the Cumbaza River basin and its vegetation over the past decades. Based on the interviews conducted, a field photographic survey was carried out to corroborate the testimonies

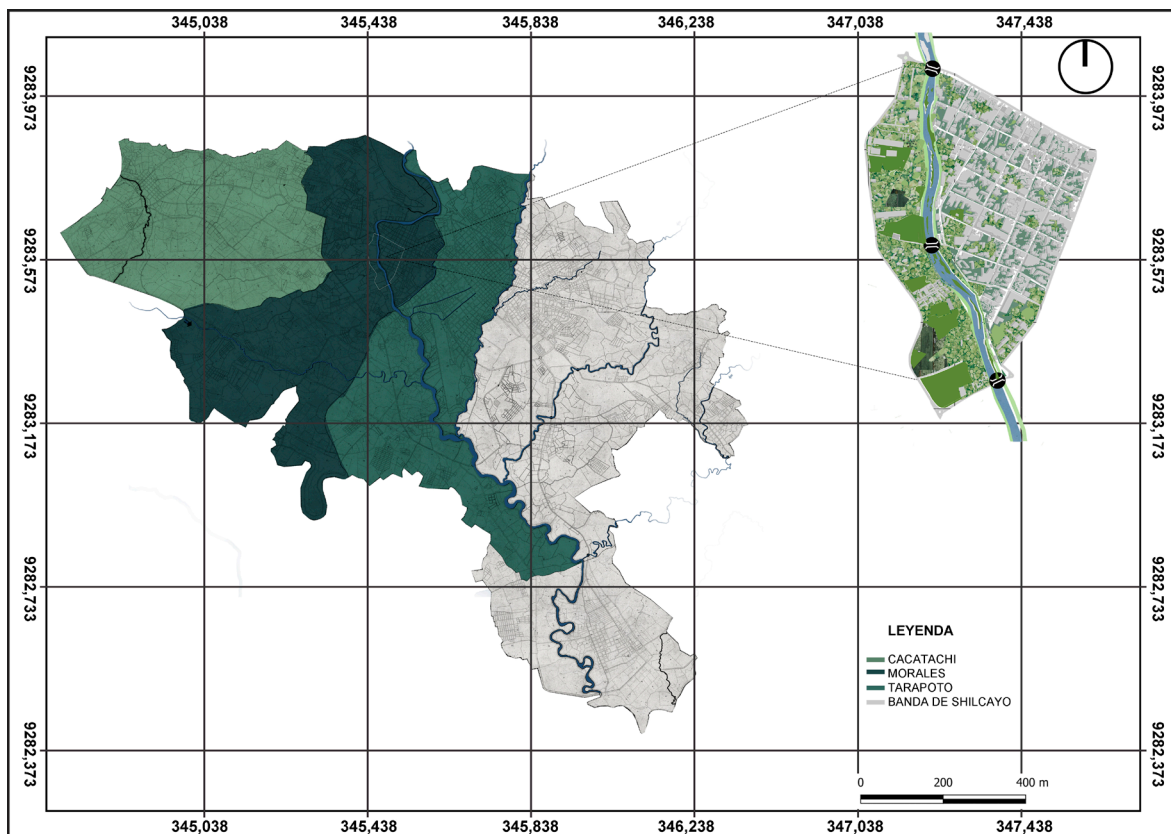


Figure 1. Study area of the Cumbaza River basin, San Martín Province and Region, Peru (2024).

Source: Author's own work (2024[1])

obtained and compare them with the actual conditions of the territory. This enabled the identification of land-use changes and urban expansion, especially in areas near the river channel or banks. Consequently, the interviews addressed three main themes: perceived changes in land use, the transformation of the natural

landscape, and the impacts of urban expansion on the Cumbaza River. All the information was analyzed qualitatively through thematic coding, complementing and interpreting the results obtained from the multitemporal cartographic analysis.



Figure 2. Identification points of affected areas, Morales District, San Martín Province and Region (2024).
Source: Author's own[2.1] work (2024)

3. Results

The results show rapid urban growth alongside a decline in agricultural and forested areas (Table 2). This expansion is driven by high demand for land and population growth, which has reduced vegetation cover and affected the Cumbaza River basin. Since the 1960s, urban expansion has

replaced large areas of forest with native and exotic species. The impact is evident in areas such as Villa Sofía, Las Sombrillas, Mirador del Cumbaza, San Andrés, Cumbacillo, Villa Blanca, and Betania, where urban growth has disrupted the ecological balance.

Table 2. Land-use classification for the years 1969, 1985, 2005, and 2024, expressed in hectares (2024)
Source: Compiled by the author (2024)

Level 1		Level 2	1969 (ha)	1985 (ha)	2005 (ha)	2024 (ha)
1	Urbanized area	1.1 Built-up areas	0.81	4.03	20.96	41.90
		1.2 Landscaped green areas	8.97	9.16	11.16	7.16
2	Agricultural areas	2.1 Temporary crops	0.00	8.75	5.80	1.85
		2.2 Permanent crops	0.00	0.00	1.17	2.35
		2.3 Pastures	9.65	8.44	20.01	40.03
3	Wooded and semi-natural areas	3.1 Forests	28.96	25.31	17.53	11.53
		3.2 Shrub and herbaceous areas	57.93	50.63	30.63	8.44
TOTAL			106.32	106.32	107.27	113.26

3.1. Soil classification over time

The multitemporal study reveals a clear process of urban expansion and degradation of the natural landscape in the Cumbaza River basin (Figure 3). According to the maps analyzed (Figure 4), in 1969, urban development was in its early stages, concentrated on the left bank of the river, while the right bank retained significant vegetation cover. Between 1985 and 2005, crops and housing began to appear on the right bank, although the left bank continued to grow at the same pace. From 2005 to 2024, urbanization accelerated significantly, progressively encroaching on agricultural land and transforming the natural environment.

Urbanized area: The figure shows a steady increase in urbanized area from 1969 to 2024. In the early years, built-up areas covered a small area, but beginning in 1985, they grew progressively, reaching nearly 60% of the total area by 2024. This increase reflects a sustained process of urban expansion that has altered the original configuration of the landscape and the land use distribution in the watershed.

Agricultural areas: Land devoted to agriculture shows a downward trend throughout the analyzed period. In 1969 and 1985, they were the

predominant land use; however, since 2005, they have shown a significant reduction, occupying a smaller percentage by 2024. This change indicates that much of the agricultural land has been converted into residential, industrial, or recreational areas in response to population growth and the expansion of urban infrastructure.

Forested and semi-natural areas: Forested and semi-natural land cover declined sharply over the five decades of the study, from around 80% in 1969 to less than 20% in 2024. This progressive loss of natural vegetation is associated with the pressure exerted by urban development, which has led to habitat fragmentation, reduced biodiversity, and alterations in ecological processes.

Figure 3 shows the interpretation of Table 2 in percentages ranging from 0 to 80, from which we can obtain precise data regarding this analysis:

Analysis for 1969: The urbanized area covers 9.77 ha, representing 10% of the total occupied area within the study area; agricultural areas covered 9.65 ha, also representing 10%, and forested and semi-natural areas covered 86.89 ha, representing 80% of the total study area (Figure 4).

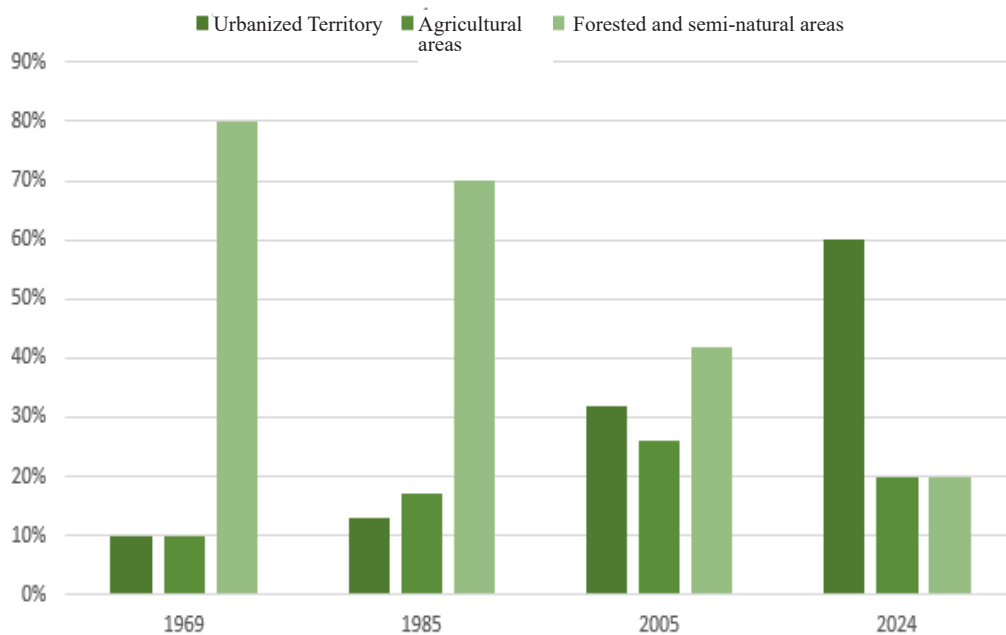


Figure 3. Land use classification for the years 1969, 1985, 2005, and 2024 expressed as percentages (2024).
Source: Author's own work (2024)

Analysis for 1985: The urbanized area covers 13.19 ha, representing 13% of the total area; agricultural areas cover 17.19 ha, representing 17%; and forested and semi-natural areas cover 75.94 ha, representing 70% of the total study area (Figure 4).

Analysis for 2005: The urbanized area covers 32.12 ha, representing 32% of the total area; agricultural areas cover 26.99 ha, representing 26%; and forested and semi-natural areas cover 48.16 ha, representing 42% of the total study area (Figure 4).

Analysis for 2024: Urbanized land covers 49.06 ha, representing 60% of the total area in the study area; agricultural areas, covering 44.23 ha,

account for 39% of the analyzed area, highlighting the persistence of agricultural activities in peri-urban sectors of the watershed; and forested and semi-natural areas, covering 19.98 ha, currently account for 20% of the total study area (Figure 4).

The maps presented (Figure 4) illustrate the progressive expansion of the urban sprawl into areas previously covered by vegetation. Comparing the different periods, it is evident that the increase in construction and infrastructure has transformed the landscape and affected local biodiversity. These results highlight the need for responsible urban planning that mitigates the loss of natural resources and promotes sustainable development.

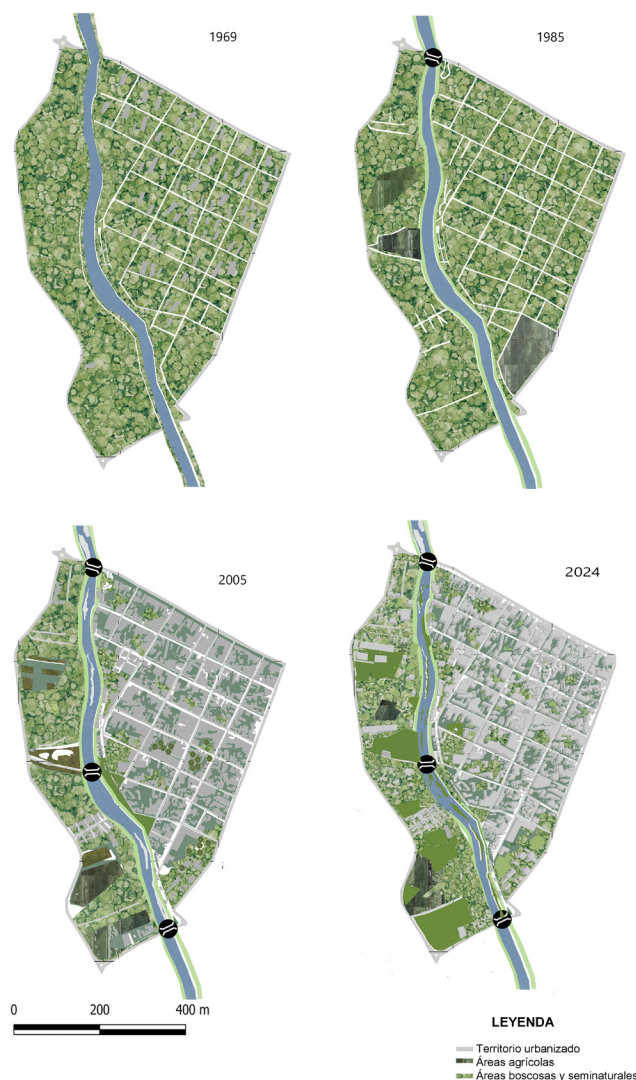


Figure 4. Land use classification for the years 1969, 1985, 2005, and 2024 (2024).
Source: Author's own work (2024)

Riparian vegetation, vital to the balance of the river ecosystem, is increasingly being reduced, compromising the sustainability of water resources. This trend would, in the long run, lead to multiple negative impacts. Among them are deteriorating water quality, loss of biodiversity, and increased risks such as erosion and flooding. Riparian vegetation is essential for maintaining river health and the sustainability of water resources.

3.2. Analysis of drone imagery

Figure 5 presents an aerial view of the Cumbaza Bridge, currently undergoing expansion. It shows rapid urban growth encroaching on the watershed, causing a significant impact on the natural environment. It is evident how green areas have been fragmented to make way for new buildings, altering the original land use.

In the center of the figure, the Cumbaza River is visible; it still retains vegetation along its banks,

although it has sections with a reduced channel and dry areas. This watercourse serves as a natural boundary and regulator, but many nearby buildings do not comply with ANA regulations, increasing the risk of erosion and pollution. Uneven urban growth is evident, with homes featuring corrugated metal roofs alongside multi-story structures, reflecting spontaneous development driven by population growth and the absence of land-use planning. The few remaining green spaces are fenced off or used as home gardens. In the lower reaches, trees, shrubs, and bamboo can still be seen. However, this vegetation cover is diminishing as the construction expands, leaving only a few traces of the original vegetation.

Figure 6 shows a continually expanding urban environment, where urbanization has clearly impacted vegetation and the natural landscape. The Cumbaza River features artificial riverbank defenses, such as retaining walls designed to control the riverbed and reduce erosion;



Figure 5. Aerial view of the area surrounding the Cumbaza Bridge (2024).
Source: Author's own work (2024)

however, these structures alter natural processes and prevent adequate water absorption by the soil. Furthermore, they fragment the habitat and disrupt the area's ecological balance. On the river's left bank, numerous structures are visible, replacing large areas of vegetation, as shown by multitemporal maps. The loss of trees and plants is evident, giving way to homes, dirt roads, and small developed plots. The presence of a swimming pool and buildings near the riverbed highlights the encroachment into previously natural areas and the disregard for the rational Water Authority's regulations. Overall, the image reflects urban development lacking environmental planning, resulting in reduced vegetation cover and profoundly transforming the original landscape.

On the other hand, the upper right part of the figure shows small but dense vegetation, corresponding to conservation areas designated for tourism, where respect for vegetation and the commitment to preserving the ecosystem and ecology are

evident. This area has not yet been affected by urbanization due to its land-use designation in the Urban Development Plan of the Provincial Municipality of San Martín (2019).

These images show an urban landscape in constant growth, where expansion has been rapid and unplanned, generating a clear impact on the natural environment. The replacement of vegetation, the modification of the river channel, and the scarcity of green spaces demonstrate that urban development has exceeded the city's capacity to integrate sustainably and protect its watershed.

3.3. Pollution of the Cumbaza River Basin

The Cumbaza River is a vital source of water for the local population and a key element for biodiversity in the Amazon region. However, in recent years, it has suffered severe pollution, primarily due to wastewater discharges and the accumulation of solid waste. This situation



Figure 6. Aerial view of the area surrounding the Vado Bridge (2024).
Source: Author's own work (2024)

not only threatens the ecological balance of the ecosystem that depends on its waters but also jeopardizes the health and well-being of nearby communities, which use it for fishing, agricultural irrigation, and, in some cases, domestic consumption.

One of the most critical factors contributing to the degradation of the Cumbaza River is the direct discharge of wastewater. In much of the region, wastewater treatment is scarce or nonexistent, leading to liquid waste being discharged untreated. This situation causes serious environmental impacts and poses a health risk, as contact with contaminated water exposes the population to disease. The lack of adequate wastewater treatment infrastructure is a structural cause of the problem. Discharges from domestic and industrial sources are observed in several sections of the river, altering water quality, degrading soil, and affecting the watershed's dynamics. In addition, visual pollution is evident due to foam and floating debris, persistent foul odors, and the accumulation of solid waste that obstructs the riverbed. Compounding this is the burning of trash nearby, which contributes to air pollution and the presence of toxic particles in the river environment.

The pollution in the Cumbaza River is linked not only to environmental factors but also to social and economic factors. Many of the communities settled near the river live in poverty, limiting their access to adequate sanitation systems and leading them to use the river as a natural dumping ground

for wastewater and trash. Furthermore, the lack of a culture of water conservation and environmental awareness among residents exacerbates the situation. Local authorities have made efforts to reduce these pollution levels, but there remains a great need for investment in infrastructure and environmental education to address this problem effectively.

During the interviews, one participant identified various sources of pollution in the study area. He noted that the accumulation of trash on the banks of the Cumbaza River is one of the main causes of pollution, and expressed concern about the presence of wastewater, which, in addition to emitting an unpleasant odor as it flows by, affects the ecology and health of residents living near the watershed. Based on these interviews, a field photographic survey was conducted to corroborate the testimonies and analyze how land use and urban expansion have contributed to this environmental problem.

In summary, the pollution of the Cumbaza River by wastewater and trash is a complex problem that affects both the environment and local communities. It is urgent to implement comprehensive measures to address wastewater treatment and proper solid waste management, and to promote environmental awareness among the population to preserve this valuable natural resource and protect the watershed. Furthermore, this situation, linked to rapid urban expansion in the watershed, often results in land use expansion without proper planning or adequate sanitation infrastructure.

4. Discussion

Various studies show that urban expansion and land-use changes have a significant impact on the watershed's ecosystems. In analyzing the results, priority was given to residents' perceptions (Murunga et al., 2024). The expansion of urban areas, especially near the river, has caused significant environmental consequences, as identified in both the interviews and the fieldwork. Among the main impacts are the rapid loss of vegetation, the accumulation of solid waste, and

the discharge of wastewater—factors that have caused a series of alterations in the ecosystem and direct effects on the population.

Changes in land use have been driven by population growth and unregulated urban expansion. This process has transformed extensive forest and agricultural areas into residential, commercial, and industrial zones, resulting in the loss of large tracts of vegetation

(Amazonian Forests, 2023). The reduction in vegetation cover directly affects the soil's ability to retain water and regulate river flow. Unplanned urbanization has intensified erosion, increased sedimentation in the Cumbaza River, and altered both soil structure and water quality. This accumulation of sediments, combined with the discharge of wastewater and solid waste, degrades water resources, threatening aquatic species and the communities that depend on this resource.

Furthermore, increased air pollution resulting from deforestation and urban development contributes to habitat degradation, affecting terrestrial fauna and disrupting local ecological balance. Trees and other vegetation act as natural barriers that prevent soil erosion and allow water to infiltrate (Zhao & Huang, 2022). Without this vegetation, the soil becomes more vulnerable to erosion, which increases sedimentation in the Cumbaza River.

Urban expansion involves the construction of infrastructure that seals the ground. This prevents the natural infiltration of rainwater, increasing surface runoff. As a result, water flows directly into the river, carrying sediment, trash, and pollutants (Fletcher et al., 2013). The uncontrolled flow of water increases the risk of flooding and bank erosion along the Cumbaza River, affecting communities and the aquatic fauna and flora that depend on the ecosystem's balance.

According to the 2019–2029 Urban Development Plan for the City of Tarapoto, the Cumbaza River has experienced a steady decline in its flow, linked to deforestation in its surrounding areas. This process has fragmented natural habitats and put biodiversity at risk, a key element for maintaining ecological balance and the environment's resilience to extreme weather events. Similar situations are observed in other watersheds, such as that of the Rímac River in

Lima, where unplanned urban growth has led to vegetation loss and deteriorating water quality. Internationally, the Yangtze River in China and the Paraná River in Argentina exhibit similar patterns of uncontrolled urban expansion and loss of riparian ecosystems. These cases underscore the need for zoning and restoration policies that protect biodiversity and sustain water resources.

Another effect of unplanned urban expansion is increased pollution. As growth intensifies, so do human activities that generate solid and liquid waste. The discharge of wastewater and the accumulation of trash in the river have worsened due to inadequate waste management infrastructure (García Sinti, 2016). In this context, the study area lacks an efficient wastewater treatment system, causing some of the waste to end up in the river. This situation not only compromises water quality but also the health of residents who depend on this resource (Garzón-Ortiz & Pardo-García, 2022).

According to Salazar et al. (2020), many residential developments discharge untreated domestic waste into rivers or watersheds, creating lethal pollution hotspots in the primary water source for an entire city. In the case of the Cumbaza River, this problem is evident in a collection of photographs showing the pollution generated by the direct discharge of wastewater into the river.

Changes in land use and the loss of vegetation from rapid housing development are having a significant negative impact on the Cumbaza River watershed and its surroundings. Deforestation, erosion, disrupted water flows, and increased pollution are among the effects of this uncontrolled development. The findings align with those of Harvey (2007), who argues that urbanization processes linked to economic growth place pressure on natural ecosystems when adequate land-use planning methods are lacking.

5. Conclusions

This research identifies the dynamics of land-use change and alterations in local ecosystems, providing relevant information for sustainable urban planning and the conservation of the natural environment in the Cumbaza River basin. The results show accelerated urban growth, displacing forested and agricultural areas, leading to landscape fragmentation, reduced vegetation, and changes in watershed dynamics. This demonstrates the direct relationship between urbanization and local ecosystems, with significant consequences for biodiversity and environmental quality. Between 2005 and 2024, a significant urban expansion toward the western sector of the basin is observed, increasing urbanized areas compared to previous periods.

The practical implications of these findings underscore the need to implement comprehensive territorial planning strategies that balance urban development with environmental preservation. Measures such as efficient waste management, water treatment, soil conservation, and peri-urban reforestation can mitigate negative impacts on ecosystem services. Furthermore, socioeconomic and political factors, such as housing pressure and the absence of sustainable urban planning, contribute to the observed changes, reinforcing the importance of responsible management of urban space and the watershed.

Limitations related to the temporal availability of satellite imagery and the lack of additional socioeconomic variables to complement the analysis are acknowledged. Therefore, it is recommended that future studies consider biodiversity monitoring, analysis of the effects of climate change on precipitation patterns and river flows, and evaluation of the effectiveness of sustainable practices implemented in the Cumbaza River watershed. This future research

will deepen our understanding of how urban growth impacts local ecosystems and ecology, as well as water behavior in the watershed, and will help guide more appropriate planning and conservation policies.

It is essential to acknowledge the methodological limitations that may influence the interpretation of the results. For example, the accuracy of satellite imagery used to analyze and cover changes can be affected by variations in spatial resolution, which limits the precision in identifying urbanized areas and remaining vegetation. Furthermore, comparing multitemporal data presents challenges, as environmental conditions and data capture and processing techniques may have varied over time, introducing potential margins of error and affecting the consistency of the results.

Given the magnitude of the impacts, sustainable urban planning is required to preserve the natural environment. Zoning regulations must be implemented to limit expansion in sensitive areas, such as the banks of the Cumbaza River. It is recommended to reforest peri-urban areas with native species to restore vegetation and strengthen ecosystems. Furthermore, proper wastewater management and the use of green infrastructure will help reduce pollution, erosion, and the effects of unplanned urban growth.

If this rate of growth continues unchecked, residents' quality of life could be affected, and the area's natural resources could suffer further deterioration. Observing these changes enables a deeper understanding of environmental impacts and encourages the development of strategies to conserve ecosystems and ensure community well-being.

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Access to Comprehensive Sexuality Education in Argentina's Secondary Schools According to the 2022 Aprender Assessment

El acceso a educación sexual integral en escuelas secundarias de Argentina según las Pruebas Aprender 2022

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Access to Comprehensive Sexuality Education in Argentina's Secondary Schools According to the 2022 Aprender Assessment

El acceso a educación sexual integral en escuelas secundarias de Argentina según las Pruebas Aprender 2022

Abstract:

This article examines the access to Comprehensive Sexual Education (CSE) among secondary school students in Argentina, based on data from a national survey conducted with students and school principals. Drawing on responses to the CSE module of the 2022 Aprender Assessment (195.804 participants), the study characterizes the students' exposure to CSE. The evaluation considers four analytical dimensions: the relevance, the universality, the comprehensiveness, and the cross-curricular integration of the contents received. The results reveal a gap between students' widespread acknowledgment of the importance of CSE and its effective implementation, with disparities observed by sex, educational background of the household, and region. Moreover, there is a predominance of approaches focused on biology and health, to the detriment of dimensions related to affectivity, diversity, and rights.

Keywords: comprehensive sexual education, Argentina, secondary school, cross-curricular approach, comprehensiveness.

Resumen:

Este artículo analiza el acceso a la Educación Sexual Integral (ESI) por parte de estudiantes de escuelas secundarias de Argentina, basándose en datos de un relevamiento nacional. A partir de las respuestas al módulo sobre ESI de las Pruebas Aprender del año 2022 (195.804 participantes), se realizó un análisis descriptivo que caracteriza el contacto que los estudiantes de secundaria han tenido con la ESI. La evaluación se realizó utilizando como dimensiones de análisis la pertinencia, la universalidad, la integralidad y la transversalidad con que los contenidos fueron recibidos por los estudiantes. Los resultados encontraron una distancia entre el reconocimiento generalizado de la relevancia de la ESI por parte de los estudiantes y su efectiva implementación, existiendo disparidades por sexo, capital educativo de origen y región, así como una prevalencia de abordajes centrados en la biología y la salud, en detrimento de los ejes vinculados con la afectividad, la diversidad y los derechos.

Palabras clave: educación sexual integral, Argentina, escuela secundaria, transversalidad, integralidad.

1. Introduction

Comprehensive sexuality education is a curriculum-based process that addresses the cognitive, emotional, physical, and social aspects of sexuality in an integrated manner (UNESCO, 2018). It consists of an approach within the field of sexuality education policies, specifically school-based policies. In Western countries, these policies acknowledge significant changes beginning in the 1960s and 1970s (Weaver et al., 2005), decades during which Argentina experienced transformations in perceptions and values regarding the family, gender, and sexuality (Cosse, 2006; Cosse, 2009). According to Zemaitis (2021), starting in the 1960s, expert knowledge and discussions emerged in Argentina that gradually formed a field capable of demanding that the State, by the late 1980s, develop sex education programs for the formal education system.

Internationally, the response to the global AIDS epidemic in the 1980s marked a turning point that spurred a revision of school-based sex education programs, reorienting them toward prevention and health. Following this precedent, it was at the 1994 International Conference on Population and Development (ICPD) that a new consensus was established regarding the criteria by which numerous countries would henceforth address the relationship between sexuality and education (Greene et al., 2002). The 179 signatory countries recognized sexuality as a right and assumed the responsibility of promoting adolescents' access to sex education, related information, and reproductive health services. While the objectives of its program of action were numerous, a priority was the reduction of teenage pregnancy. The ICPD placed adolescents at the center of new policies on sexuality and incorporated into the concept of reproductive health a component linked to the ability to experience a satisfying and safe sex life, the possibility of procreating, and the freedom to decide whether or not to do so, when, and how often (United Nations [UN], 1995).

In Argentina, Law 26,150 on Comprehensive Sex Education, enacted in 2006, adopted many of these guidelines and adapted them to the national context. As noted by Carnero et al. (2013), the law was a key milestone in the implementation of the ICPD Program of Action in Argentina. This legislation established the National Comprehensive Sexuality Education Program, designed to ensure the teaching of comprehensive sexuality education content in educational institutions—both public and private—from early childhood through teacher training (SEIE, 2022).

In 2018, the Federal Council of Education supplemented the guidelines of Law 26,150 through Resolution 340/18, establishing, among other things, the commitment of all jurisdictions in the country to address the content of this policy based on five conceptual pillars: caring for the body and health; valuing emotional well-being; ensuring gender equity; respecting diversity; and exercising rights (Mariani & Messina, 2025).

The implementation of ESI in Argentina falls within the framework of a federal education system, in which the 24 jurisdictions (23 provinces and the Autonomous City of Buenos Aires) are responsible for their respective education systems. As Ruiz (2023) notes, the National Constitution establishes that the jurisdictions administer their own education systems, while the national government defines the general regulatory frameworks and sets educational policy guidelines. Coordination between the two levels is channeled through the Federal Council of Education, a body that brings together provincial ministers and whose resolutions require jurisdictional endorsement to take full effect (Romualdo, 2024). This institutional structure generates dynamics of educational federalism in which national guidelines are implemented in heterogeneous ways across territories, conditioned by the management capacities, cultural traditions, and political priorities of each jurisdiction (Ruiz, 2023).

This heterogeneity is also evident in ESI's regulatory framework. Law 26,150 itself delegated to each jurisdiction the design of teaching proposals, the selection of materials, and the organization of teacher training programs, thereby establishing a decentralized implementation scheme within a common national framework. In this context, several provinces moved forward with the enactment of their own regulations. The National Ministry of Education, for its part, supported the process by providing teaching materials and organizing teacher training sessions. However, the effective scope of these actions depended in each case on jurisdictional adoption (Mariani & Messina, 2025). This multi-level regulatory and management framework constitutes the institutional context within which the territorial inequalities in access to ESI revealed by the analyzed data must be interpreted.

From the very beginning, research on the implementation of ESI in Argentina has highlighted a gap between policy objectives and their classroom implementation. The study conducted by Faur et al. (2015), which combined questionnaires for teachers and administrators with observations in schools across several provinces, found that a significant portion of the teaching staff was ill-prepared to address the law's content, struggled to incorporate it into the institutional educational project, and tended to reduce the content to the biological and reproductive dimensions, to the detriment of the themes of affectivity, diversity, and rights. Similarly, Kornblit et al. (2013) found that public school teachers' conceptions of sexuality and gender frequently reproduced biologicistic and heteronormative frameworks that hindered the implementation of a comprehensive approach.

Subsequent studies delved deeper into institutional conditions. Romero (2021) analyzed competing interpretations of the cross-cutting nature of ESI in schools in La Plata, identifying two modes of implementation (curricular and institutional) whose prevalence varied across schools according to each school's cultural context. Dellacasa et al. (2025) point to the inadequate institutionalization of support teams in the province of Buenos Aires as an unresolved

issue, while Russo Sierra and Lovey (2023) identified insufficient professional development, the weak integration of ESI into educational projects, and the persistence of fragmented approaches as obstacles in secondary schools in Rosario. In terms of best practices, Faur and Lavari (2018) described institutional conditions that favor more comprehensive implementations, but noted that these constitute specific cases rather than the norm within the system. A recent review of the academic literature (Cuello et al., 2025) indicates that research on ESI in Argentine secondary schools has tended to focus on the teacher's role, without giving equal consideration to students' perspectives.

This study aims to expand knowledge about students' reception of and access to comprehensive sexuality education by analyzing data from the 2022 Aprender Tests. Examining this source allows us not only to position students as key informants but also to underpin and complement the extensive body of qualitative research on ESI with information from a nationwide, probability-based survey.

To advance these objectives, a descriptive analysis is presented that focuses on four dimensions of the policy's implementation: relevance, universality, comprehensiveness, and cross-cutting nature. These dimensions of the ESI design in Argentina were intended to guide implementation actions. Relevance implies that the information and materials made available to students must be relevant to those who receive them and tailored to their cultural, social, and personal characteristics. Universality stems from the fact that this policy is designed to cover all levels of education that children in the country undergo (early childhood, primary, and secondary), through both privately and publicly (State) managed institutions. Comprehensiveness refers to how the regulations and the subsequent resolutions that accompanied their implementation view sex education as something that goes beyond the merely biological or reproductive, broadening its scope to include education about body care, emotional well-being, gender equity, diversity, and the exercise of rights. Finally, mainstreaming refers to the pedagogical approach, which establishes that sex education cannot be restricted to a specific subject or

activity in students' education, but must instead be a set of content present throughout the entire curriculum, and that can be addressed both during regular class time and through supplementary talks, special workshops, projects, etc.

Although the education system incorporated these dimensions during the implementation of this policy, this research posits that the implementation process may have involved nuances, leading to gender, institutional, territorial, and regional inequalities.

Through this research, we seek to partially answer questions such as: To what extent have students been exposed to Comprehensive Sexuality Education (CSE) throughout their education? How relevant is this content to them

in schools? Are there differences in the reception of ESI among adolescents from different regions, from public and private schools, or with other distinctive characteristics? What was the scope of the dimensions—universality, comprehensiveness, and cross-cutting nature—with which the policy was designed?

In the context of this article, access to ESI constitutes the object of study. It refers to the degree and manner in which the policy's content effectively reached its intended audience. Students' reception of the content is the primary empirical dimension used to measure this access. Finally, information from school administrators helps to understand the institutional implementation conditions that frame this reception.

2. Materials and Methods

2.1. Sources

This study employs a quantitative, descriptive, and cross-sectional approach, based on data from the national "Pruebas Aprender 2022" survey. This survey assesses student learning and systematizes information regarding living conditions and the school environment. Its objective is to produce diagnostic evidence for decision-making aimed at guaranteeing the right to education. The supplementary questionnaires from 2019 and 2022 included a module of ESI questions at the secondary level for both students and school administrators.

The target population comprised students enrolled in their final year of secondary school (5th or 6th year, depending on the jurisdiction) during 2022. The survey reached 403,539 students and 11,719 schools. This study used a probability sample comprising 50% of students who responded to the specific Comprehensive Sexuality Education (CSE) module, yielding 195,804 valid responses. This module included information on the ESI topics students reported covering, how these topics were addressed (e.g., in classes, through workshops), and the sources adolescents use when they have questions or concerns about sex

education topics. The survey covers secondary-level educational institutions, including both public and private schools, across urban and rural areas

2.2. Dimensions of Analysis

This research focuses its analysis on the four dimensions mentioned above, which are part of the current school sex education policy in Argentina:

- **Relevance:** measured by the degree of student interest in exploring ESI content in greater depth and the identification of the main sources of information (the Internet, family, peers, or school).
- **Universality:** assessed based on students' reports of exposure to at least one of the thirteen topics surveyed and the administrative directive regarding the inclusion of ESI in the Institutional Curriculum Project (PCI).
- **Comprehensiveness:** assessed based on access to content covering the five conceptual pillars of the Federal Council of Education: body care, emotional well-being, gender equity, diversity, and the exercise of rights. The study relates these pillars to the surveyed items as indicated in Table 1.

- Cross-curricularity: determined by the approach used, with cross-curricular implementation considered when activities spanning multiple subjects or the use of at least two planned institutional strategies were reported.

The data were analyzed using descriptive statistical analysis based on open-access microdata. We calculated relative frequencies (percentages) to characterize the reception of ESI according to:

- Student gender: the “gender” category is used as asked in the Aprender Tests item. Its categories are: female, male, and X.
- Household educational capital: operationalized based on the mother’s educational level, a variable available in the Aprender Tests’ supplementary questionnaire. Three levels are distinguished: low (incomplete or complete primary education), medium (incomplete or complete secondary education), and high (incomplete or complete tertiary or university education).
- Student socioeconomic status: a variable available in the source, constructed by the Ministry of Education based on a principal component analysis that synthesizes the variables of the father’s and mother’s

educational levels, household overcrowding, perception of subsidies, and ownership of technological devices. The levels are classified as low, medium, and high.

- Region: the regional classification used in the Aprender Tests is employed, with the following regions: Central, Northwest (NOA), Northeast (NEA), Cuyo, and South.
- Type of school management: distinguishes between state-run and privately run schools, in accordance with the survey’s classification.
- Principal characteristics: includes age, grouped into three broad categories, and the principal’s gender in the categories: male, female, and X.
- School supervision: a variable reported by school administrators, indicating whether the school received external supervision visits during the reference year.
- Presence of an institutional ESI representative: a variable reported by school administrators, indicating whether the school had a person or team designated as ESI representatives at the time of the survey.

For data processing, we excluded blank, multiple-choice, or “not applicable” responses from the analysis and treated them as missing data.

Table 1: Correspondence between topics assessed in the Aprender Tests and the five conceptual pillars defined by the Federal Council of Education.

Source: Prepared by the authors (2025) based on Resolution 340/18 and Aprender Test questionnaires.

Axes CFE	Topics in Aprender Tests (question 35)
Caring for the body and health	Reproduction, pregnancy, childbirth, motherhood, and fatherhood
	Teenage pregnancy
	Contraceptive methods
	Prevention of sexually transmitted infections
	Taking care of your body and health and striving for independence
Valuing emotional connection	Partnerships, love, and mutual care in romantic relationships
Ensuring gender equality	Gender-based violence in dating relationships
	Responsible use of social media and prevention of cyberbullying
	Beauty standards and their relationship to consumption
Respecting diversity	Diversity: gender identity, sexual orientation, or physical appearance. Recognition and respect for the different ways of being a woman and a man
Exercising our rights	The rights of adolescents and young people to access sexual and reproductive health services
	Legal frameworks for voluntary termination of pregnancy
	Discrimination, violence, harassment, abuse, mistreatment, sexual exploitation, and trafficking

3. Results

The results are organized around the research questions posed in the introduction, addressing the relevance of ESI for students, the degree of exposure to this content, inequalities in its reception, and the extent of its universality, comprehensiveness, and cross-curricular dimensions. The data source enables us to examine these dimensions from the students' perspective, supplemented by information from school administrators.

3.1. Relevance of ESI for Students

To determine how relevant ESI is to students, we analyze the degree of importance they assign to different topics in the school setting. In this

regard, in the ranking of content that students consider important to explore in greater depth or incorporate into secondary school, ESI ranks second (84%), behind Physical and Emotional Health (87%) and ahead of bullying (83%) (Figure 1). It also ranks above topics such as technology, programming, and robotics, as well as those related to labor market demands.

It is important to note that the three most requested topics (physical and emotional health, ESI, and bullying) are included in the ESI curriculum, reflecting a selection of content closely aligned with students' preferences based on the topics offered.

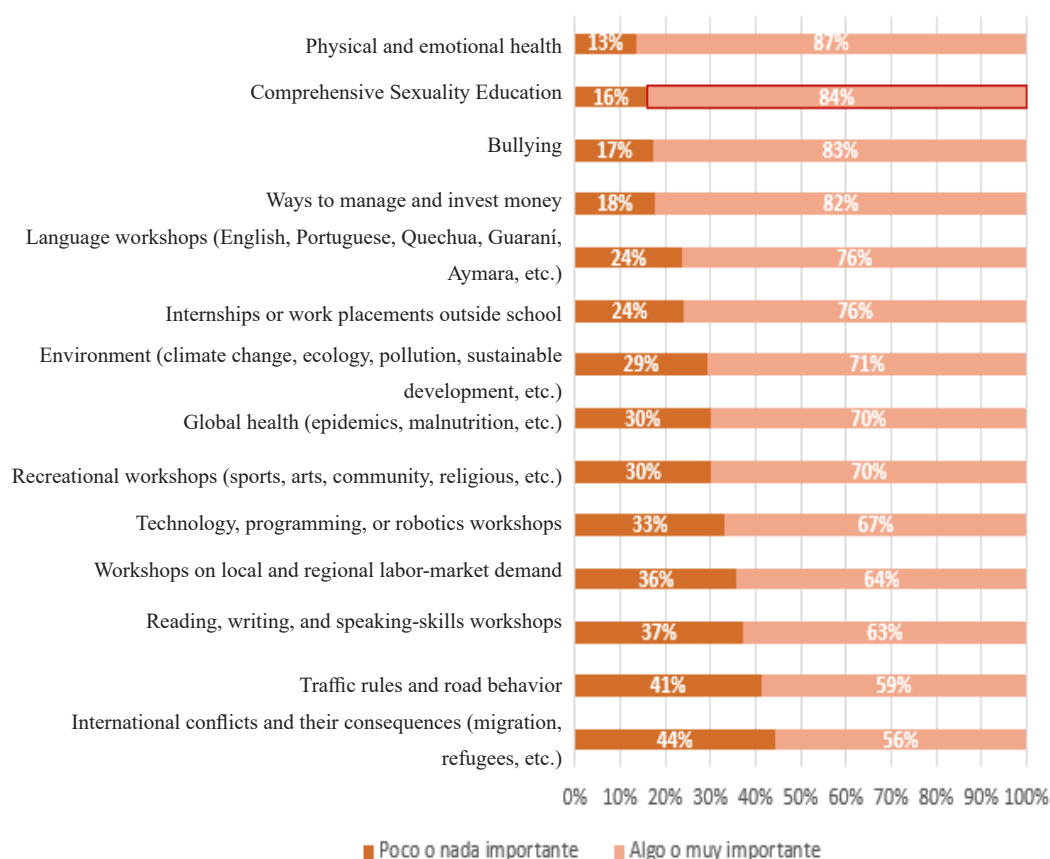


Figure 1: Percentage of 5th- and 6th-grade students by degree of importance for exploring or incorporating specific topics in their assigned school. Argentina, 2022.

Source: Author's own analysis (2025) based on microdata from the Aprender Tests.

Notes: Ratings of 1 and 2 on a scale of 1 to 4 are considered not very important or not important at all, where 1 is not important at all and 4 is very important; ratings of 3 and 4 on that same scale are considered somewhat important or very important. Blank responses (-9), multiple-choice responses (-6), or responses categorized as "not applicable" (-1) were considered missing data.

However, the demand for these topics to be included in school curricula coexists with students' weak perception of a connection between them and school. In this regard, adolescents reported that their main source of information on sexuality is the Internet and social media (69.5%) (Figure 2). In second place is consulting a family member (50.1%), and another significant group turns to peers and classmates (46.6%) or a partner (23.6%). School staff (teachers, homeroom teachers, or the guidance team) are not the people students most often turn to for questions about sexuality or for information on the topic. Only 22.4% of students reported turning to school teachers, and 7.6% to homeroom teachers, school administrators, or the school counseling team.

With certain caveats, it can be stated that the majority of young people in the country believe that Comprehensive Sexuality Education should be introduced and expanded in secondary school. Even so, we will see that not all of them have addressed CSE-related topics.

3.2. Universality of Comprehensive Sex Education in Argentina

Regarding the question posed about the extent to which students are exposed to Comprehensive Sexuality Education (CSE) throughout their school career, the coverage of the topics addressed is examined. The Aprender tests cover 13 topics related to CSE, including teenage pregnancy, contraceptive methods, and beauty standards, and their relationship to consumption. Considering only the girls and boys who provided valid responses (195,804 in total), it is observed that, at the national level, 10.1% of adolescents in the 5th and 6th years of secondary school did not address any of the thirteen topics surveyed (Figure 3). Analysis of the question regarding differences in ESI delivery across student groups shows low variability. However, greater deficits are identified among female students and males, among those with children—particularly males—among those from low socioeconomic

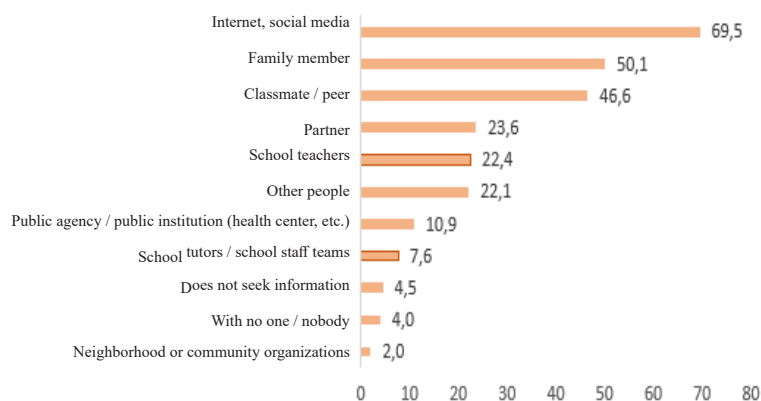


Figure 2: Percentage of 5th- and 6th-year students by whom they turn to for information on sexuality. Argentina, 2022.

Source: Author's own analysis (2025) based on microdata from the Aprender Tests.

Note: Blank responses (-9) and "not applicable" (-1) were considered missing data.

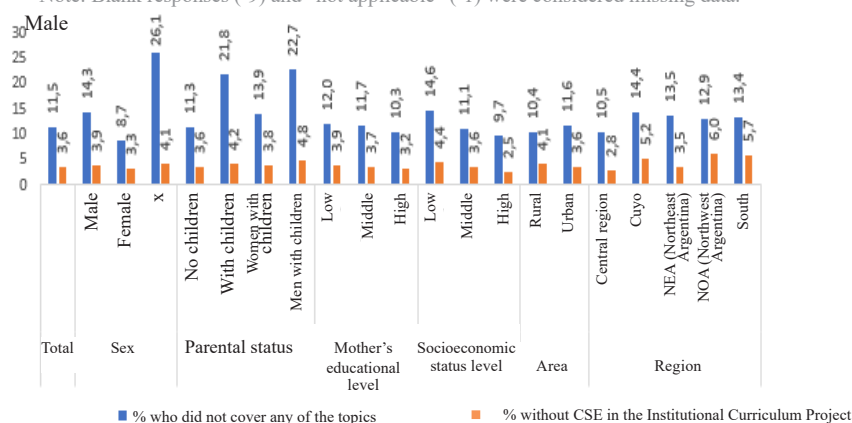


Figure 3: Percentage of students who reported not having covered any of the ESI topics surveyed, and percentage of students whose school principal reported that the Institutional Curriculum includes ESI, by individual and household characteristics. Argentina, 2022.

Source: Author's own analysis (2025) based on microdata from the Aprender Tests.

Note: Blank responses (-9), multiple-choice responses (-6), or responses categorized as "not applicable" (-1) were considered missing data.

backgrounds, and among residents of the Cuyo region.

To complement the analysis of the universal dimension of ESI, we examine the information collected from school administrators. The percentage of principals who stated that Comprehensive Sex Education is not included in their schools' Institutional Curriculum Project is 3.6%. This percentage is relatively lower than that indicated by the information provided by students. Under this definition of universality (that all students have Comprehensive Sexuality Education in their schools' curriculum plans), the groups mentioned above also appear as those with lower coverage, and those from the NOA and Southern regions are added (Figure 3).

Among the school-related factors that could affect the implementation of ESI, the lack of supervision stands out as a decisive factor in the exclusion of ESI from the Institutional Curriculum Project: schools that reported not having received supervisory visits during the year had 13.6% of institutional projects without ESI, a rate higher than the 2.2% observed in schools where supervision did occur (Figure 4). Regarding the other characteristics evaluated, student responses remained stable (within the

range of 4% to 5%), regardless of whether an ESI coordinator was present in the schools. This role was found to influence the inclusion of ESI in the institutional curriculum, but not the proportion of students who did not receive any ESI content in their coursework.

3.3. Comprehensiveness of ESI in Argentina

The results presented so far refer to the limitations in coverage that ESI might have as a nationwide public policy, defining "lack of coverage" (in its full sense) as the failure to address any of the topics examined, or their omission from the school's Institutional Curriculum Framework. As mentioned earlier, one of the principles of ESI is comprehensiveness. That is, addressing sexuality not only from a biological or epidemiological perspective, but also incorporating its emotional and relational dimensions, and recognizing its link to personal well-being and access to rights. To answer the question regarding the scope of ESI's comprehensiveness, we analyze the extent to which the various pillars comprising this policy have been effectively addressed. The level of comprehensiveness demonstrated in the implementation of ESI will be considered a comprehensive approach, in which the student

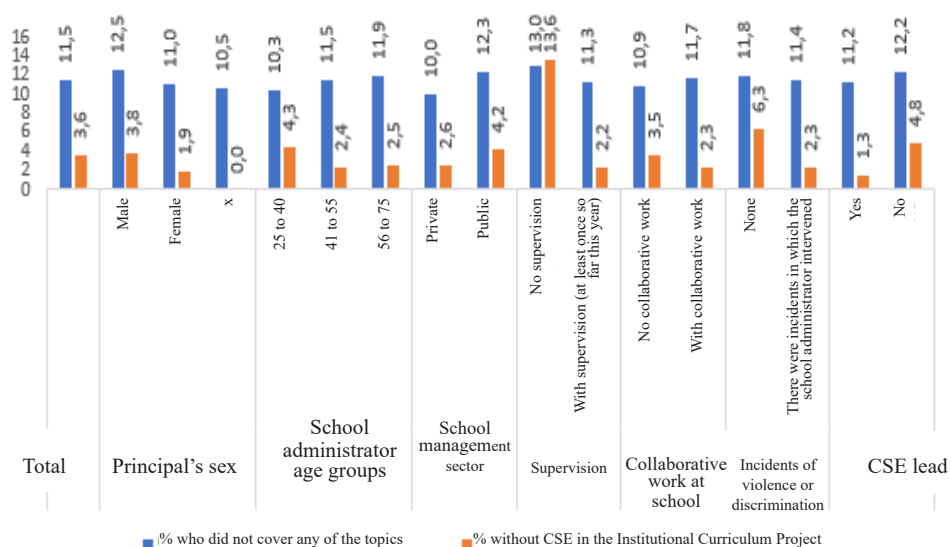


Figura 4: Percentage of students who reported not having covered any of the ESI topics surveyed; and percentage of students whose school administrator reported that the Institutional Curriculum includes ESI, by school characteristics, Argentina, 2022.

Source: Author's own analysis (2025) based on microdata from the Aprender Tests.

Note: Blank responses (-9), multiple-choice responses (-6), or responses categorized as "not applicable" (-1) were considered missing data.

has been exposed to topics from the five pillars defined by the CFE. As shown in Figure 5, only 42.5% of students have been exposed to content from all five pillars. Of the girls and boys who were exposed to topics on sexuality, 15.6% received content on one or two of the pillars, and a significant group, 41.9%, reported having covered between three and four pillars.

Unlike what was observed regarding the universal nature of ESI, where boys had less access than girls, in the case of comprehensiveness, more

boys report having received education in all five areas (46.9%) than girls (39.0%) and students of gender X (39.9%). A difference is also observed based on the mother's educational capital, inferred from the mother's educational level and, more directly, from the SES (socioeconomic status) indicator; students whose mothers have a low educational level are those who demonstrate greater comprehensiveness in receiving ESI, compared to the rest. The same is true for students from rural areas and the Central (43.2%) and NOA (44.3%) regions.

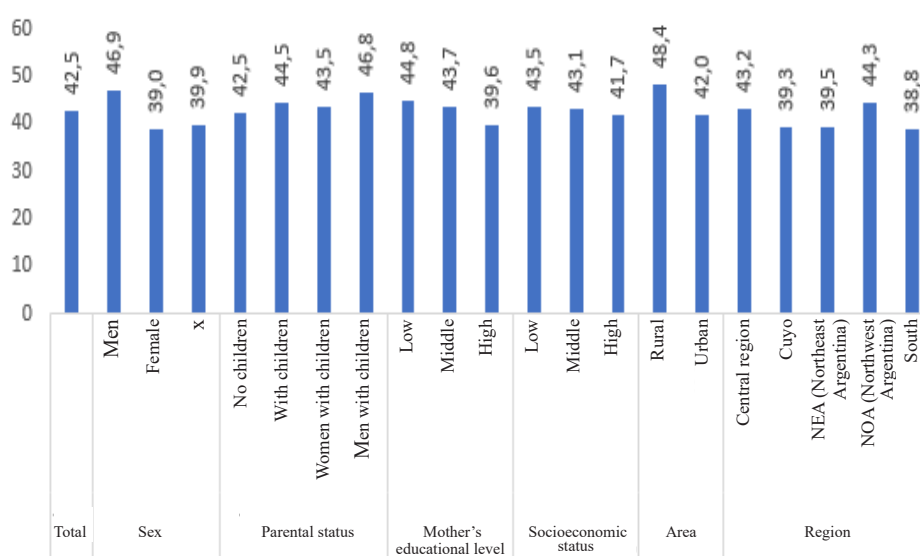


Figure 5: Percentage of students who received instruction on the five areas defined by the CFE, by individual and household characteristics. Argentina, 2022.

Source: Author's own analysis (2025) based on microdata from the Aprender Tests.

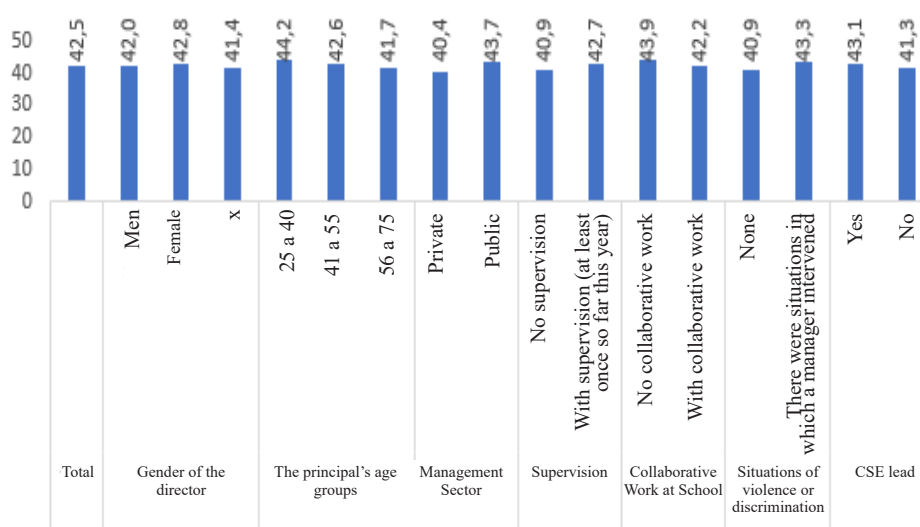


Figure 6: Percentage of students who received instruction on the five core areas defined by the CFE, by school characteristics. Argentina, 2022.

Source: Author's own analysis (2025) based on microdata from the Aprender Tests.

No notable differences are observed based on the characteristics of the educational institution. The percentage of students who received comprehensive ESI ranges from 40.4% to 44.2%, with the latter being the highest, corresponding to students with young administrators aged 25 to 40. Greater comprehensiveness is observed in public schools compared to private ones (43.7% versus 40.4%), in schools with supervision (42.7% versus 40.9%), and in schools with an ESI liaison (43.1% versus 41.3% without one).

3.4. Mainstreaming of ESI in Argentina

Finally, in response to the question about the cross-curricular nature of ESI, the diversity of curricular spaces in which these topics are addressed is examined. That is, the cross-curricular dimension seeks to assess the extent to which ESI is integrated into the curriculum without being limited to a specific subject or to isolated activities potentially disconnected from daily learning.

Based on the question of how topics related to ESI¹ are addressed in school, the most common approaches were “activities in one of the

subjects” and “special classes or workshops with specialists”: 39.8% correspond to the first option and 45.7% to the second.

The composite indicator used to quantify whether the principle of cross-curricular integration was met is based on two conditions: whether the option “With activities across multiple subjects” was selected, or whether at least two planned methods of delivering ESI were selected. Based on these indicators, the results on the extent of cross-curricular integration are presented by analysis category.

In this regard, it is worth noting that the approach to ESI is relatively uniform across the observed groups, though there are some differences. For example, in the public sector, the cross-curricular reach is greater than in the private sector: 18.2% versus 14.7%. There are also differences between regions: Cuyo has the lowest cross-cutting reach of ESI compared to the NOA, which has the highest (12.3% and 18.3%, respectively).

Regarding institutional or leadership characteristics, practices of greater or lesser cross-curricular integration show striking stability, with values ranging from 14.7% to 18.8% across the gender and age of the administrator, management sector, presence of ESI liaisons, and other variables (Figure 8). This interpretation is consistent with the assessment information that,

1 The term “planned” excludes the following options from the survey: g) “we discuss it when the topic comes up,” and h) “my school does not address topics related to ESI.”

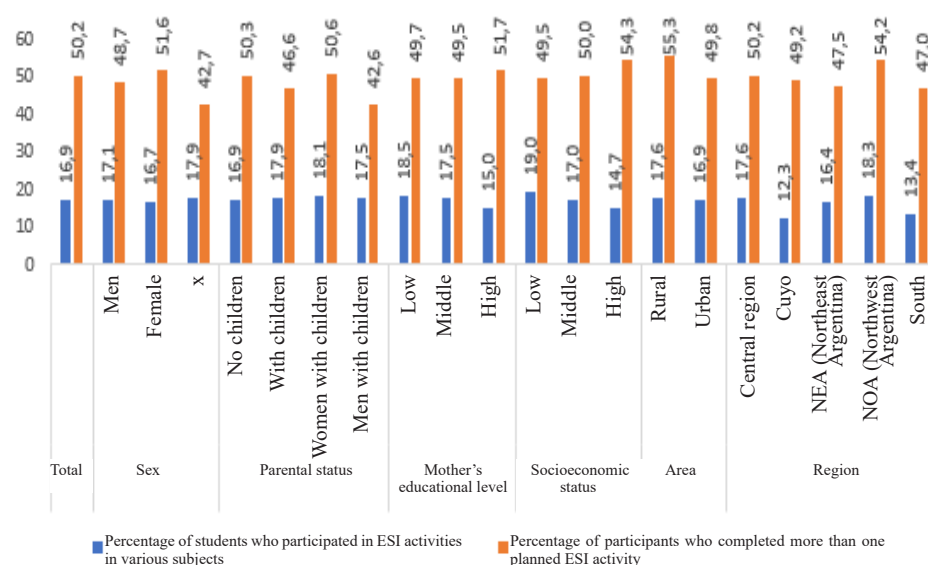


Figura 7: Porcentaje de estudiantes que recibieron ESI de manera transversal, por características individuales y del hogar. Argentina, 2022.

Fuente: Elaboración propia (2025) en base a microdatos de las Pruebas Aprender.

according to students, more than one strategy for implementing ESI was deployed at the school. In this second way of operationalizing the cross-curricular nature of implementation, the values range from 48.2% to 52%, with slight differences across each of the observed variables.

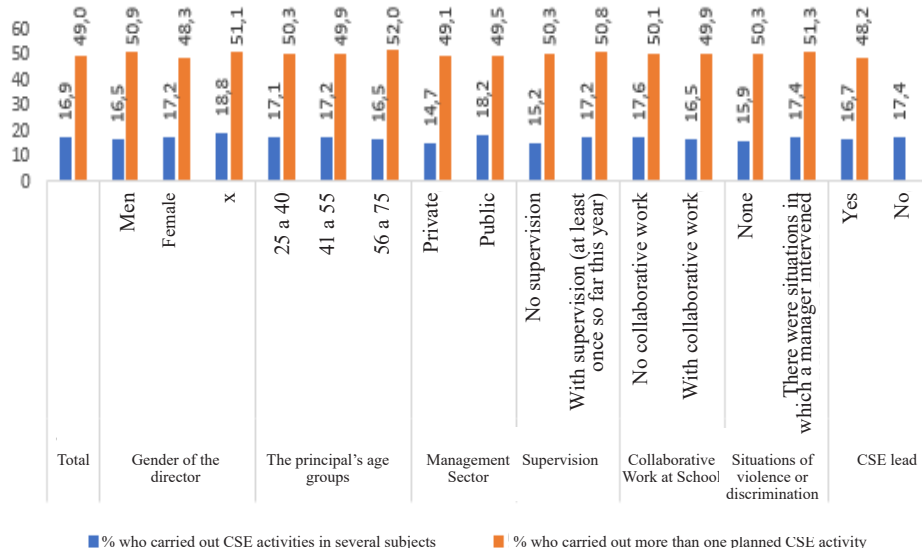


Figura 8: Percentage of students who did not receive ESI in a cross-curricular manner, by individual and household characteristics. Argentina, 2022.
Source: Author's own analysis (2025) based on microdata from the Aprender Tests.

4. Discussion

In 2006, Argentina enacted a law to provide comprehensive sexuality education to students from early childhood through higher education (SEIE, 2022). At the regional level, while nearly half of the countries in Latin America have specific programs on comprehensive sexuality education in their educational systems, the existence of a specific law is quite exceptional (Cimmino et al., 2024). In turn, each country exhibits strengths and weaknesses in these policies linked to its educational and cultural traditions, among other factors. In the case of the program in Argentina, the implementation design proposes a cross-cutting and comprehensive approach within educational curricula, with universal coverage. Despite this, there is evidence that the Argentine education system only partially achieved these objectives.

To contextualize our results, it should be noted that research on ESI in Argentina is both very extensive and extremely fragmented in its territorial coverage. The most influential studies, such as that by Faur et al. (2015), are based on purposive samples and date back to the first decade of the law's implementation. In many cases, ethnographic research and studies of pedagogical experiences predominate, which allow for an understanding of concrete and valuable aspects of the implementation of this policy, but do not allow for the systematic identification of conditioning factors or the frequency of the phenomena described. Taking this body of work into account, this section engages with surveys of both national and jurisdictional scope, even though the latter do not permit generalizations across the entire territory. With this caveat, the

results of the present study are compared with subnational studies that provide comparable evidence on specific dimensions of the policy.

Previous studies document a variety of obstacles encountered in the implementation of this policy, such as the not always met needs for staff training, the honorary nature of school ESI coordinators in many jurisdictions, resistance from families and teaching staff, and the lack of dedicated time for planning, among others (Faur, 2020; Dellacasa et al., 2025; Fundación Huésped, 2021).

In our analysis, we found a gap between the importance students attribute to Comprehensive Sexuality Education and its actual implementation. While the vast majority consider incorporating this content into schools to be relevant, many reported not having received any CSE topics (10.1% of the sample) or having received them only partially. This gap between demand and actual delivery indicates that the policy succeeded in creating a social expectation among its target audience but has not yet been able to meet it universally. This suggests that the obstacles do not lie in the legitimacy of Comprehensive Sex Education in students' eyes (who generally endorse it), but rather in the institutional and pedagogical conditions of its implementation.

Regarding universality, local and national surveys highlighted the limitations in achieving it. A 2018 survey conducted by the Ministry of Education and Innovation of the City of Buenos Aires reveals that 13% of participating students (out of a total of 44,123 cases, equivalent to 8% of the total student body) reported not having covered comprehensive sexuality education content. This proportion rose to 22% among teaching staff (out of 850 cases, or 62% of the teaching staff) who reported not having addressed these topics in the previous year (GCBA, 2018). For its part, the National Ministry of Education, in the 2019 edition of the Aprender tests, found that 8% of students reported not having received any comprehensive sexuality education (ESI) content. This figure is lower in the private sector (5.7%) and higher in the public sector (9.4%) (SEIE, 2020). The fact that the 2022 national data

presented here places that percentage at 10.1% indicates that the universality gap did not change significantly during a unique historical period marked by more than a year of remote learning due to the COVID-19 pandemic.

In addition, we observed inequalities in access to comprehensive sex education based on student characteristics such as gender, parental status, educational background, and region. This creates tension regarding compliance with the principle of universality established in the regulations. Female students who do not have children and live in urban areas report higher levels of exposure. In contrast, non-binary individuals, males with children, and students from rural areas appear to be the most underserved groups. Similarly, school is not the primary place where students obtain information about sexuality or turn to for guidance.

The cross-curricular dimension, according to which students should receive comprehensive sexuality education across various subjects and in different types of activities, has not been fully established: slightly less than half of students receive it in this manner. This issue was also observed in the Chilean case, where the integration of sex education content into subject-specific curricula is generally limited and varies widely by subject (Vargas et al., 2024). Regarding the situation in Argentina, qualitative studies suggest the value of having a teacher available in a private, trustworthy setting to address questions students do not voice in class (Díaz, 2011).

An analysis of the results on cross-curricular integration suggests that, overall, ESI tends to focus on specific, isolated activities (such as talks, workshops with external specialists, and events during ESI Week) rather than on content integrated across subjects. This is consistent with the findings of Romero (2021), who identified two modes of implementing cross-curricular integration in schools in La Plata: a curricular approach, which is difficult to implement, and an institutional approach, based on events or special days. The national data presented here suggest that this pattern is not unique to a single jurisdiction but characterizes this policy as a whole.

Nor do those who received the five content areas reflecting the comprehensiveness of the current official school sex education policy constitute a majority. The curricular approach places greater emphasis on biological and health aspects, relegating affectivity, sexual diversity, and the exercise of rights. This bias not only runs counter to the comprehensive perspective of the law but also disregards the interests of students, who, in interviews conducted as part of a study in middle schools in the city of Buenos Aires, expressed their interest in addressing content beyond that associated with the risks of sexuality (Díaz, 2011).

The 2019 edition of the Aprender tests already highlighted this imbalance: the two most frequently discussed topics, according to secondary school students that year, were the prevention of sexually transmitted infections (75%) and unintended teenage pregnancy: contraceptive methods (68%) (SEIE, 2020).

The persistence of this biologicistic bias warrants reflection that goes beyond mere note-taking. Two decades after the enactment of Law 26,150, and eight years after the formalization in CFE Resolution 340/18 of the five comprehensive pillars of ESI, the preeminence of body care and health over affectivity, diversity, and rights cannot be attributed solely to individual resistance among teachers. The data suggest that this is a systemic inertia: initial teacher training, available curriculum materials, and institutional assessments continue to operate within a logic closer to the biomedical model than to a comprehensive approach. Kornblit et al. (2013) documented how biologicistic and heteronormative frameworks shaped teachers' conceptions of sexuality; the fact that, more than a decade later, students continue to report a biased reception of

this pillar indicates that training interventions and policy changes have not been sufficient to modify classroom practices.

Finally, discrepancies are noted between student perceptions and those of school administrators regarding the incorporation of ESI into the curriculum. In the 2022 Aprender Tests, nearly 4% of school administrators reported that their schools' curriculum plans did not include ESI content. This figure differs from that reported by Faur et al. (2015) in a self-administered survey conducted in 2014 among 634 administrators and 1,213 teachers in Argentina, in which only 11% acknowledged that ESI content was part of their Institutional Educational Projects (PEI). Although the comparison between the two studies should be viewed with caution due to methodological differences, the presence of ESI in institutional plans appears to have increased significantly. However, the persistent gap between what administrators report about their plans and what students report having received suggests that formal incorporation does not guarantee effective implementation.

Regarding institutional plans, the survey found that more frequent external monitoring and supervision of schools are associated with greater inclusion of ESI in Institutional Educational Plans. This result contrasts with the more moderate effect of the presence of reference teams, a mechanism designed specifically to support the policy within each school. Despite this specific nature, the role of the reference team had a lesser impact on universality than external supervision. This may be explained by the characteristics that Dellacasa et al. (2025) documented regarding the role of the institutional reference point: in the province of Buenos Aires, and in other jurisdictions as well, it was honorary, largely informal, and lacked effective institutional support.

5. Conclusions

This study examined the relevance, universality, comprehensiveness, and cross-curricular nature of the sex education content adolescents receive, while accounting for potential gaps in access.

Through a descriptive quantitative analysis of data from the 2022 Aprender Tests, we addressed questions such as: To what extent have students been exposed to Comprehensive Sex Education

(ESI)? How relevant is it to them? Are there differences in the reception of ESI among adolescents with distinct characteristics? What was the scope of the dimensions on which the policy of universality, comprehensiveness, and cross-cutting nature was designed?

The results confirm that, despite regulatory advances and institutional consolidation, ESI coverage in Argentina remains incomplete. Even though the vast majority of students consider the inclusion of this content in schools to be relevant, many reported not receiving it or receiving it only partially. Its implementation varies, with boys, adolescents with children, and students outside the city of Buenos Aires having less access.

Nor have the dimensions of cross-curricular and comprehensive ESI been fully established: slightly less than half of students receive it in a cross-curricular manner, and a similar proportion receive comprehensive ESI content. The prevalence of “biomedical approaches” (Romero, 2018) and preventive approaches limits the development of comprehensive sexuality education in the full sense, one that addresses

emotional, social, and rights-based dimensions. It is worth noting that the survey results indicate that more frequent monitoring and external supervision of schools is associated with better integration of ESI into institutional educational projects, which constitutes a relevant finding for the design and implementation of public policies in the educational sphere.

This study suggests several lines of research to further explore the findings. First, it is important to investigate the differences observed between the level of ESI coverage reported by students and by school administrators. In this regard, questions arise regarding how students recognize and identify the content, as well as potential biases in the responses of institutional actors.

Second, considering that a significant proportion of students (22.4%) turn to teachers for consultations on sexuality, it would be interesting to conduct a more in-depth analysis of these interactions, identifying practices, institutional conditions, and pedagogical strategies that foster their development, and to assess the potential for scaling up such practices.

6. Acknowledgments

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Use of Generative AI and Research Skills Among Computer Science Education Students

Uso de IA Generativa y competencias investigativas en estudiantes de Pedagogía en Informática

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Use of Generative AI and Research Skills Among Computer Science Education Students

Uso de IA Generativa y competencias investigativas en estudiantes de Pedagogía en Informática

Resumen:

This study aimed to analyze the relationship between the level of use of generative artificial intelligence and research skills in students of the Computer Science Education program at the National University of Loja. The research was conducted using a deductive method, with a quantitative approach, a descriptive-explanatory scope, and a non-experimental, cross-sectional field design. Data collection was carried out through a survey using a structured questionnaire validated with the Lawshe method and supplemented with statistical tests. The results showed a moderate and statistically significant positive relationship between the two variables ($\rho = 0.453$; $p < 0.001$). It is concluded that, in the studied population, a higher level of use of this technology is associated with higher levels of research skills, providing empirical evidence of its relevance in the context of higher education.

Keywords: educational innovation, generative AI, research skills, higher education.

Abstract:

El presente estudio tuvo como objetivo analizar la relación entre el nivel de uso de inteligencia artificial generativa y las competencias investigativas en estudiantes de la carrera de Pedagogía de las Ciencias Experimentales Informática de la Universidad Nacional de Loja. La investigación se desarrolló mediante un método deductivo, con enfoque cuantitativo, alcance descriptivo-explicativo y de campo, con diseño transversal no experimental. La recolección de datos se realizó mediante encuesta, a través de un cuestionario estructurado validado con el método de Lawshe y complementado con pruebas estadísticas. Los resultados evidenciaron una relación positiva moderada y estadísticamente significativa entre ambas variables ($\rho = 0.453$; $p < 0.001$). Se concluye que, en la población estudiada, un mayor nivel de uso de esta tecnología se asocia con mayores niveles de competencias investigativas, aportando evidencia empírica sobre su vinculación en el contexto de la educación superior.

Palabras clave: innovación educativa, IA generativa, competencias investigativas, educación superior.

1. Introduction

In the current context, emerging technologies, particularly artificial intelligence, have established themselves as powerful tools with vast potential to drive innovation, automate tasks, and develop solutions across various fields, including education. Among its recent manifestations, generative artificial intelligence (GAI) has altered the dynamics of content production, access to knowledge, and interaction with information.

In the field of higher education, the emergence of GAI is reshaping traditional pedagogical approaches, as well as academic research processes; this technological phenomenon, characterized by its exponential development, presents unprecedented opportunities, raises questions regarding its relationship with the development of cognitive competencies, and poses complex challenges for the training of future professionals and researchers. Although these tools are positioned as catalysts for educational innovation, their large-scale implementation lacks sufficient empirical support to analyze their relationship with the development of essential competencies, such as research skills, in specific educational contexts.

The disconnect between rapid technological adoption and scarce empirical evidence regarding correlations generates uncertainty about their pedagogical effectiveness, since the lack of studies establishing statistical correlations between the level of OGI use and the strengthening or deterioration of research skills in university students constitutes a critical gap that limits the understanding of OGI and directly affects educational stakeholders.

Several recent studies highlight issues associated with the use of these tools. Zumba et al. (2024) note that certain levels of IAG use could be linked to a decline in critical reasoning skills, while Mendiola and Degante (2023) argue that the unregulated use of these tools can lead to technological dependence, affecting research

skills such as independent argumentation. Additionally, Guerra and Tass (2024) report a progressive loss of creative skills among higher education students, with academic work that is less innovative and conceptually uniform. On the other hand, Gallent et al. (2023) note that the absence of an institutional regulatory framework exacerbates the uncertainty of higher education faculty when evaluating work produced with AI assistance, particularly regarding dimensions such as originality and analytical depth; the lack of clear institutional parameters intensifies this problem.

Internationally, the Inter-American Development Bank (IDB) (2024) indicates that universities often implement reactive policies driven by competition rather than pedagogical principles. While frequent use of AI-assisted writing in academic writing has been detected, there is a clear lack of documentation regarding its actual educational impacts and its correlation with the development of competencies. This lack of evidence is replicated at the regional level, where in Latin America, the absence of empirical studies on the relationship between IAG and the development of student skills is directly noted (Tiglla, 2025). On the other hand, in the national context, Cárdenas et al. (2025) note that the usefulness of GAI in managing information and facilitating academic work is recognized; however, they highlight the need to build an empirical foundation regarding its link to research competencies.

At the local level, no previous studies have been identified that address the relationship between these variables; therefore, it is pertinent to analyze the relationship between the level of generative artificial intelligence use and the level of research competencies among higher education students, addressing a current and relevant issue. The choice of the Experimental Sciences and Computer Science Education program was driven by the educational nature of this program, which is closely linked to the use of digital technologies

and to processes of information search, analysis, and production—aspects that are directly related to the use of generative artificial intelligence and the development of research competencies. In this sense, this academic context provides a relevant setting for examining the relationship between these two variables among higher education students.

Consequently, this study is theoretically and practically relevant by analyzing, through an innovative approach, the intersection of technological advancement and educational quality in higher education. This innovation lies in the study's addressing the gap in empirical evidence by analyzing the relationship between GAI use and the mastery of research skills among university students, thereby going beyond predominantly theoretical or descriptive approaches to the topic, in addition to the methodological contribution, which involves the design and validation of a specific research instrument that allows for the rigorous operationalization and measurement of both variables, thereby generating quantifiable data on an emerging educational issue.

In this regard, the present study aimed to generate situated empirical evidence on both variables within a specific university context. Based on this, the general objective of the research was to analyze the relationship between the level of generative AI use and research competencies among students in the Experimental Sciences and Computer Science Education program at the National University of Loja. Specifically, the following objectives were set: 1) to describe the level of use of generative artificial intelligence among participating students; 2) to identify the level of research competencies in the study population; and 3) to determine the relationship between both variables.

1.1 Background

The literature shows early efforts to characterize the impact of GAI on higher education, although significant gaps remain regarding its relationship to the development of research competencies. Among the studies reviewed, the work of Zumba

et al. (2024) stands out; they investigated the influence of tools such as ChatGPT and Gemini on text production, concluding that while these technologies significantly optimize efficiency in text creation, they can simultaneously inhibit the development of fundamental cognitive skills, such as critical thinking and argumentative originality, especially when their use lacks adequate pedagogical guidance.

Thus, this study highlights a central paradox inherent in adopting these emerging technologies, as their potential to facilitate access to knowledge contrasts with the risk of eroding cognitive autonomy. Complementarily, Carhuaricra et al. (2024) explored the relationship between the general use of artificial intelligence and research skills among students at a private university in Lima, Peru; their findings revealed a significant relationship, providing a basis for specifically exploring AAI in local educational contexts.

At the national level, the study by Cárdenas et al. (2025) analyzed the potential of artificial intelligence as a tool for developing research competencies in higher education. It proposed concrete methodologies for effective integration, using innovative, structured approaches.

Although this research does not focus specifically on Generative Artificial Intelligence (GAI), it constitutes a valuable contribution to understanding the role of AI in academic training, providing a framework for comparing and interpreting future findings on the relationship between GAI use and the development of research skills.

Along the same lines, Romeu et al. (2025) demonstrated that targeted training optimizes the effective use of GAI; however, they also identified concerns about the indiscriminate use of these tools and the need to establish clear guidelines. This is because unregulated use can negatively affect the development of research competencies, thereby supporting the need for the present research. Consequently, the background presented justifies the relevance of this study, which addresses this correlation as a critical aspect in the context of higher education and scientific research.

1.2 Generative Artificial Intelligence and Its Use in the Educational Context

Generative artificial intelligence is a type of AI geared toward the production of multimedia content through the use of advanced learning algorithms that enable it to create original material such as texts, images, audio, or video, based on pattern analysis and data processing. As Russell and Norvig (2020) point out, these systems fall into the category of those that “act rationally,” as they replicate creative processes by identifying and leveraging structures based on pre-existing information. Among its fundamental characteristics, its multimodal nature stands out—that is, the ability to interpret and generate content in various formats. Thus, this versatility significantly broadens its scope of application, enabling the development of innovative solutions in fields such as digital art, interactive education, research, and the automation of creative processes.

In the educational context, this technology catalyzes pedagogical transformation. According to UNESCO (2024), AI has the potential to reshape the education sector—from administrative management to teaching methodologies—provided it is implemented ethically and critically. On the other hand, in the research context, AI-driven generative models (AGMs) are seen as a valuable tool, as Muñoz et al. (2025) argue that they enable the analysis of complex data from different perspectives, helping researchers identify trends that might otherwise go unnoticed. Furthermore, it automates key processes, such as literature reviews and the generation of preliminary hypotheses, thereby optimizing time and resources in academic projects.

Currently, the integration of NLP in the academic sphere represents a strategic resource for students, as, according to Peralta (2024), it allows them to optimize time and bibliographic searches, facilitating everything from the initial planning and structuring of documents to the review of style and coherence. Based on the observations of UNESCO (2024) and Lúndin (2024), Table 1 outlines the main uses of GAI in research, which reflect its potential to transform academic and methodological processes.

Within the research landscape, generative artificial intelligence has demonstrated a significant impact on the scientific research process; GAI's intrinsic ability to process and generate natural language has opened new avenues to assist both researchers and students in creating, revising, and refining their academic documents. Figure 1 classifies the key functionalities of generative AI in the academic context.

Generative AI positions itself as a strategic tool in scientific research by integrating capabilities that transform the creation, revision, and presentation of academic and research content. Nevertheless, it is important to consider that its implementation requires conscious and ethical use. In addition to challenges such as the risk of plagiarism due to the reproduction of content without attribution, the generation of false references, and the need for transparency in its use. Thus, accelerated adoption entails a critical educational duality that can affect the development of competencies: although generative AI democratizes knowledge and access to advanced research processes, its inappropriate use threatens to progressively erode cognitive skills such as critical thinking and deep synthesis. This duality poses a central

Table 1. Uses of Generative AI in Research.
Source: Adapted from UNESCO (2024) and Lúndin (2024).

Dimension/Use	Description
Conceptual: Research Idea and Design	This constitutes the initial foundation for any research; here, GAI tools enable the automatic generation of innovative ideas and approaches for scientific projects.
Informational: Information search, management, and collection	It enables the handling of large volumes of data, facilitates the automatic translation of academic texts, breaking down language barriers and expanding access to global information.
Textual: Writing and editing	It optimizes the creation of academic texts or drafts, reviews and improves grammar and spelling, and enhances their clarity and coherence.
Visual Analytics: Visual Data Generation and Analysis	It enables the automatic generation of visualizations (graphs, tables) to effectively communicate results. It is also key in data analysis for discovering complex patterns.

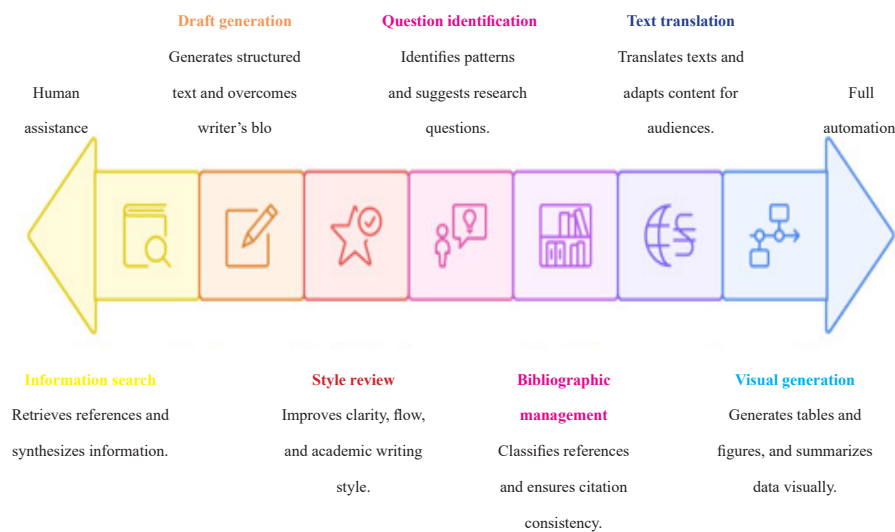


Figure 1: Uses of GAI.
Source: Image created using the Napkin tool (2025).

paradox: a tool designed to enhance intellectual capacity could, if implemented indiscriminately, weaken research competencies.

1.3. Research Competencies in Higher Education Students

Research competencies are conceived as an integrated set of knowledge, skills, attitudes, and values that enable individuals to conduct research processes in a rigorous, systematic, and critical manner. According to Muñoz and Hernández (2020), these competencies are understood as the capabilities necessary to identify problems, formulate research questions, design appropriate methodologies, analyze data, and communicate results effectively. Complementarily, the European Commission (2022) defines them as essential capabilities encompassing disciplinary, methodological, and cross-cutting knowledge, as a factor in ensuring the excellence, integrity, and social impact of science. In this sense, research competencies involve mastery of methodological techniques and tools, as well as a critical and reflective approach to knowledge.

In Ecuador, the Council for Quality Assurance in Higher Education (CACES) (2023) establishes research competencies as an integral part of core university functions, promoting practices of self-assessment, continuous improvement, and the generation of relevant knowledge. For its part, the Council for Higher Education (CES) (2020) emphasizes that these competencies, along with professional, communicative, and digital competencies, are essential for students to address complex problems both critically and systematically, holding institutions accountable for fostering skills that include the formulation of relevant questions, methodological design, rigorous analysis, and effective communication of results.

Therefore, the development of research competencies is crucial for students to contribute to social, scientific, and technological progress, meet workplace demands, and promote disciplinary innovation. These competencies, according to Ochoa (2024) and García and Martínez (2020), are organized into four interrelated dimensions: cognitive, procedural, attitudinal, and communicative, which are specified in Table 2.

Table 2. Dimensions of research competencies.

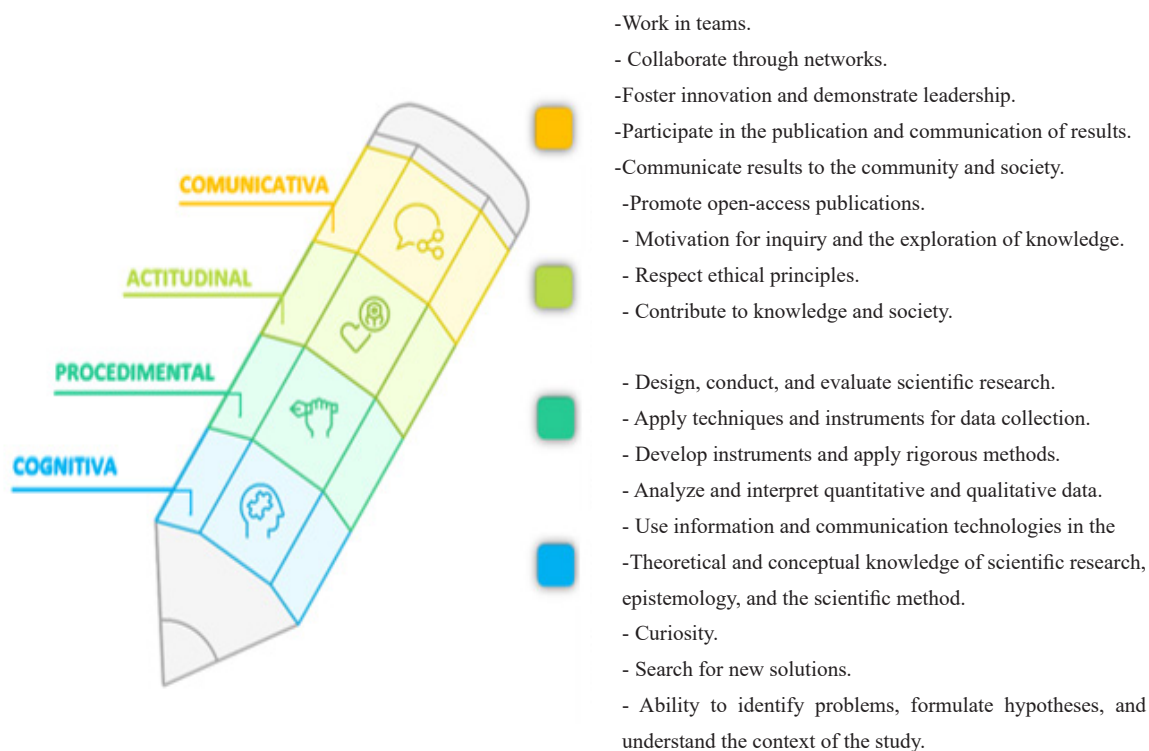
Source: Adapted from Ochoa (2024) and García and Martínez (2020).

Dimension	Characteristics
Cognitive	Includes theoretical and conceptual knowledge of scientific research, as well as epistemology and the scientific method. This dimension addresses competencies related to thinking, conceptualization, abstraction, and knowledge generation.
Procedural	Involves the practical skills necessary to design, conduct, and evaluate research. It also encompasses the collection, analysis, and interpretation of data using appropriate techniques and tools. Finally, it focuses on the rigorous application of methodologies.
Attitudinal	It encompasses values, attitudes, and dispositions such as professional ethics, scientific curiosity, perseverance, and responsibility, as well as social commitment in the production and use of knowledge. It includes values, attitudes, and behaviors that promote the ethical, responsible, and motivated conduct of research.
Communicative	This refers to the ability to interact, communicate, and work effectively with others, as well as the dissemination and sharing of research results.

In a constantly evolving world, where information is abundant but not always reliable, the ability to conduct research critically and systematically becomes an indispensable tool. Thus, these competencies foster critical thinking, creativity, autonomy, and the ability to collaborate—all skills highly valued in professional and academic settings, as those who master research are better equipped to tackle the challenges of their respective disciplines, contribute to innovation, and even adapt to the dynamics of the labor market.

Based on the above, Figure 2 outlines the research competencies that higher education students should possess, according to Andrade and Cabrera (2022), Ochoa (2024), and the European Commission (2022).

In essence, research competencies transform students from mere consumers of information into creators or disseminators of knowledge, preparing them for a future where curiosity and inquiry are invaluable assets—essential for university students to develop solid, ethical, critical, and relevant research projects.

**Figure 2.** Research competencies in higher education students.

Source: Adapted from Andrade and Cabrera (2022); Ochoa (2024) and the European Commission (2022).

2. Materials and Methods

The study was conducted in the Experimental Sciences and Computer Science Education (PCEI) program at the National University of Loja, Ecuador, where the relationship between the level of use of generative artificial intelligence and students' research competencies was analyzed. To this end, the deductive method was employed, with a quantitative approach and a non-experimental cross-sectional design. This design was chosen because the purpose of the research was to examine the relationship between both variables at a specific point in time, without manipulating them. Applied in nature and with a descriptive-explanatory scope, the research employed a field study methodology, enabling analysis of the issue based on primary data collected directly from the educational context under study.

Regarding the study population, it consisted of 148 students in the PCEI program, with a sample of 107 students, who were administered a structured questionnaire designed based on guidelines established by the European Commission (2022), UNESCO (2024), Días and Rodríguez (2024), Ochoa (2024), Lúndin (2024), and Pedraza (2023), using the survey technique. This instrument allowed for the evaluation of four dimensions of the first study variable, "Generative AI" (Conceptual; Informational; Textual; Visual-Analytical), and four of the second variable, "Research Competencies" (Cognitive; Procedural; Attitudinal, and Communicative), using an adapted DIGCOMP (2022) scale with four ratings: 1 = Basic, 2 = Intermediate, 3 = Advanced, and 4 = Highly Specialized. The adaptation of this scale involved adopting the gradual proficiency framework proposed by DIGCOMP and contextualizing it to measure the level of generative AI use and the level of research competencies among university students, in alignment with the study's dimensions and objectives. This adaptation was supported by the instrument's content validation process, based on expert criteria and statistical tests. This structure ensured alignment with the study's specific objectives by enabling the identification of the

level of generative artificial intelligence use, the assessment of research competency levels, and the analysis of the relationship between these two variables.

Before administration, the research instrument underwent a validation process structured in three sequential phases: the first focused on the design and theoretical foundation of the instrument; followed by content evaluation through expert judgment using the Lawshe method to verify the relevance and clarity of the items; culminating in the statistical analysis phase, which included: the evaluation of temporal stability using Pearson's R correlation coefficient; the analysis of internal consistency using Cronbach's alpha coefficient; and the general assessment of inter-rater agreement using the Fleiss Kappa method. Table 3 summarizes the results derived from the validation process.

To collect the data, a face-to-face meeting was held with students in the program under study, during which the purpose of the research was explained, and their participation was encouraged. Subsequently, the structured questionnaire was administered via Google Forms. Once the data were collected, they were analyzed using a statistical procedure that began with verifying normality assumptions using the Shapiro-Wilk and Kolmogorov-Smirnov tests. Since the data did not follow a normal distribution, we used Spearman's Rho nonparametric correlation test in SPSS. Subsequently, the results were analyzed using descriptive and inferential statistics, which enabled graphical representation of both the level of use of generative artificial intelligence and research competencies, as well as the correlation between the two variables.

Regarding ethical considerations, participants' rights were fully protected by obtaining informed consent in advance. This procedure was complemented by the rigorous application of the fundamental ethical principles of scientific research, which guided all interactions with the student population involved in the study.

Table 3. Summary of the research instrument validation process.
Source: Prepared by the authors (2025).

Phase	Process
Phase 1: Design and rationale of the research instrument	Instrument Name: Questionnaire to assess the level of use of generative artificial intelligence and the level of research competencies. Structure and Rationale: Variable 1: Use of generative artificial intelligence (GAI). Dimensions: Conceptual, Informational, Textual, and Visual-Analytical. Variable 2: Research competencies. Dimensions: Cognitive, Procedural, Attitudinal, and Communicative. Based on: European Commission (2022), UNESCO (2024), Días and Rodríguez (2024), Ochoa (2024), Lindin (2024), and Pedraza (2023).
Phase 2: Content Validity Index (CVI) of the research instrument.	1. Determined through the judgment of three experts in education and technology, using the Lawshe method (1975). 2. A three-point scale was used: 1 = not necessary, 2 = useful but not essential, 3 = essential, with a minimum CCI of 0.78 established as the acceptance criterion. 3. Following the evaluation, 36 out of 40 items were approved.
Phase 3: Statistical analysis of the research instrument	Assessment of temporal stability 1. Reliability test, applying the Test-Retest method to 10 volunteers, using Pearson's r coefficient, whose result of 0.92 indicated a "strong correlation" between the two applications of the instrument. Internal consistency assessment 2. Reliability test: The internal consistency of the instrument was determined using Cronbach's α (α). The result was $\alpha = 0.90$, which is interpreted as an "Excellent" level of reliability. Validation of the level of agreement among experts 3. The theoretical basis, adequacy, clarity, coherence, quality, and relevance of the instrument were evaluated. The results of this evaluation showed a maximum score of 5/5. 4. Additionally, Fleiss' Kappa was applied to determine the degree of inter-expert agreement, yielding a coefficient of $\kappa = 1$, which, according to the Landis and Koch (1977) scale, corresponds to a level of "almost perfect" agreement.

3. Results

This section provides a comprehensive analysis of the study's findings, linking them to the theoretical and empirical framework underpinning the research. First, we present the results regarding the level of use of generative artificial intelligence and research competencies among students in the Experimental Sciences and Computer Science Education program, obtained using the validated instrument. The level of generative AI use, corresponding to the first study variable, is illustrated in Figure 3.

The analysis of generative AI usage reveals a distribution concentrated at the "Intermediate" level, accounting for 52%, indicating a functional but not specialized use of these tools. Additionally, the "Basic" level represents 31% of the sample, while the "Advanced" and "Highly Specialized" options account for 13% and 4%, respectively. Collectively, these results suggest an incipient adoption of technology, reflecting a developing

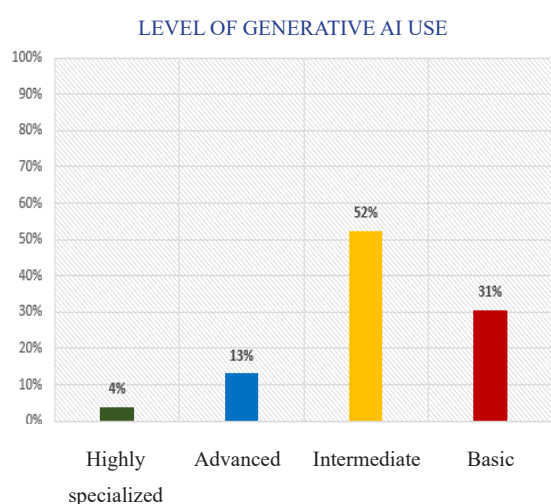


Figure 3. Level of use of generative artificial intelligence.
Source: Author's own work (2025).

learning curve. Secondly, Figure 4 shows the analysis of research competencies in the study population, revealing the following distribution.

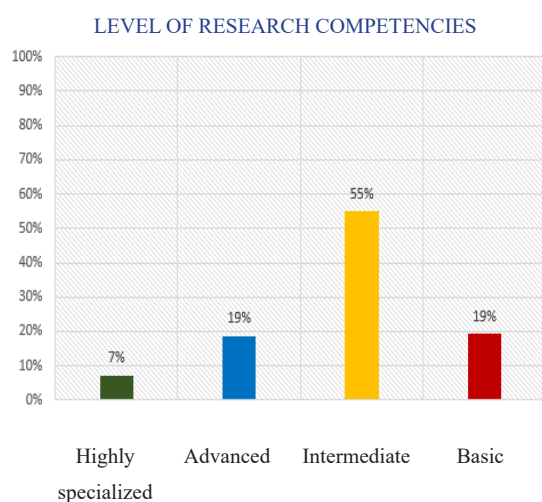


Figure 4. Level of research competencies.
Source: Author's own work (2025)

The data obtained show that the “Intermediate” level accounts for the largest percentage—55% of the sample—followed by 19% at the “Basic” level and 19% at the “Advanced” level, in contrast to the “Highly Specialized” level, which comprises a smaller percentage of 7%. This pattern suggests that, while most students have developed fundamental research skills, there is a polarization at the extremes of the competency scale. The fact that the “Basic” and “Highly Specialized” levels share the same percentage indicates the coexistence of two distinct realities within the same student population, which could be due to different learning paces, access to resources, or research training opportunities.

Thus, the results of the variables reveal distinct profiles in the studied context: on the one hand, the use of generative AI shows a concentration at the intermediate level (52%), followed by the basic level (31%), suggesting a developing technological adoption. On the other hand, research competencies show a more balanced distribution between the intermediate level (55%) and the combined basic and advanced levels (19% each), indicating a solid educational

foundation, though with room to strengthen the extremes of the competency scale.

Based on the findings, the level of generative AI use was correlated with the level of research competencies. To this end, statistical assumptions were verified using a normality test, which determined the choice of the appropriate correlation analysis. For the correlational analysis, the principles of inferential statistics were considered; within this methodological framework, the following hypotheses and criteria were considered.

Hypothesis

α value = 0.05

Ho-Null Hypothesis: The data FOLLOW a normal distribution.

Ha-Alternative hypothesis: The data DO NOT follow a normal distribution.

Decision criteria

If the p-value is “LESS THAN OR EQUAL TO” 0.05, the null hypothesis is rejected and the alternative hypothesis is accepted, meaning that the data DO NOT follow a normal distribution; therefore, a NONPARAMETRIC test is used for the correlation.

If the p-value is “GREATER” than 0.05, the null hypothesis is accepted and the alternative hypothesis is rejected; therefore, the data DO follow a normal distribution, and thus PARAMETRIC tests are used.

Based on this, the assumption of normality was made, and given that the sample size was $n=107$, the Kolmogorov-Smirnov test was considered, the results of which are detailed below.

Table 4. Normality tests applied.
Source: Author's own work (2025).

Normality tests	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Level of generative AI usage	,127	107	,000	,964	107	,005
Level of research competencies	,140	107	,000	,948	107	,000

a. Lilliefors significance correction

According to the results, all significance values (Sig.) obtained were less than the α value of 0.05, leading to the rejection of the null hypothesis and the acceptance of the alternative hypothesis. This finding confirms the nonnormality of the data distribution, necessitating the use of nonparametric statistical methods for correlation analysis. Consequently, Spearman's Rho was applied as a nonparametric test to examine the bivariate relationship between the study variables, yielding the following results, presented in Table 5.

The bivariate correlation analysis using Spearman's Rho coefficient revealed the existence of a statistically significant "moderate positive" relationship between the level of generative AI use and the level of research competencies

in the study sample ($\rho = 0.453$, $p = 0.000$). The correlation, which was significant at the 0.01 bilateral level and is presented in Figure 5, shows that greater frequency and depth of use of generative artificial intelligence tools are associated with higher levels of research skills among students.

While the scatter of points reflects individual variability, the predominant clustering along the diagonal confirms that an increase in one variable is associated with progress in the other, establishing a consistent link between both dimensions in the analyzed student population. In general terms, this association suggests that the study variables tend to progress in parallel and complementary ways.

Table 5. Correlation results between study variables.
Source: Author's own work (2025).

Correlations				
			Level of generative AI use	Level of research skills
Spearman's rho	Level of generative AI use	Correlation coefficient	1,000	,453**
		Next (bilateral)	.	,000
		N	107	107
	Level of research skills	Correlation coefficient	,453**	1,000
		Sig. (two-tailed)	,000	.
		N	107	107

**. The correlation is significant at the 0.01 level (two-tailed).

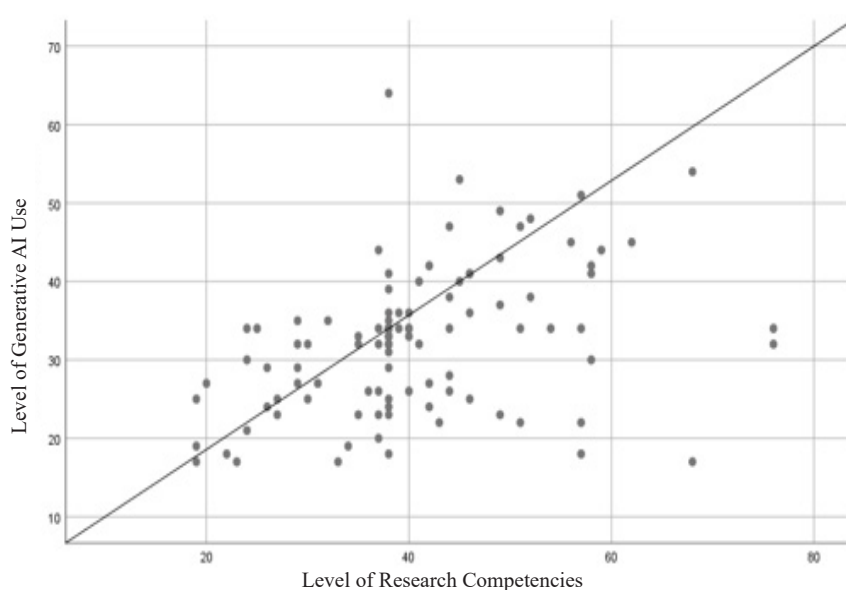


Figure 5. Scatter-correlation plot.
Source: Generated using SPSS. (2025).

4. Discussion

The results obtained allow for a critical interpretation of the relationship between the level of use of generative artificial intelligence and research competencies in the student population analyzed. First, the predominance of an intermediate level in both the use of generative artificial intelligence and research competencies suggests the consolidation of average digital literacy, characterized by a functional adoption of this technology. This scenario highlights the need for institutional guidance and pedagogical support to foster more advanced or specialized levels of adoption. These findings align with UNESCO's (2024) perspective regarding the need to accompany technological evolution with pedagogical strengthening. In turn, the parallel development of the variables studied aligns with Pedraza's (2023) approach, which holds that the integration of technologies in education typically progresses in parallel with the maturity of students' cognitive skills.

Furthermore, the moderate positive correlation identified suggests a favorable statistical association between the two variables. This result partially diverges from the argument put forward by Guerra and Tass (2024), who note that the use of generative artificial intelligence may lead to a gradual loss of creative skills among higher education students. However, this discrepancy must be interpreted in light of the context of technology use, as the findings of the present study are more consistent with research such as that of Madrid and Salgado (2023), who reported that regular, though not specialized, use of generative artificial intelligence is associated with developing research competencies. In this regard, the results suggest a complementary relationship between technological proficiency and research methodological skills, without implying a direct causal relationship.

On the other hand, the presence of outliers (students with high levels of generative AI use but average research competencies, and vice versa) suggests, in line with Arroyave (2024), that mere exposure to the technology does not in itself

guarantee the development of advanced research competencies. These specific cases indicate the possible influence of moderating variables, such as faculty support, intrinsic motivation, or the quality of the methodological training received. In summary, the general trend observed is consistent with UNESCO's (2024) perspective on the facilitative role of generative artificial intelligence in research processes; however, the dispersion at the extremes of the distribution highlights the need to implement differentiated pedagogical strategies that address the various profiles of technological adoption identified.

Nevertheless, the findings of this study must be interpreted in light of certain specific limitations. First, the research was conducted within a particular institutional and disciplinary context, limited to students in the Experimental Sciences and Computer Science Education program at an Ecuadorian university, which restricts the generalizability of the results to other academic programs or higher education contexts. Second, the non-experimental cross-sectional design allowed identification of associations between variables at a single point in time but did not permit causal inference or longitudinal observation. Third, the data were collected using a structured self-report questionnaire, which may introduce biases due to the subjectivity of responses. Finally, the presence of outliers suggests that the observed relationship could be influenced by other factors not addressed in this study, such as faculty support, student motivation, or the quality of the methodological training received.

Given these limitations, future research could expand the analysis to other degree programs, institutions, and geographic contexts to test the consistency of the results obtained. Likewise, it would be appropriate to incorporate longitudinal or comparative designs that allow for examining the evolution of generative AI use and its relationship with research competencies over time. Similarly, the complementarity of quantitative and qualitative approaches could enrich our understanding of the phenomenon

by delving deeper into students' and teachers' specific experiences, perceptions, and practices regarding the use of these tools. Finally, it would be valuable to explore the effect of intervening

variables, such as prior methodological training, digital literacy, institutional pedagogical guidance, and the frequency of academic use of generative artificial intelligence.

5. Conclusions

The study's results show that, in the analyzed population, both the use of generative artificial intelligence and research competencies are predominantly at an intermediate level, reflecting moderate development in both. Likewise, a moderate and statistically significant positive correlation was identified between the level of use of these tools and research competencies, allowing us to conclude that, among the students analyzed, higher levels of generative artificial intelligence use are associated with higher levels of research competencies.

In this regard, the present study provides empirical evidence on the relationship between both variables in a specific university context, contributing to a field in which theoretical or reflective approaches still predominate. However, due to the cross-sectional and non-experimental nature of the research, the findings should be interpreted in correlational rather than causal terms. Consequently, the incorporation of generative artificial intelligence into research training requires pedagogical and institutional guidelines that promote ethical, critical, and academically relevant use.

6. Recommendations

Given the level of GAI use and research competencies (intermediate), institutions should view generative AI as an operational support tool rather than a substitute. In this regard, we recommend the design and implementation of faculty training courses on the appropriate ethical use of this emerging tool, as well as courses,

workshops, or tutorials for students to foster critical thinking about the use of GAI. Finally, it is important to promote a culture of responsible use to support the deconstruction of traditional pedagogies, in the interest of quality education that contributes to the development of society.

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Desarrollo y validación de una escala de autogestión del estudiantado entre estudiantes filipinos de décimo grado

Development and Validation of a Student Self-Management Scale Among Filipino Grade 10 Students

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Development and Validation of a Student Self-Management Scale Among Filipino Grade 10 Students

Desarrollo y validación de una escala de autogestión del estudiantado en estudiantes filipinos de grado 10

Abstract:

La autogestión del estudiantado es ampliamente reconocida como un factor clave para fomentar la resiliencia, la adaptabilidad y el desarrollo integral; sin embargo, los instrumentos validados para estudiantes de nivel secundario siguen siendo limitados, especialmente en contextos de países en desarrollo. Este estudio desarrolló y validó la Escala de Autogestión del Estudiantado (SSMS) para evaluar la autorregulación, la resiliencia al estrés y la orientación a metas en estudiantes de educación secundaria. Tras un proceso de generación sistemática de ítems, la validación por expertos y la aplicación de pruebas piloto, se recopilaron datos de 346 estudiantes filipinos, refinando 113 ítems iniciales a 27 indicadores. Los análisis psicométricos incluyeron consistencia interna, análisis factorial exploratorio y confirmatorio, y validez concurrente mediante el rendimiento en matemáticas. La SSMS mostró excelente consistencia interna global ($\alpha = .94$). El análisis factorial exploratorio apoyó una estructura de tres componentes; sin embargo, el análisis factorial confirmatorio indicó un ajuste del modelo parcial y de carácter provisional. La dimensión de orientación a metas estuvo representada por un solo ítem, lo que limita su solidez psicométrica. La validez concurrente

Resumen:

Student self-management is widely recognized as a key factor in fostering resilience, adaptability, and holistic student development; however, validated instruments for secondary-level learners remain limited, particularly in developing-country contexts. This study developed and validated the Student Self-Management Scale (SSMS) to assess self-regulation, stress resilience, and goal orientation among secondary school students. Following systematic item generation, expert validation, and pilot testing, data were collected from 346 Filipino secondary students, refining 113 initial items to 27 indicators. Psychometric analyses included internal consistency reliability, exploratory and confirmatory factor analyses, and concurrent validity testing using mathematics achievement. The SSMS demonstrated excellent overall internal consistency ($\alpha = .94$). Exploratory factor analysis supported a three-component structure; however, confirmatory factor analysis indicated only partial and provisional model fit. The goal orientation dimension was represented by a single item, limiting its psychometric robustness. Concurrent validity with mathematics achievement was weak and should be interpreted cautiously, potentially reflecting both construct distinctiveness and limitations in the selected

con el rendimiento en matemáticas fue débil y debe interpretarse con cautela, ya que podría reflejar tanto la distintividad del constructo como limitaciones del criterio externo utilizado. En conjunto, la SSMS constituye un instrumento preliminar y contextualizado que requiere mayor refinamiento para fortalecer su validez estructural y su aplicabilidad en diversos contextos educativos

Palabras clave: medición educativa, análisis factorial, motivación, teoría de la autodeterminación, bienestar.

external criterion. Overall, the SSMS represents a preliminary but contextually grounded instrument, with further refinement needed to strengthen its structural validity and applicability in diverse educational settings.

Keywords: educational measurement, factor analysis, motivation, self-determination theory, well-being

1. Introducción

Las rápidas transformaciones en la educación contemporánea han intensificado la necesidad de la autogestión de los estudiantes como competencia fundamental para el aprendizaje a lo largo de la vida, la adaptabilidad y el desarrollo holístico. Dentro del marco más amplio del aprendizaje socioemocional (SEL), la autogestión se define comúnmente como la capacidad de regular las emociones, las cogniciones y los comportamientos de manera que apoyen el logro de metas y el funcionamiento adaptativo en contextos académicos y sociales (Lawson et al., 2019; Pham, 2024). Sin embargo, a pesar de su importancia, el constructo se utiliza a menudo de manera intercambiable con conceptos relacionados, como la autorregulación y otras competencias socioemocionales, lo que da lugar a una ambigüedad conceptual (Gagne et al., 2021; Lozano-Peña et al., 2021).

La autogestión también está estrechamente relacionada con constructos más amplios, como las funciones ejecutivas y las habilidades no cognitivas. Las funciones ejecutivas se refieren a procesos cognitivos subyacentes, como la memoria de trabajo, el control inhibitorio y la flexibilidad cognitiva, mientras que las habilidades no cognitivas abarcan una gama más amplia de atributos socioemocionales, incluyendo la motivación, la persistencia y las competencias interpersonales. Por el contrario, en este estudio

se conceptualiza la autogestión como la puesta en práctica observable y dependiente del contexto de estas capacidades subyacentes, lo que refleja cómo los estudiantes traducen los procesos de regulación interna en comportamientos orientados a objetivos en entornos de aprendizaje complejos caracterizados por la incertidumbre, la autonomía y mayores exigencias cognitivas y emocionales (Skinner-Nikhol, 2025; Ruffini et al., 2023).

La pandemia de COVID-19 acentuó aún más la importancia central de las habilidades de autogestión, particularmente a medida que los estudiantes realizaban la transición a modalidades de aprendizaje digitales, modulares e híbridas (Ruiz-Ramírez et al., 2021; Blanchard et al., 2024). En estas condiciones, se exigió a los estudiantes que gestionaran su tiempo de forma independiente, mantuvieran la motivación, se enfrentaran al estrés y regularan su participación con una supervisión externa limitada (Bashir et al., 2021; Sato et al., 2024). La evidencia empírica demuestra de manera consistente que los estudiantes con sólidas capacidades de autogestión exhiben un mayor rendimiento académico, mejores resultados de salud mental y una integración social más positiva, mientras que las deficiencias se asocian con la desmotivación, el estrés elevado y una mayor vulnerabilidad a las dificultades emocionales y conductuales

(Al-Abyadh y Abdel Azeem, 2022; Smith et al., 2022; Zhang et al., 2024). Estos hallazgos subrayan la necesidad de una comprensión conceptualmente sólida y empíricamente fundamentada de la autogestión como un constructo multidimensional.

A pesar del creciente consenso sobre su importancia, la disponibilidad de instrumentos de medición válidos y culturalmente sensibles sigue siendo limitada, particularmente para los estudiantes de nivel secundario en contextos no occidentales y de países en desarrollo (Pham, 2023; Arbués et al., 2025). Muchas de las escalas existentes están integradas en marcos más amplios de aprendizaje socioemocional (SEL) o desarrolladas en sistemas educativos que difieren sustancialmente en cuanto a estructuras pedagógicas, acceso tecnológico y expectativas socioculturales (Hayashi et al., 2022). En consecuencia, es posible que estos instrumentos no capten adecuadamente la naturaleza contextualizada e integradora de la autogestión tal como se pone en práctica en diversos entornos de aprendizaje, lo que limita la capacidad de los educadores y los responsables de políticas para generar evaluaciones precisas y diseñar intervenciones basadas en la evidencia adaptadas a las necesidades locales (Camp-Spivey et al., 2021; Noordman et al., 2024).

Si bien se han desarrollado varios instrumentos para evaluar la autogestión, la autorregulación y las competencias socioemocionales relacionadas, estas medidas a menudo se centran en dimensiones discretas —como las estrategias metacognitivas, la motivación o la autorregulación académica— en lugar de conceptualizar la autogestión como un constructo unificado y multidimensional (Kanayama et al., 2024; Lourenço et al., 2025). Muchos están integrados en marcos teóricos más amplios y carecen de especificidad como herramientas independientes para una evaluación integral (Roscoe y Craig, 2022; Zhang, 2024). Además, estos instrumentos se han validado predominantemente en contextos educativos occidentales y es posible que no capten plenamente la integración de los procesos conductuales, emocionales y orientados a objetivos que se requieren en entornos de aprendizaje con recursos limitados y en rápida evolución (Fuchs

y Fuchs, 2025; Jian et al., 2025). Como resultado, su aplicabilidad a los estudiantes de nivel secundario en contextos de países en desarrollo, particularmente en condiciones modulares y pospandémicas, sigue siendo limitada.

En el contexto educativo filipino, el rápido cambio al aprendizaje modular y a distancia puso de manifiesto desafíos persistentes relacionados con el mantenimiento de la motivación de los estudiantes, la gestión de las cargas de trabajo académicas y el apoyo al bienestar psicológico, especialmente entre los estudiantes de entornos socioeconómicos desfavorecidos (Codilla, 2025). Aunque la investigación global sobre el aprendizaje socioemocional (SEL) se ha expandido considerablemente, siguen siendo escasos los instrumentos validados localmente capaces de captar la autogestión de los estudiantes dentro de estas realidades contextuales (Durneva y LeRouge, 2026). Abordar esta brecha es fundamental para monitorear la resiliencia de los estudiantes, informar las prácticas de instrucción y mitigar las desigualdades digitales que continúan marcando las experiencias de aprendizaje.

En respuesta a estas limitaciones, el presente estudio propone una conceptualización de la autogestión de los estudiantes como un constructo multidimensional que comprende tres dominios interrelacionados: autorregulación y control, resiliencia al estrés y orientación hacia metas (Martínez-López et al., 2024; Barakou et al., 2023). Estas dimensiones reflejan la integración de procesos reguladores, mecanismos de afrontamiento adaptativos y comportamientos motivacionales orientados a metas. Conceptualmente, esta estructura también representa la consolidación de los dominios identificados inicialmente —control de impulsos, manejo del estrés, autodisciplina y motivación, establecimiento de metas y habilidades organizativas— en un modelo de tres factores más parsimonioso y teóricamente coherente (Wang et al., 2025). Específicamente, el control de los impulsos y las habilidades organizativas se alinean con la autorregulación y el control (Van y Raz, 2023); la gestión del estrés corresponde a la resiliencia al estrés (Peyer et al., 2022); y la autodisciplina, la motivación y el establecimiento de metas convergen en la orientación hacia

las metas (Avcı y Durak, 2022). Este marco proporciona una base conceptual para anticipar la estructura dimensional del constructo y guiar su validación empírica.

Guiado por este modelo conceptual, el presente estudio tuvo como objetivo desarrollar y validar una Escala de Autogestión Estudiantil (SSMS) para estudiantes de secundaria en Filipinas. La escala se basó en la teoría establecida del SEL y se enriqueció a través de conocimientos cualitativos derivados de las experiencias de los estudiantes. Se empleó un riguroso proceso de validación psicométrica, que incluyó validación de contenido, análisis factorial exploratorio y análisis factorial confirmatorio, para evaluar la fiabilidad y la validez estructural de la escala.

Más allá de su función como instrumento de medición, la SSMS contribuye al perfeccionamiento del trabajo teórico y empírico en el ámbito del SEL al ofrecer una conceptualización de la autogestión más claramente delineada y basada en el contexto. Al proporcionar una herramienta de evaluación confiable y culturalmente sensible, este estudio respalda los esfuerzos educativos más amplios destinados a promover el bienestar de los estudiantes, la pedagogía inclusiva y la adaptabilidad digital. En última instancia, responde a la necesidad urgente de dotar a los alumnos de las competencias necesarias para prosperar académica, emocional y socialmente en entornos educativos cada vez más complejos y en constante evolución.

2. Materiales y métodos

2.1. Diseño de la investigación

Este estudio adoptó un diseño de investigación para el desarrollo y la validación de una escala, guiado por marcos psicométricos y estándares metodológicos consolidados (Boateng et al., 2018; Kyriazos y Stalikas, 2018). El diseño siguió un enfoque secuencial y multifásico destinado a maximizar la claridad de los constructos, la precisión de la medición y el rigor empírico. Específicamente, el proceso comprendió (a) la generación de ítems teóricos y empíricos, (b) la validación del contenido por expertos, (c) pruebas piloto iterativas, (d) el análisis factorial exploratorio (AFE) para identificar dimensiones latentes, (e) el análisis factorial confirmatorio (AFC) para examinar la estructura del modelo propuesto, y (f) la evaluación de la consistencia interna y la validez relacionada con el criterio.

Cada fase sirvió de base para las etapas posteriores, lo que permitió un perfeccionamiento sistemático del instrumento. Se utilizaron muestras independientes para el EFA y el CFA a fin de reducir la influencia del azar y fortalecer la validación del constructo. Este diseño se ajusta a las recomendaciones de mejores prácticas

para el desarrollo de instrumentos educativos culturalmente sensibles y psicométricamente sólidos.

2.2. Participantes

Los participantes fueron reclutados mediante un muestreo intencional de escuelas secundarias públicas seleccionadas en Nueva Vizcaya, Filipinas. La población objetivo estaba compuesta por estudiantes filipinos de décimo grado matriculados en el plan de estudios regular de la escuela secundaria durante el período de recolección de datos. Los criterios de exclusión incluyeron respuestas incompletas al cuestionario y la retirada del consentimiento.

Participaron un total de 346 estudiantes en tres fases piloto distintas: Prueba piloto 1 ($n = 100$), Prueba piloto 2 ($n = 100$) y Prueba piloto 3 ($n = 146$). Cada fase piloto contó con un grupo único de encuestados para preservar la independencia de la muestra en todos los análisis. El tamaño acumulado de la muestra cumplió con las proporciones recomendadas de participantes por ítem de 5 a 10 encuestados por ítem para los procedimientos de análisis factorial, lo que garantizó una potencia estadística suficiente

y la estabilidad de las soluciones factoriales (Mundfrom et al., 2005). Las características demográficas de los participantes se presentan en la Tabla 1.

2.3. Desarrollo del instrumento

La Escala de Autogestión del Estudiante (SSMS) se desarrolló mediante estrategias deductivas e inductivas de generación de ítems. De manera deductiva, los ítems se derivaron de modelos teóricos establecidos de aprendizaje socioemocional, autorregulación y resiliencia (Nelson et al., 2007; Dusenbury et al., 2019; Zimmerman, 2023). De manera inductiva, se realizaron entrevistas semiestructuradas con estudiantes de secundaria para captar comportamientos y desafíos específicos del contexto relacionados con la gestión de la carga de trabajo académica, el estrés emocional, las limitaciones de tiempo y la búsqueda de metas en entornos de aprendizaje modulares y presenciales. Se generó un conjunto inicial de 113 ítems que se clasificaron en cinco dominios conceptuales: control de impulsos, manejo del estrés, autodisciplina y motivación, establecimiento de metas y habilidades organizativas. Todos los ítems se redactaron como enunciados autorreferenciales y las respuestas se registraron utilizando una escala de Likert de cinco puntos que iba desde «totalmente en desacuerdo» (1) hasta «totalmente de acuerdo» (5). La redacción de los ítems se revisó para verificar su adecuación a la edad, claridad lingüística y relevancia cultural antes de la validación por expertos.

2.4. Validez de contenido

La validez de contenido se examinó mediante la aplicación del enfoque del Índice de Validez de Contenido (CVI) (Polit y Beck, 2006).

Cinco expertos en psicología educativa, psicometría y educación secundaria evaluaron de forma independiente cada ítem en términos de relevancia y claridad utilizando una escala ordinal de cuatro puntos. Los valores del CVI a nivel de ítem (I-CVI) se obtuvieron determinando la proporción de expertos que calificaron un ítem como bastante relevante (3) o muy relevante (4). Los valores del I-CVI se interpretaron utilizando criterios establecidos: los valores de 0,79 y superiores se consideraron aceptables, los valores entre 0,70 y 0,79 indicaron la necesidad de revisión, y los valores inferiores a 0,70 justificaron la eliminación del ítem (Rodrigues et al., 2017). Los ítems que se situaron por debajo del umbral aceptable se revisaron o eliminaron en base al consenso de los expertos.

La validez de contenido a nivel de escala (S-CVI) se calculó como la media de los valores de I-CVI de los ítems retenidos, y se consideraron indicativos de una validez de contenido aceptable los valores de 0,80 o superiores (Rodrigues et al., 2017).

2.5. Prueba piloto y análisis factorial exploratorio

La prueba piloto se llevó a cabo en dos fases secuenciales para examinar la dimensionalidad del instrumento y refinar iterativamente el conjunto de ítems. La estructura factorial subyacente se examinó utilizando el análisis factorial exploratorio (EFA) a través del análisis de componentes principales (PCA) con rotación varimax para mejorar la interpretabilidad y lograr una estructura factorial más simple. Se empleó el PCA como técnica inicial de reducción de datos para identificar la estructura subyacente del conjunto de ítems.

Tabla 1. Características demográficas de los participantes (n = 346)
Fuente: Elaboración propia (2025)

Variable	n	%	Mean	SD	Min	Max
Edad	346	100	15.84	0.63	15	17
Sexo	Hombre	167	48.30	—	—	—
	Mujer	179	51.70	—	—	—
Calificación de Matemáticas Generales	346	100	86.72	6.87	75	98

La retención de factores se guió por múltiples criterios, incluyendo valores propios mayores que 1, la inspección del gráfico de scree, la proporción de varianza explicada y la interpretabilidad de la estructura factorial resultante. Estos criterios se aplicaron de manera consistente a lo largo de las fases piloto para asegurar que la solución factorial retenida fuera tanto estadísticamente adecuada como conceptualmente significativa. Los ítems se retuvieron basándose en cargas factoriales de al menos 0,50, comunalidades superiores a 0,30 y la ausencia de cargas cruzadas sustanciales.

Se llevó a cabo la prueba piloto 1 ($n = 100$) para examinar la dimensionalidad preliminar, evaluar la idoneidad de los datos para la extracción de factores y realizar una extracción inicial de factores que sirviera de guía para la reducción de ítems. Los procedimientos de selección preliminares incluyeron verificaciones de valores faltantes, normalidad univariante y valores atípicos. La adecuación de la matriz de correlación se evaluó utilizando la medida de adecuación de muestreo de Kaiser–Meyer–Olkin (KMO) y la prueba de esfericidad de Bartlett. Con base en estos procedimientos, se aplicaron criterios para identificar y eliminar ítems débiles o redundantes, lo que condujo al refinamiento del conjunto de ítems.

La prueba piloto 2 ($n = 100$) consistió en una segunda ronda de EFA utilizando el conjunto de ítems refinados para examinar y estabilizar aún más la estructura factorial. Las decisiones sobre la retención de ítems se basaron tanto en indicadores estadísticos como en la coherencia teórica, asegurando que los ítems retenidos representaran de manera significativa sus respectivos constructos. De acuerdo con las recomendaciones de Williams et al. (2010), se eliminaron los ítems redundantes o débiles, lo que dio como resultado un conjunto parsimonioso de ítems que representaban un número menor de factores interpretables.

2.6. Análisis factorial confirmatorio y pruebas de fiabilidad

Se llevó a cabo un análisis factorial confirmatorio utilizando los datos de la Prueba Piloto 3 ($n = 146$) para evaluar el ajuste del modelo de

medición de dos factores con un indicador adicional identificado mediante el AEF. El AFC se realizó utilizando el software JASP con estimación de máxima verosimilitud. La adecuación del modelo se examinó mediante una combinación de indicadores de ajuste absolutos e incrementales, incluyendo la relación chi-cuadrado a grados de libertad (χ^2/df), el Índice de Ajuste Comparativo (CFI) y el Error Cuadrático Medio de Aproximación (RMSEA), de acuerdo con las directrices psicométricas establecidas (Mulaik et al., 1989).

Se evaluó la confiabilidad de consistencia interna para la escala general y las subescalas individuales utilizando el alfa de Cronbach. Los coeficientes alfa de 0,70 o más se interpretaron como aceptables, los valores superiores a 0,80 como buenos y los valores superiores a 0,90 como excelentes (Cronbach, 1951; Hajjar, 2018).

2.7. Validez relacionada con el criterio

La validez relacionada con los criterios se examinó mediante una validación concurrente, correlacionando las puntuaciones del SSMS con las calificaciones de Matemáticas Generales de los estudiantes obtenidas de los expedientes escolares. La relación entre las variables se analizó mediante el análisis de correlación de Pearson para determinar tanto la magnitud como la dirección de la asociación. Los tamaños del efecto se interpretaron de acuerdo con las directrices de Cohen, tal y como las resume Rosenthal (1996), con el fin de facilitar la interpretación de los resultados estadísticos junto con sus implicaciones prácticas.

2.8. Consideraciones éticas

La aprobación ética del estudio fue otorgada por la Oficina de la División de Nueva Vizcaya antes de la recopilación de datos. Se obtuvo la autorización de los directores de las escuelas participantes y se coordinó con los docentes para minimizar la interrupción de las actividades de enseñanza. Se obtuvo el consentimiento informado de todos los estudiantes participantes, junto con el consentimiento de los padres o tutores, de acuerdo con las directrices éticas para la investigación con menores.

La participación fue totalmente voluntaria, y se informó a los estudiantes de su derecho a abandonar el estudio en cualquier momento sin consecuencias. Se mantuvo la confidencialidad y

el anonimato mediante el uso de identificadores codificados, y todos los datos de la investigación se almacenaron de forma segura y se utilizaron exclusivamente con fines académicos.

3. Resultados

3.1. Generación de ítems y validación del contenido

El conjunto inicial de 113 ítems se desarrolló mediante un proceso integrador que combinó la evidencia de la literatura previa sobre la autogestión, la autorregulación y la resiliencia de los estudiantes con datos cualitativos derivados de entrevistas a los estudiantes. Este enfoque dual garantizó tanto la base teórica como la relevancia contextual de los ítems. Los ítems generados se organizaron en cinco dominios con base teórica: control de impulsos, manejo del estrés, autodisciplina y motivación, establecimiento de metas y habilidades organizativas. En conjunto, estos dominios reflejan los componentes conductuales, emocionales y cognitivos fundamentales de la autogestión de los estudiantes, tal como se articulan en los marcos contemporáneos de aprendizaje socioemocional y autorregulación.

Para establecer la validez de contenido, el conjunto de ítems se sometió a una evaluación por expertos utilizando el procedimiento del Índice de Validez de Contenido (CVI). Cinco expertos en la materia evaluaron de forma independiente cada ítem en términos de relevancia, claridad y representatividad del constructo. Los valores del CVI a nivel de escala (S-CVI) alcanzaron o superaron el umbral recomendado de 0,80 en todos los dominios, lo que indica una excelente concordancia entre los expertos y una fuerte representatividad del contenido. Los ítems que no cumplieron con los criterios mínimos de CVI a nivel de ítem fueron eliminados o revisados. Como resultado de este proceso, se conservaron 92 ítems para la prueba empírica. Las Tablas 2 y 3 presentan la distribución de los ítems en los distintos dominios y los resultados de la validez de contenido, lo que confirma la adecuación conceptual del conjunto de ítems refinado.

Tabla 2. Ítems generados a partir de la literatura y las respuestas de los estudiantes
Fuente: Elaboración propia (2025)

Ámbito	N.º de ítems	Ejemplo de ítem
Control de impulsos	19	«Controlo muy bien mis emociones, incluso cuando estoy enojado».
Manejo del estrés	22	«Tengo confianza en mi capacidad para manejar mis problemas personales».
Autodisciplina y motivación	21	«Prefiero materiales que realmente me supongan un reto, para poder aprender cosas nuevas».
Establecimiento de metas	23	«Me fijo metas a corto plazo para ayudarme a alcanzar mis metas a largo plazo».
Habilidades organizativas	28	«Preparo una lista de tareas pendientes todos los días».
Total	113	

Tabla 3. Índice de validez de contenido (CVI) y retención de ítems
Fuente: Elaboración propia (2025)

Dominio	Ítems iniciales	Ítems retenidos	S-CVI	Interpretación
Control de impulsos	19	17	0.88	Excellent
Manejo del estrés	22	16	0.8	Excellent
Autodisciplina y motivación	21	15	0.8	Excellent
Establecimiento de metas	23	22	0.98	Excellent
Habilidades organizativas	28	22	0.9	Excellent
Total	113	92	—	—

3.2. Factorabilidad de los datos

Antes de realizar el análisis factorial exploratorio, se llevaron a cabo pruebas preliminares para determinar la idoneidad del conjunto de datos para la extracción de factores. La medida de adecuación de la muestra de Kaiser-Meyer-Olkin (KMO) arrojó un valor de 0,767, superando el umbral mínimo comúnmente aceptado de 0,60 para el análisis factorial. La prueba de esfericidad de Bartlett fue estadísticamente significativa, $\chi^2 = 9804,097$, $p < 0,001$, lo que indica que la matriz de correlación no era una matriz de identidad y que existían suficientes correlaciones entre los ítems.

En conjunto, estos resultados confirmaron que el conjunto de datos cumplía con los supuestos estadísticos requeridos para el análisis factorial exploratorio y justificaban continuar con los procedimientos de extracción de factores. Los resultados de estas pruebas preliminares se resumen en la Tabla 4.

Tabla 4. Idoneidad de los datos para el análisis factorial (Piloto 1)
Fuente: Elaboración propia (2025)

Prueba	Valor
Kaiser-Meyer-Olkin (KMO)	0.767
Prueba de esfericidad de Bartlett	$\chi^2 = 9804.097$, $p < .001$

3.3. Análisis factorial exploratorio

Se llevó a cabo un análisis factorial exploratorio (AFE) en dos fases iterativas para perfeccionar el instrumento e identificar su estructura latente. En la prueba piloto 1 ($n = 100$), el conjunto de 92 ítems se sometió a un análisis de componentes principales con rotación varimax para mejorar la interpretabilidad y lograr una estructura de componentes simple. Las decisiones sobre la retención de ítems se basaron en múltiples criterios, incluyendo cargas de componentes de al menos 0,50, communalidades adecuadas y la ausencia de cargas cruzadas sustanciales.

La retención de componentes se vio respaldada además por valores propios superiores a 1 y la inspección del gráfico de scree. La extracción inicial indicó una solución de tres componentes,

con valores propios que superaban el umbral recomendado y un claro punto de inflexión observado después del tercer componente en el gráfico de scree. Los tres componentes retenidos tenían valores propios de 26,03, 4,63 y 3,30, respectivamente, y en conjunto representaban el 36,92 % de la varianza total. El componente 1 explicaba el 28,30 % de la varianza, seguido del componente 2 (5,03 %) y el componente 3 (3,59 %). Aunque otros componentes también presentaban valores propios superiores a 1, sus contribuciones incrementales a la varianza total eran mínimas y no lograban producir agrupaciones de ítems estables o interpretables. Este patrón sugiere que estos componentes adicionales probablemente reflejan una varianza específica de los ítems, más que constructos latentes sustancialmente distintos. En consecuencia, se mantuvo la solución de tres componentes, ya que lograba un equilibrio óptimo entre la adecuación estadística, la parsimonia y la interpretabilidad teórica.

Este análisis inicial dio lugar a la eliminación de ítems débiles o redundantes y produjo un conjunto reducido de 42 ítems. La Tabla 5 resume los valores propios y la proporción de varianza explicada por cada componente retenido en la Prueba Piloto 1.

Tabla 5. Valores propios y varianza explicada por los componentes retenidos (Prueba piloto 1)
Fuente: Elaboración propia (2025)

Componente	Valor propio	% de la varianza	% acumulativo
1	26,03	28,30	28,30
2	4,63	5,03	33,33
3	3,3	3,59	36,92

La prueba piloto 2 ($n = 100$) consistió en una segunda ronda de EFA utilizando el conjunto de ítems refinado. La eliminación adicional de ítems se basó en indicadores estadísticos y en la coherencia teórica, asegurando que los ítems retenidos representaran de manera significativa sus respectivos constructos.

Este proceso dio como resultado una solución parsimoniosa de 27 ítems que comprendía dos componentes principales y un indicador exploratorio adicional: (a) Autorregulación y

control, que integraba el control de los impulsos, la autodisciplina y los comportamientos organizativos; (b) Resiliencia ante el estrés, que reflejaba la capacidad de los estudiantes para gestionar y afrontar los factores estresantes académicos y personales; y (c) Orientación hacia las metas, representada por un único ítem que captaba la motivación académica prospectiva de los estudiantes. Dado que este constructo está representado por un solo ítem, no constituye una subescala plenamente desarrollada. En consecuencia, se interpreta como un indicador exploratorio más que como una dimensión consolidada, y no se calculó ninguna estimación de consistencia interna. Este hallazgo sugiere la necesidad de un mayor desarrollo de los ítems para captar más plenamente este constructo en futuras investigaciones.

Cabe destacar que la aparición de una estructura de tres componentes indica una posible reconceptualización del marco de cinco dominios propuesto inicialmente. La convergencia del control de los impulsos, la autodisciplina y los comportamientos organizativos en un único componente de autorregulación y control sugiere que estos constructos pueden no funcionar como dimensiones discretas en esta población, sino más bien como manifestaciones interdependientes de una capacidad reguladora más amplia. Este patrón indica que la distinción entre estos dominios es menos pronunciada entre los estudiantes de secundaria, y que estos aspectos de la autogestión tienden a coexistir como un patrón integrado de comportamiento regulador. Por lo tanto, la estructura observada refleja no solo parsimonia estadística, sino también una organización del constructo sensible al contexto.

En la Tabla 6 se presenta un resumen de las etapas y los resultados del AEF.

Tabla 6. Resultados del análisis factorial exploratorio
Fuente: Elaboración propia (2025)

Etapas	n	Ítems evaluados	Ítems retenidos	Componentes extraídos
Piloto 1	100	92	42	3
Piloto 2	100	42	27	3

3.4. Análisis factorial confirmatorio

Se realizó un análisis factorial confirmatorio (AFC) utilizando una muestra independiente ($n = 146$) para evaluar la adecuación del modelo de medición de dos factores con un indicador adicional identificado mediante el AFF. El ajuste del modelo se evaluó utilizando múltiples índices para captar tanto el ajuste absoluto como el incremental. La relación entre el chi-cuadrado y los grados de libertad ($\chi^2/df = 2,70$) indicó un nivel aceptable de ajuste relativo. Sin embargo, los índices de ajuste incremental, incluyendo el Índice de Ajuste Comparativo (CFI = 0,72), el Índice de Ajuste Normalizado (NFI = 0,62) y el Índice de Ajuste Relativo (RFI = 0,59), se situaron por debajo de los umbrales comúnmente recomendados. Además, el Error Cuadrático Medio de Aproximación (RMSEA = 0,11) sugirió un ajuste absoluto deficiente del modelo.

Estos hallazgos indican un respaldo empírico parcial para la estructura de medición propuesta y sugieren la necesidad de un mayor refinamiento de los ítems, particularmente para las dimensiones subrepresentadas. La Tabla 7 presenta los índices de ajuste del AFC y las interpretaciones correspondientes.

Tabla 7. Análisis factorial confirmatorio (Piloto 3, $n = 146$)
Fuente: Elaboración propia (2025)

Índice de ajuste	Valor	Interpretación
χ^2/df	2.70	Acceptable
Índice de ajuste comparativo (CFI)	0.721	Below acceptable
Índice de ajuste normalizado (NFI)	0.624	Below acceptable
Índice de ajuste relativo (RFI)	0.591	Below acceptable
RMSEA	0.108	Poor fit

3.5. Fiabilidad y validez relacionada con el criterio

Los análisis de confiabilidad de consistencia interna demostraron una excelente confiabilidad general para la Escala de Autogestión del Estudiante de 27 ítems ($\alpha = 0,94$). El componente de Autorregulación y Control mostró una consistencia interna muy alta ($\alpha = 0,94$), lo que indica una fuerte coherencia entre los ítems

que miden los comportamientos de aprendizaje disciplinados. El componente de Resiliencia al Estrés mostró una confiabilidad moderada ($\alpha = 0,63$), probablemente atribuible al número limitado de ítems retenidos.

No se calculó la estimación de la confiabilidad para el indicador de Orientación hacia las metas debido a su estructura de un solo ítem. Por lo tanto, este constructo se trata como un indicador exploratorio en lugar de una subescala completamente desarrollada. Los coeficientes de confiabilidad detallados se presentan en la Tabla 8.

La validez relacionada con el criterio se examinó correlacionando las puntuaciones del SSMS con las calificaciones de los estudiantes en Matemáticas Generales. El análisis reveló una

asociación muy débil y no significativa ($r = 0,03$, $p = 0,70$), lo que indica que la autogestión, tal como se operacionaliza en el SSMS, no predice directamente el rendimiento académico en una materia específica. Estos resultados sugieren que la autogestión de los estudiantes representa una competencia más amplia y transferible, distinta del logro específico en un dominio. Los resultados de la validez concurrente se resumen en la Tabla 9.

Tabla 9. Prueba de validez concurrente
Fuente: Elaboración propia (2025)

Par de variables	n	r	p
Escala de autogestión × Calificaciones en matemáticas generales	146	0.032	0.697

Tabla 8. Fiabilidad y validez de criterio de la Escala de Autogestión del Estudiante
Fuente: Elaboración propia. (2025)

Componente de la escala	N.º de ítems	α de Cronbach	Nivel de fiabilidad	Etiqueta propuesta
1	24	0.935	Muy alto	Autorregulación y control
2	2	0.633	Moderada	Resiliencia ante el estrés
—	1	—	No calculado	Orientación hacia las metas (indicador exploratorio)
General	27	0.942	Muy alta	—

4. Discusión

4.1. Estructura factorial y características psicométricas

La Escala de Autogestión del Estudiante (SSMS) arrojó una estructura con base teórica e interpretable empíricamente, aunque preliminar, que consta de dos componentes principales y un indicador exploratorio adicional, lo que refleja las dimensiones clave de la autogestión del estudiante en los contextos educativos contemporáneos. El componente más destacado y relativamente sólido, la autorregulación y el control, integró indicadores de comportamiento relacionados con la regulación de los impulsos, la atención sostenida, las prácticas de estudio disciplinadas y las habilidades organizativas. La alta consistencia interna de este componente

subraya su papel central dentro de los marcos de aprendizaje socioemocional (SEL), que identifican sistemáticamente la autorregulación como un mecanismo fundamental que sustenta la persistencia académica, el funcionamiento adaptativo y la competencia de aprendizaje a lo largo de la vida (Lawson et al., 2019; Zimmerman, 2023). La convergencia de múltiples dominios teóricamente relacionados en este componente sugiere que, entre los estudiantes de secundaria, la regulación conductual y el control organizativo operan como aspectos interrelacionados de una capacidad reguladora más amplia, en lugar de como dominios de habilidades discretos, en consonancia con los modelos integradores del aprendizaje autorregulado (Zimmerman, 2023; Panadero, 2017).

El componente de resiliencia ante el estrés demostró una consistencia interna moderada, lo que refleja la capacidad percibida de los estudiantes para manejar los factores estresantes académicos, las exigencias emocionales y la recuperación de los reveses. Aunque el coeficiente de confiabilidad se sitúa por debajo de los umbrales convencionales para una fuerte consistencia interna, es probable que este resultado se vea influido por el número limitado de ítems retenidos y la naturaleza intrínsecamente multidimensional de la resiliencia. La literatura existente hace hincapié en que la resiliencia abarca procesos emocionales, cognitivos y contextuales que pueden no captarse plenamente a través de un pequeño conjunto de indicadores (Pham, 2024; Ungar, 2018). Como tal, los presentes hallazgos deben interpretarse como preliminares, indicando la presencia de un componente significativo pero poco desarrollado que requiere una mayor elaboración.

Por el contrario, la orientación hacia las metas estuvo representada por un solo ítem retenido y, por lo tanto, se trata como un indicador exploratorio más que como un componente plenamente desarrollado. Esta limitación restringe tanto la estimación de la fiabilidad como la cobertura conceptual, lo que indica que el constructo no está suficientemente operacionalizado dentro del instrumento actual. Dada la importancia establecida de la orientación hacia las metas para apoyar el compromiso académico, el aprendizaje autodirigido y la persistencia (Claro y Loeb, 2019; Pintrich, 2000), su representación limitada pone de relieve un área crítica para el desarrollo futuro de la escala. Se necesitan ítems adicionales para captar tanto los procesos de establecimiento de metas a corto plazo como las orientaciones motivacionales a más largo plazo.

Para situar mejor estos hallazgos dentro de la literatura más amplia, es importante considerar cómo se compara la estructura actual con los instrumentos existentes de autogestión y autorregulación. Si bien el desarrollo de tales instrumentos está bien establecido en la literatura internacional, el presente estudio contribuye a este conjunto de trabajos a través de su contextualización, su marco integrador y su población objetivo. Los instrumentos existentes

se han desarrollado típicamente en contextos occidentales y a menudo enfatizan dimensiones específicas como la autorregulación académica, las estrategias metacognitivas o los constructos motivacionales de manera aislada (Zimmerman, 2023; Duckworth y Yeager, 2015; OCDE, 2019). Por otro lado, el SSMS adopta un enfoque más integrador al combinar la regulación conductual, la resiliencia al estrés y los procesos orientados a objetivos dentro de un único marco. La estructura resultante, caracterizada por un componente dominante de autorregulación y control junto con dimensiones más limitadas pero conceptualmente significativas, sugiere que la autogestión puede experimentarse como un constructo más integrado y menos diferenciado entre los estudiantes de secundaria en este contexto, particularmente en entornos que requieren un funcionamiento adaptativo bajo condiciones limitadas (Gagne et al., 2021; Lozano-Peña et al., 2021).

Además, la inclusión de aportaciones cualitativas de estudiantes filipinos durante la generación de ítems mejora la relevancia contextual del instrumento, particularmente en entornos de aprendizaje modulares y pospandémicos donde los estudiantes se enfrentan a una mayor autonomía y a restricciones externas. Por lo tanto, la SSMS está específicamente posicionada para abordar una brecha en las herramientas validadas para estudiantes de nivel secundario en contextos de países en desarrollo, donde los factores culturales y contextuales moldean significativamente la manifestación de los comportamientos de autogestión (Hayashi et al., 2022; Noordman et al., 2024; Durneva y LeRouge, 2026).

A la luz de estas consideraciones, la contribución de la SSMS no radica en la novedad del desarrollo de la escala en sí misma, sino en su diseño sensible al contexto, su estructura derivada empíricamente y su potencial aplicación como herramienta de diagnóstico y desarrollo en entornos educativos subrepresentados. Sin embargo, estas interpretaciones estructurales deben considerarse provisionales a la luz del ajuste inadecuado del modelo observado en el análisis confirmatorio, como se discute en la siguiente sección, lo que limita la solidez de las conclusiones que se pueden extraer con respecto a la validez dimensional de la escala.

4.2. Ajuste del modelo y necesidades de refinamiento

El análisis factorial confirmatorio (AFC) proporcionó solo un respaldo empírico parcial para la estructura de medición propuesta, con varios índices de ajuste que indicaban un ajuste inadecuado del modelo. Aunque la relación entre el chi-cuadrado y los grados de libertad sugería un ajuste relativo aceptable, los índices incrementales (CFI, NFI y RFI) cayeron sustancialmente por debajo de los umbrales recomendados, y el valor del RMSEA excedió los límites aceptables. Estos resultados indican que la estructura hipotética no explica completamente las relaciones entre las variables observadas y que la validez estructural de la escala sigue siendo provisional. En consecuencia, el modelo actual no debe interpretarse como una representación definitiva del constructo, sino más bien como una aproximación inicial que puede no representar adecuadamente la dimensionalidad subyacente de la autogestión de los estudiantes.

El mal ajuste del modelo observado puede atribuirse a varios factores interrelacionados. En primer lugar, el fuerte predominio del componente de autorregulación y control sugiere que la escala puede reflejar una estructura más unidimensional o jerárquica de lo que se especifica actualmente, lo que podría oscurecer las distinciones entre constructos relacionados. En segundo lugar, el número limitado de ítems dentro del componente de resiliencia al estrés puede restringir su capacidad para representar adecuadamente la naturaleza multidimensional de la resiliencia. En tercer lugar, la inclusión de la «Orientación hacia las metas» como un indicador exploratorio de un solo ítem limita su contribución al modelo y restringe la adecuación de su representación estructural (Kline, 2013; Brown, 2015).

En conjunto, estos hallazgos sugieren que, si bien la SSMS demuestra una consistencia interna y una coherencia conceptual prometedoras, su configuración estructural actual requiere un mayor refinamiento. Por lo tanto, el modelo debe interpretarse con cautela, particularmente con respecto a la interpretación dimensional y la separación de constructos. En consonancia con los marcos establecidos para el desarrollo de escalas

(Boateng et al., 2018), las investigaciones futuras deberían dar prioridad a la ampliación de las dimensiones infrarrepresentadas (especialmente la orientación hacia las metas) y a la reevaluación del modelo de medición utilizando muestras más amplias y diversas. Además, la prueba de especificaciones de modelos alternativos, como los modelos de orden superior o bifactoriales, podría proporcionar una representación más precisa del constructo subyacente (Reise, 2012).

4.3. Diferenciación respecto al rendimiento académico

La ausencia de una asociación significativa entre las puntuaciones del SSMS y las calificaciones en Matemáticas Generales respalda la conceptualización de la autogestión como una competencia no cognitiva y transferible, en lugar de un predictor directo del rendimiento académico en una materia específica. Este hallazgo concuerda con la literatura existente que indica que las habilidades de autogestión influyen principalmente en la persistencia en el aprendizaje, la regulación emocional y el bienestar general, más que en resultados académicos aislados medidos a través de las calificaciones (Bashir et al., 2021; Claro & Loeb, 2019; Zhang et al., 2024).

Sin embargo, este resultado merece una interpretación cautelosa teniendo en cuenta las expectativas teóricas y las consideraciones metodológicas. Dados los vínculos establecidos entre la autorregulación y el rendimiento académico, podría haberse anticipado una relación positiva modesta (Zimmerman, 2023). La ausencia de dicha relación puede reflejar factores contextuales y relacionados con la medición, más que una falta total de asociación. Las calificaciones académicas se ven influidas por una serie de factores externos, entre los que se incluyen las prácticas de enseñanza, los formatos de evaluación y las limitaciones contextuales, que pueden atenuar su relación con las competencias de autogestión (Brookhart, 2013; Guskey, 2015). Además, se debe considerar la posibilidad de una variabilidad restringida en las distribuciones de calificaciones. Si las calificaciones de los estudiantes se agrupan dentro de un rango estrecho, la restricción resultante del rango

puede atenuar la correlación observada con las puntuaciones del SSMS (Cohen et al., 2013). Esto puede ser particularmente relevante en contextos donde las prácticas de calificación limitan la diferenciación entre los estudiantes.

Estas consideraciones sugieren que la correlación nula no debe interpretarse como una evidencia definitiva de independencia entre la autogestión y los resultados académicos, sino más bien como una indicación de que el criterio seleccionado podría no alinearse plenamente con el constructo que se está midiendo. Los futuros esfuerzos de validación deberían incorporar medidas externas alternativas más directamente relacionadas con el comportamiento autorregulado, como los hábitos de estudio, la persistencia en las tareas, la gestión del tiempo o los indicadores del bienestar de los estudiantes, para proporcionar una evaluación más completa de la validez concurrente (Duckworth y Yeager, 2015; OCDE, 2019).

En contextos educativos marcados por las interrupciones relacionadas con la pandemia, los sistemas de aprendizaje modulares y las desigualdades digitales, esta distinción cobra

especial relevancia. Los estudiantes pueden demostrar sólidas capacidades de autogestión incluso cuando las limitaciones externas restringen su rendimiento académico. Por lo tanto, el SSMS no debe interpretarse como un indicador sustitutivo del rendimiento académico, sino más bien como una herramienta de diagnóstico y desarrollo para identificar las fortalezas reguladoras de los estudiantes y las áreas que requieren apoyo (Gagne et al., 2021; Lozano-Peña et al., 2021).

Reconocer la autogestión como una competencia fundamental respalda prácticas educativas más equitativas e inclusivas, particularmente en entornos de aprendizaje con recursos limitados y posteriores a una crisis. Al enfocarse en la capacidad de los estudiantes para la regulación, la resiliencia y el funcionamiento adaptativo, los educadores y profesionales pueden diseñar mejor intervenciones que promuevan el éxito del aprendizaje a largo plazo más allá de las métricas académicas tradicionales (Codilla, 2025).

5. Conclusiones

Este estudio proporciona evidencia empírica inicial que respalda la fiabilidad y la validez estructural parcial de la Escala de Autogestión del Estudiante (SSMS) para alumnos de secundaria en Filipinas. Los hallazgos confirman la naturaleza multidimensional de la autogestión del estudiante, en la que la autorregulación y la resiliencia al estrés se perfilan como componentes relativamente fuertes. Si bien la estructura de medición propuesta demostró solo un respaldo empírico parcial y provisional, las limitaciones en la medición de la orientación hacia las metas resaltan áreas importantes para un mayor desarrollo.

La débil asociación entre las puntuaciones de la SSMS y el rendimiento en matemáticas debe interpretarse con cautela y puede reflejar tanto la singularidad de la autogestión como constructo

no cognitivo como las limitaciones del criterio externo seleccionado, lo que subraya su relevancia más allá de los indicadores académicos tradicionales.

Es importante destacar que el desarrollo del SSMS aborda la necesidad de herramientas de evaluación basadas en el contexto que reflejen las realidades socioculturales y educativas de los estudiantes filipinos. En el contexto filipino, donde los estudiantes se enfrentan a diversas condiciones de aprendizaje, a crecientes exigencias de aprendizaje independiente y al impacto continuo de las transiciones educativas pospandémicas, la autogestión se ha convertido en una competencia fundamental. El SSMS ofrece a los educadores y líderes escolares un instrumento práctico para identificar las fortalezas y las áreas de apoyo de los estudiantes,

fundamentar intervenciones específicas y orientar la implementación de programas de aprendizaje socioemocional.

En general, el SSMS representa un instrumento preliminar, pero prometedor y basado en el contexto, para evaluar la autogestión de los estudiantes y orientar la investigación, la práctica y las políticas educativas, particularmente

en entornos de aprendizaje pospandémicos y mediados digitalmente. Sin embargo, es necesaria una mayor validación, particularmente a través de una mejor representación de los ítems, especificaciones de modelos alternativos y el uso de criterios externos más alineados con el constructo, para fortalecer su validez estructural y generalizabilidad.

6. Recomendaciones

A partir de los resultados de este estudio, se sugieren varias direcciones para la investigación, la práctica educativa y las políticas futuras. En primer lugar, las investigaciones futuras deberían dar prioridad a un mayor perfeccionamiento de la Escala de Autogestión del Estudiante (SSMS), en particular ampliando las dimensiones de Orientación hacia las Metas y Resiliencia al Estrés mediante el desarrollo de ítems adicionales. Es necesario aumentar la representación de los ítems en estas subescalas para mejorar la consistencia interna, la estabilidad factorial y el ajuste general del modelo. Los esfuerzos de validación posteriores deberían incluir muestras más grandes y heterogéneas, extraídas de diversas regiones y entornos educativos, para mejorar la generalizabilidad del instrumento.

En segundo lugar, se alienta a los investigadores a realizar estudios de validez longitudinal y predictiva para evaluar en qué medida la autogestión de los estudiantes, medida por la SSMS, predice el compromiso académico a largo plazo, el bienestar psicológico, la persistencia y la adaptación escolar. También se recomienda evaluar la invarianza de la medición en función del género, el estatus socioeconómico y las modalidades de aprendizaje (por ejemplo, aprendizaje presencial, modular y en línea) para garantizar la equidad y la aplicabilidad en todos los subgrupos.

En tercer lugar, los profesionales de la educación pueden considerar la utilización del SSMS como una herramienta de diagnóstico formativa para identificar a los estudiantes que requieren apoyo específico en autorregulación y resiliencia ante el estrés. Los resultados pueden servir de base para el diseño de intervenciones escolares, programas de orientación y estrategias en el aula que desarrollen explícitamente las competencias de autogestión, particularmente en contextos caracterizados por altas exigencias académicas y apoyo externo limitado. Sin embargo, tales aplicaciones deben llevarse a cabo teniendo en cuenta las limitaciones actuales en la validez estructural de la escala.

Por último, los responsables políticos y los administradores escolares pueden considerar la integración de la evaluación de la autogestión de los estudiantes en iniciativas más amplias de aprendizaje socioemocional (SEL) y salud mental. La incorporación de instrumentos sensibles al contexto, como el SSMS, en los marcos de seguimiento y evaluación puede respaldar la toma de decisiones basada en datos, promover una pedagogía inclusiva y fortalecer las políticas educativas centradas en la resiliencia, especialmente en entornos pospandémicos y con recursos limitados. Se recomienda continuar con la validación y el perfeccionamiento del instrumento antes de su implementación a gran escala.

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Navigating Diversity: Narratives on Diversity in Spanish University Websites

Navegando sobre la diversidad: narrativas sobre diversidad en las webs de las universidades españolas

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Navigating Diversity: Narratives on Diversity in Spanish University Websites

Navegando sobre la diversidad: narrativas sobre diversidad en las websites de las universidades españolas

Resumen:

Esta investigación, como diseño cualitativo exploratorio-descriptivo con análisis crítico del discurso multimodal, analiza la conceptualización de diversidad en las universidades españolas a partir del estudio de sus websites institucionales. Se estudian las páginas de servicios o estructuras administrativas que incorporan el término diversidad en su denominación, considerando su frecuencia, accesibilidad y localización en el mapa web (sistema interactivo), así como colectivos nombrados, las funciones vinculadas al acceso, aprendizaje y participación (sistema verbal) y las imágenes asociadas (sistema gráfico). El análisis multimodal se aplica a 41 servicios de 36 universidades públicas y privadas, identificados mediante un cribado sistemático, ofreciendo una primera cartografía crítica en que el sistema universitario español proyecta sus significados sobre diversidad en sus entornos digitales. Los resultados apuntan a una conceptualización parcial y poco transformadora de la diversidad, con fuerte peso de la discapacidad frente a otras dimensiones.

Palabras clave: diversidad, educación superior, universidades, websites institucionales, inclusión.

Abstract:

This study, designed as an exploratory–descriptive qualitative inquiry using multimodal critical discourse analysis, examines how diversity is conceptualised in Spanish universities through an analysis of their institutional websites. It analyses the pages of services or administrative structures that include the term diversity in their title, considering their frequency, accessibility and location within the web architecture (interactive function), as well as the groups mentioned, the functions associated with access, learning and participation (verbal system), and the images representing them (graphic system). The multimodal analysis is applied to 41 services from 36 public and private universities, identified through a systematic screening process, and offers an initial critical mapping of how the Spanish university system projects meanings of diversity in its digital environments. The findings indicate a partial and weakly transformative institutionalisation of diversity, with a strong emphasis on disability over other dimensions.

Keywords: diversity, higher education, universities, institutional websites, inclusion.

1. Introduction

Inclusive education is a universal right and an essential pillar of sustainable development, as recognized in Sustainable Development Goal 4 (SDG 4) of the 2030 Agenda, which promotes equitable access to quality education for all. Educational environments that value diversity and promote full participation strengthen social cohesion and foster cultural, economic, and academic development globally. In this context, universities play a strategic role as spaces for implementing inclusive practices that overcome social, cultural, and gender barriers, contributing to more just and resilient societies.

In Europe, this international orientation is reflected in the ten principles on the social dimension of universities established in the Rome Communiqué (European Higher Education Area [EHEA], 2020). In Spain, university legislation, particularly Organic Law 2/2023, supports an inclusive approach that seeks to address the diversity of the student population and promote equity in access to and retention in higher education.

Despite these initiatives, the debate on the meaning, scope, and implications of the concept of “diversity” in Spanish universities is still in its infancy. However, it is relevant to international contexts (Pineda & Mishra, 2023). The literature shows that the term “diversity” is used in an ambivalent manner: some studies employ it as a euphemism for inequality, race, or multiculturalism (Langa Rosado & Lubián Graña, 2021), while others link it to academic marketing strategies, where it is presented as a

symbol of harmony and prestige (Bowl, 2016). These two narratives—diversity as a problem or as a value—shape the institutional discourse in Spanish universities (Jiménez-Millán & García-Cano, 2021).

This framework of semantic ambiguity makes its analysis relevant for understanding the orientation of inclusive policies. For example, Díaz-Jiménez et al. (2023), in examining more than 3,000 news articles from the *Diario de Noticias* of Pablo de Olavide University (Seville), show that how diversity is communicated affects social perception. Similarly, in the U.S., Wilson and Meyer (2009) demonstrate that the content and structure of university websites reflect institutional commitment to diversity. These platforms constitute the “virtual face” of the university, projecting discourses, values, and services that function as cultural expressions of the institution (Foste et al., 2022; Morpew & Hartley, 2006; Williams & Clowney, 2007).

The objective of this article is to analyze the narratives constructed around the term “diversity” on the websites of Spanish universities that incorporate this term when identifying a service or structure of the institution. To this end, the following questions were posed: How frequently is the term “diversity” used to name university services? Where are these spaces located on the website map, and what level of accessibility do they offer? Which groups are these services or organizational structures aimed at, and what functions do they perform? And finally, how is diversity represented graphically?

2. Literature Review

2.1. Narratives on Diversity in Higher Education in Spain

In Spain, the term “diversity” began to be used in the educational debate in the early 1990s, initially linked to cultural and linguistic plurality

in compulsory education. Its incorporation into the university sphere came later. It was driven by European programs such as Eurydice and Erasmus, and especially by the EHEA 2020 strategy “Widening Participation for Equity and Growth.” This strategy aimed to have universities

reflect social diversity, paying attention to vulnerable, disadvantaged, or underrepresented students (EHEA, 2020). However, the identification of these groups has been imprecise, leaving it up to the universities to define and develop them.

At the regulatory level, the Organic Law on Universities 6/2001 included measures aimed at students facing financial difficulties, family responsibilities, disabilities, or who are victims of gender-based violence or terrorism, as well as gender equality programs. Royal Decree 1393/2007 reinforced equality between men and women, and the University Student Statute (RD 1791/2010) focused primarily on students with disabilities. As a result, over the past fifteen years, many universities have established structures such as Equality Units and disability support offices. Current legislation (LOSU 2/2023) establishes the obligation to establish equality and diversity units (Art. 43), responsible for coordinating inclusive and anti-discrimination policies across the board, indicating an institutional context in transition.

Currently, most Spanish universities address diversity in the context of social responsibility (Langa Rosado & Lubián Graña, 2021), in line with European recommendations (Eurydice, 2022). However, regulations tend to conflate the terms equality and diversity, leading to conceptual and programmatic fragmentation. In this regard, García-Cano et al. (2022), in analyzing websites with content on teaching innovation at Spanish universities, highlight a notable discursive shift: equality is linked to gender, while diversity is typically associated with disability and students with special educational needs (SEN). This dissociation results in different policies depending on the term used.

Although the literature defines inclusion as a process linked to the presence, participation, and achievement of the entire student body (Calderón Almendros & Ainscow, 2025), studies show only partial implementation in Spain. Access policies have diversified the student profile (INE, 2024), particularly in socioeconomic terms and regarding first-generation university students from families without prior higher education.

However, dimensions such as participation or achievement, as well as the inclusion of other actors (faculty, technical staff), have received little attention and achieved only relative success (Benet-Gil, 2020; Moriña, 2022).

The literature has also addressed the institutionalization of diversity (AAC&U, 2015; Chun & Evans, 2019; New England Resource Center for Higher Education [NERCHE], 2016), highlighting key areas such as leadership, Support, assessment, innovation, curriculum, and institutional climate. In this regard, there is evidence of the term's growing media and institutional prominence in universities (Ocampo González, 2024). Despite this, there is little research on the image that is projected; specifically, Díaz-Jiménez et al. (2023) conclude that the discourse on diversity in university media focuses on gender and disability, leaving out other dimensions (such as cultural, sexual, religious, and age diversity), in addition to noting the term's limited presence in news related to teaching, research, or administration.

2.2. Research on Diversity Through University Websites

Internationally, particularly in the U.S. context, various studies over the past two decades have analyzed how the concept of diversity is articulated on institutional websites (Ford & Patterson, 2019; Foste et al., 2022; Holland & Ford, 2021; Ihme et al., 2016; Wilson & Meyer, 2009). These studies follow two complementary approaches. One focuses on the interactive function of these platforms, examining elements such as accessibility, the use of cookies, software, or the digital services offered. The other, which serves as the framework for this research, analyzes diversity as a substantive pillar of university policies, examining its meaning, objectives, and associated institutional practices.

The pioneering studies by Wilson and Meyer (2009) and Wilson et al. (2012) showed that websites are a key tool for students (especially those from minority groups) in selecting a university and program of study. They identified three main findings: a) the availability of information on diversity influenced decision-

making, especially among African American and Hispanic students; b) the proximity of this information to the homepage was a relevant factor; and c) images played a central role in the representation of diversity.

Furthermore, these studies revealed a series of contradictions: although universities considered diversity an institutional value, between 25% and 35% of the 80 institutions analyzed did not include specific content on the subject on their websites. Even when services were accessible from the homepage, more than 51% did not provide sufficient information about their functions or how to use them. A strategic use of images that overrepresented minorities was also detected, projecting an image of racial diversity that did not correspond to the reality on campus.

Subsequent research has delved deeper into these lines of inquiry, analyzing discourses, images, measures associated with the concept,

and target groups. Ford and Patterson (2019), focusing on visual analysis, conclude that many universities make “cosmetic” use of diversity, increasing images and symbolic references when their actual levels of student diversity are low. This superficial construction aligns with Bowl’s (2016) observations, who argues that websites project an image centered on international, cultural, and ethnic diversity but conceal underlying structural inequalities, thereby neutralizing the potential for advocacy associated with ethnic-racial categories. These findings align with Ahmed’s (2021) thesis, which argues that many universities use diversity as a “non-performative” act, invoking it in discourse without translating it into concrete practices. For their part, Foste et al. (2022) reinforce this idea by noting that the commitments expressed on websites are often limited, loosely connected to equity, and centered on aesthetic diversity, which renders their structural dimension invisible (Wilson et al., 2012).

3. Methodology

3.1. Design

This study is part of a broader research effort to analyze the processes of institutionalizing inclusion policies in Spanish universities. In different phases, practices were assessed, institutionalization proposals were designed, and improvements were identified. Specifically, this study analyzes the narratives institutions

construct around the concept of diversity. The objective is to provide useful insights for the design of inclusion policies. To this end, the study analyzes the websites of university services and structures that include the term “diversity” in their names.

Table 1. Correspondence between research questions, analytical frameworks, and research instrument
Source: Prepared by the author (2025)

Research question	Analysis systems	Specific instrument
How frequently is the term “diversity” used to name university services?	Sistema interactivo: análisis digital, interés en la localización y accesibilidad de los websites.	Documental: mediante la construcción de un archivo de registro en formato Excel para la identificación de casos y el conteo hasta el acceso dentro de los espacios web de cada universidad.
Where are these spaces located, and what is their level of accessibility?	Interactive system: digital analysis, focusing on the location and accessibility of websites.	Documentary: by creating a record archive in Excel format to identify cases and track access to each university’s web spaces.
Which groups are targeted by the organizational structures identified with the term “diversity,” and what functions do they perform?	Sistema gráfico: imágenes, interés en elementos visuales (fotografías, iconos, logotipos).	Documental: mediante la construcción de archivos en PDF con el contenido alojado en cada uno de los websites identificados en cada universidad.

The study is qualitative, exploratory-descriptive, and was conducted through a critical analysis of multimodal discourse (Zhao et al., 2018), based on the assumption that public website content informs and influences the construction of social representations (Foste et al., 2022). From this perspective, and considering the multisemiotic nature of digital communication (Cárcamo, 2018; O'Halloran, 2012), three elements were analyzed to address the research questions:

3.2. Sample selection

The unit of analysis was the website of university services or units whose name includes the term “diversity.” The study considered all 90 Spanish universities—both public and private—as listed by the Ministry of Science, Innovation, and Universities (2024). Based on this list, a two-phase screening process was applied to identify only those universities that had an institutional unit bearing that name.

In the first phase, each university’s internal search engine was used with the term “diversity.” Links referring to one-off activities (conferences, courses, chairs, or research groups), adjectival uses of the term, regulatory protocols, or services exclusive to specific faculties were excluded. Only those referring to an organizational structure

or central university service that included that term in its name were included.

In the second phase, when no results were found using the internal search engine, the Google search engine was used, with the term “diversity” combined with the university’s name. The same inclusion and exclusion criteria as in the previous phase were applied.

After identifying potential cases, their validity was verified by tracing the navigation path from each university’s homepage to the corresponding service or institutional structure. This stage was crucial for confirming whether the service or structure within the institution had disappeared or changed its name.

The final sample consisted of 41 services and/or structures within the organizational charts of 36 universities (26 public and 10 private); that is, some universities had more than one service or structure identified as “diversity” (Figure 1). The sample identification and definition phase took place between May and June 2024.

3.3. Analysis Process

The analysis of the multimodal corpus focused on elements of interactive (digital), semantic

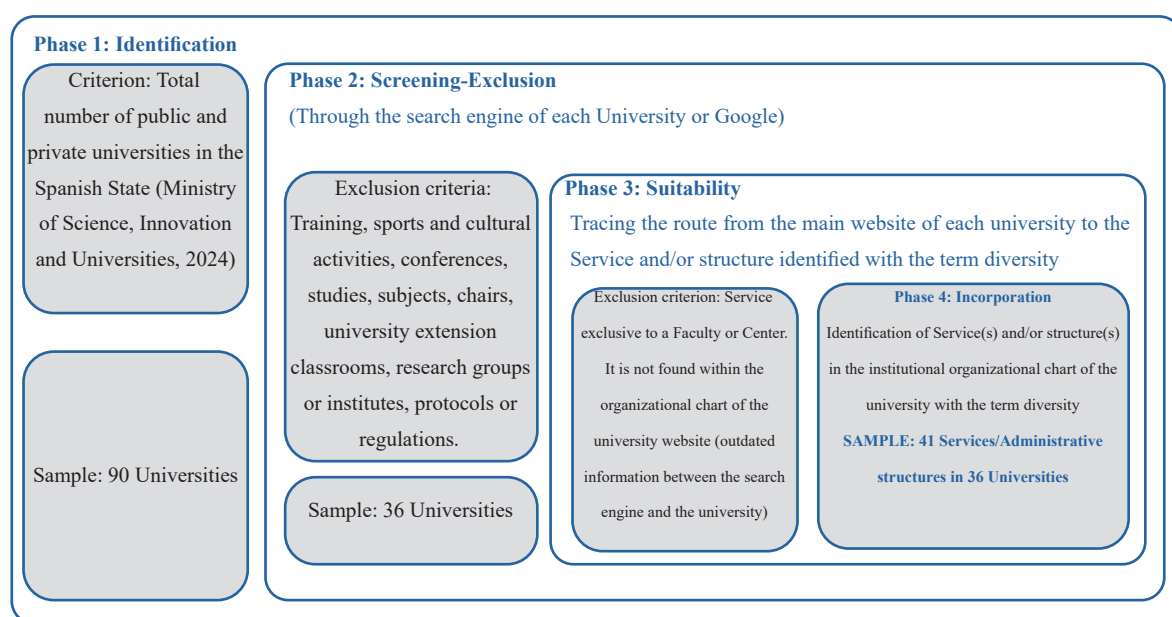


Figure 1: Sample selection.
Source: Author's own compilation of field data (2024)

(text), and graphic (image) communication (O'Halloran, 2012) to address the study's central objective.

To this end, the services and/or structures were first identified in an Excel document, recording their names, affiliated universities, and access paths from the institutional website. This process allowed us to answer the questions: How frequently is the term “diversity” used to name university services? Where are they located, and what level of accessibility do they offer? Thus, the interactive communication system and its institutional integration were analyzed.

Each website identified was converted to a PDF to capture the content at a specific point in time (May–June 2024). All available hyperlinks on the pages were accessed, excluding attached documents (plans, regulations, or programs in PDF format). At universities with more than one service in the sample, these were combined into a single document, resulting in a corpus of 36 files. The textual content was coded using ATLAS.ti v.24 software, initially with 69 codes. Subsequently, these codes were grouped into two main categories:

1. Groups: disability/functional diversity, age, ethnicity, language, SEN/NEAE, origin, sex, sex-gender (particularly LGTBIQ+), socioeconomic status, and other conditions.
2. Functions: access, learning, and participation.

This text analysis enabled the identification of which groups each service targets and which functions are attributed to the concept of diversity. Regarding the visual elements, static images (excluding videos) present in the PDF documents were extracted. The images were organized

by university and coded into the following categories: logos, staff portraits, buildings, and technical resources. Of the 36 universities in the sample, three did not include images (ESIC, University of Castilla-La Mancha [UCLM], University of Granada [UGR]), so this dimension could not be analyzed.

Multiple triangulations were performed to ensure the study's reliability. This was based on four strategies:

- a) Agreement among authors during the different phases of the work, including screening, exclusion, and eligibility criteria for sample selection and coding of all data.
- b) Sample selection, screening, and suitability verification performed by one author, with 25% of this work repeated by another researcher to ensure reliability.
- c) Cross-referencing of codes and categories between textual and image analysis.
- d) Conducting repeated readings at different stages of the study, producing interim reports, and jointly discussing the theoretical interpretation of the data.

The sample of 36 documents corresponding to 41 services was considered analytically sufficient, as it enabled consistent identification of the groups and functions associated with the concept of diversity. During the initial textual coding, significant thematic convergence was observed: the 69 original codes were systematically repeated across the services and could be coherently grouped into the categories of groups and functions, with no new codes emerging in the analysis of the final cases. This convergence indicates that conceptual saturation was achieved, supporting the conclusion that the number of services and pages analyzed was sufficient to meet the study's objectives.

4. Results

4.1. Interactive System: Frequency, Accessibility, and Location

Of the 90 Spanish universities (public and private) analyzed, 40% (36 universities) include

at least one service or administrative structure whose name contains the term “diversity.” Three of them—the University of Salamanca [USAL], Miguel Hernández University [UMH], and the University of A Coruña [UDC]—have two

distinct services this term. In the latter two cases, one unit holds the rank of vice-rectorate and the other reports hierarchically to it. The University of Jaén [UJA] has the most administrative structures with this name—three—one of them as a vice-rectorate and the other two as subordinate units.

In total, 41 administrative structures were identified with the word “diversity” in their names, reflecting a considerable level of institutionalization of the term. However, they exhibit great variety in their internal organization. Most take the form of units (22 cases), followed by services (6) and offices (5). In four cases, they are vice-rectorates, and in two, they are areas; other structures, such as general directorates and secretariats, appear once each (Figure 2).

This overview demonstrates the formal consolidation of the concept of diversity within the Spanish university system, albeit with uneven development in terms of hierarchy and institutional visibility. The analysis reveals that most administrative structures incorporating the term “diversity” occupy an intermediate position in the institutional organizational chart, with those identified as units predominating. These services typically have a defined structure and designated staff. However, in two cases (the departments at the Complutense University

[UCM] and the Autonomous University of Madrid [UAM]), although contact information is provided, their organizational nature is not clearly specified, suggesting a functional, cross-cutting nature. Likewise, only four universities (UJA, University of Valencia [UVA], UMH, and UDC) have a vice-rectorate that includes “diversity” in its name, representing just 11% of the total identified structures.

Regarding accessibility, in most cases (63%; 26 out of 41 structures), it takes between three and four clicks from the homepage to reach the service’s webpage. In nine cases, it was possible to reach it with 2 clicks, and in 6 cases, more than 4 clicks were required. These data indicate an indirect location, which may hinder initial access for interested members of the public.

4.2. Verbal System: Target Groups and Functions

Analysis of the verbal system allows us to identify how universities discursively construct the concept of diversity through the target groups and functions described in their organizational structures. On the websites analyzed, the term appears accompanied by adjectives or nouns that specify its scope, such as “functional,” “sexual/affective-sexual,”

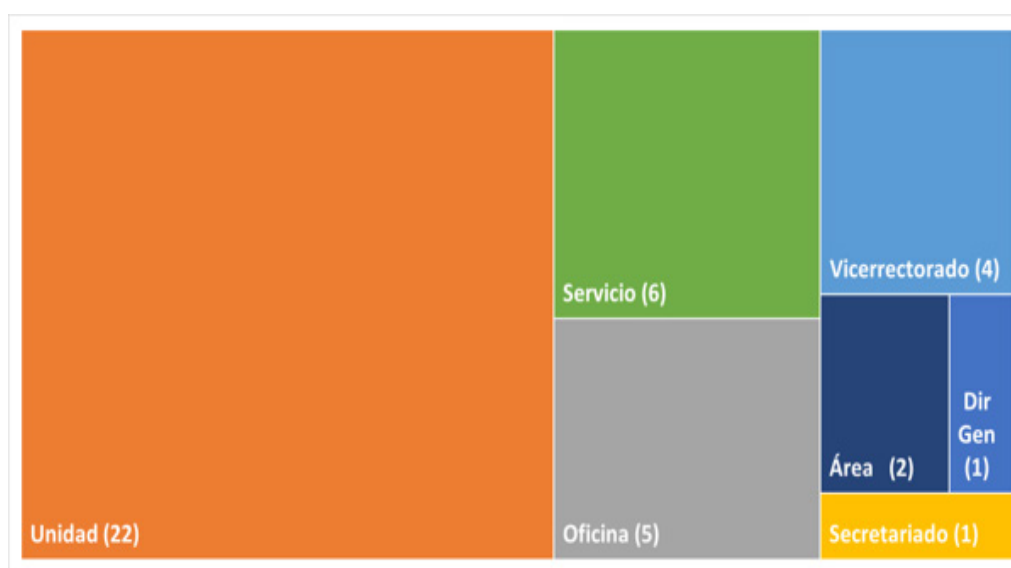


Figure 2: Typology of administrative structures.
Source: Author’s own compilation of field data (2024)

“disability,” “special educational needs/specific educational support needs (SEN/SESN),” “equality,” or “culture” (Table 2). These linguistic elements, together with the available content and links, reflect the institutional meaning attributed to diversity within each administrative structure.

An analysis of website content reveals that the identified university structures rarely specify target groups, opting instead for lists of overlapping personal or social conditions. A representative example is as follows:

The hallmarks of this Office of the Vice President are to work across the board to promote a committed, inclusive, and diverse university, guaranteeing the university community that, in the exercise of their rights and the fulfillment of their duties, they will not be discriminated against on the basis of birth, racial or ethnic origin, sex, sexual orientation, gender identity, religion, belief or opinion, age, disability, nationality, illness, socioeconomic status, language, political or union affiliation, appearance, or any other personal or social condition or circumstance (UJA, 2025).

When specific groups are identified, people with disabilities stand out (107 mentions) and students with SEN/NEAE not associated with disability (36 mentions). Sex-gender status is also mentioned, with specific reference to LGBTIQ+ groups (30 mentions).

In terms of functions, they are grouped into three categories: access, learning, and participation (Calderón Almendros and Ainscow, 2025). Most of the actions are oriented toward learning (78 citations), followed by participation (61) and access (28). These functions are distributed unevenly depending on the group they target (Figure 3).

Regarding the measures grouped under the access category (28 citations, represented in the blue area of the diagram), most of these services describe access as a guiding principle of the university, particularly with regard to students with disabilities or special educational needs (SEN/SEN). University staff (PTGAS or PDI) are also mentioned, though in general terms and without detailing specific mechanisms to ensure their access. This principle characterizes the concept of diversity in two fundamental ways:

Table 2. Identification of administrative structures and the terms associated with them
Source: Author’s own compilation of field data (2024)

Grouping of university structures containing the term “diversity” based on their names	Frequency
Office/Unit/Diversity Services	7
General Directorate/Unit/Diversity Office	7
Vice-Rector’s Office/Unit/Equality and Diversity Division	6
Unit/Service for Supporting People with Disabilities	5
Unit/Support for Diversity and Inclusion	3
Educational Guidance, Diversity, and Inclusion Unit	2
Office of the Vice President for Culture, Equality, and Diversity	2
Office of Diversity and Social Responsibility	1
Vice-Rectorate for Equality, Diversity, and Social Responsibility	1
Inclusion Unit: University, Disability, and Diversity	1
Sexual and Gender Diversity	1
Sexual and Gender Diversity	1
Office of the Vice President for Equality, Diversity, and Inclusive Policies	1
Diversity and Disability Unit	1
Student Support Service for Students with Diverse Needs and Educational Support Needs	1
Diversity and Volunteer Services	1

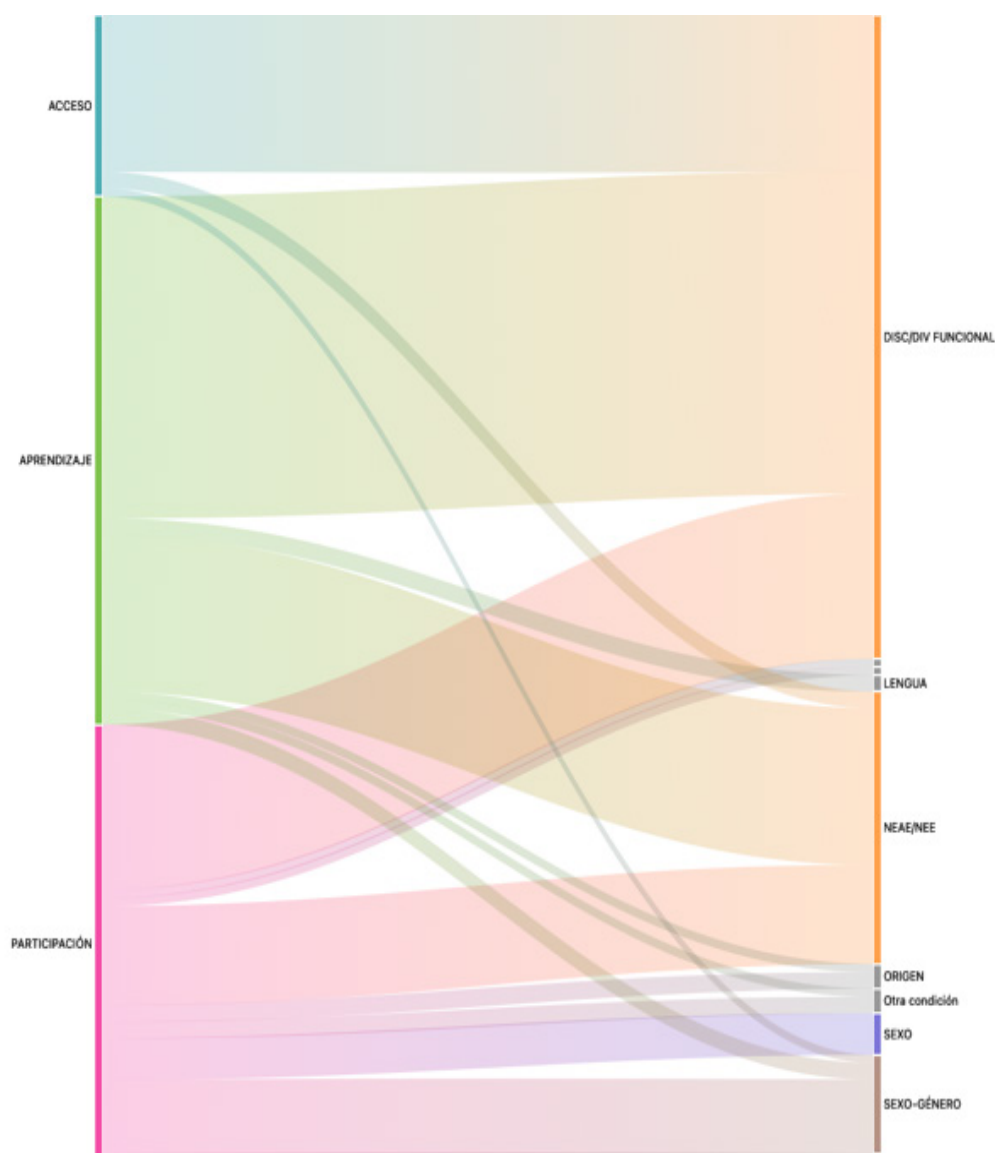


Figure 3: Sankey diagram of co-occurrences of citations between named groups and functions.
Source: Author's own analysis of field data (2024)

1. Reserved quotas for students with disabilities. Only three public universities (University of Zaragoza [UZA], University of Burgos [UBU], Rovira i Virgili University [URV]) explicitly mention this reservation, despite the fact that the regulations (Royal Decree 412/2014) stipulates that all public universities must reserve at least 5% of their spots for students with a disability rating of 33% or higher, ensuring inclusion in bachelor's and master's programs. This is how the URV expressed it on its website:

What does the 5% quota for university students with disabilities mean? This

means that, of the total available spots in each degree program, 5% will be reserved for all students with a recognized disability of 33% or higher, as well as for students with permanent special educational needs associated with a disability who, during their previous schooling, required support to achieve full educational inclusion.

In connection with this quota, some universities offer financial benefits, announcing tuition discounts for students with a disability of 33% or higher: "Regarding financial assistance, the Open

University of Catalonia (UOC) offers a discount to students with a disability of 33% or higher who enroll in an official degree program” (UOC, n.d.).

2. Removal of barriers and infrastructure management to ensure physical and informational access. Two narratives emerge here: some universities explicitly present themselves as accessible, for example: “Accessible campus and facilities. Rest areas, adapted study spaces, and assistive devices” (Universitat Jaume I [UJI], n.d.).

Other universities mention accessibility within the framework of their functions through resources or furniture adapted on demand (University of Alicante [UA], University of Almería [UAL], UAM, UBU, University of Cantabria [UC], University of Cádiz [UCA], UDC, Isabel I University [UII], UMH, University of Murcia [UMU], UNIE, UOC), plans to remove barriers (UC), or the creation of units or observatories to improve accessibility (UZA, UC). For example:

Resource Bank. The University of Cantabria has a set of technical resources to ensure that people with disabilities have equal access to university services. The purpose of this bank is to create a repository of technical resources that enable accessibility and autonomy for students and university-affiliated personnel (UC).

Regarding the learning category (78 citations, represented in the green zone in the diagram), six main areas are identified that are primarily aimed at students with disabilities, though not exclusively:

1. Care, guidance, counseling, and support. This is the function with the most citations, aimed primarily at students with disabilities or SEN/SEA and offering guidance for their academic development: “The service offers individualized and specialized care, addressing the academic needs of students with disabilities: guidance on choosing a

program of study, enrollment, processing documents, and information on scholarships and specific job offers” (UBU).

2. Welcome services. Aimed at students already enrolled, especially those with disabilities, SEN/SEAL (UAM, UJI), and refugees (UCM). Providing information on services and resources.

3. Provision of scholarships. For students in situations of “vulnerability,” “difficulty,” or “risk of exclusion” to ensure educational continuity and cover expenses (tuition, housing, materials, etc.). “Financial aid for students in situations of special difficulty. Enrolled students who, for economic, social, or family reasons, face difficulties that affect the continuity of their studies. The aid may cover tuition, transportation, housing, and educational materials, up to 3,500 euros” (URV).

4. Curricular accommodations and educational support. This is the most common function. All the universities analyzed, except for the service identified at the UMH, offer specialized services for non-substantial accommodations and support for academic monitoring and exam administration, including entrance exams, as noted, for example, by the UBU: “Support for students with disabilities. Individualized attention that addresses academic needs.” Specialized materials on various disabilities are frequently available for students, faculty, and the university community.

5. University and teacher training. This includes formal and extracurricular activities designed to raise awareness and disseminate information on digital accessibility, gender diversity, disability, and gender. For example: “Because we believe that the university is more than just a campus, we have developed activities to enhance your education” (UNIE).

Faculty training is linked to curriculum adaptations, offering support, guidance, and resources to improve their teaching,

as explained by the European University of the Canary Islands [UEC]: “In terms of addressing diversity and inclusive education, we train your faculty to equip them with the necessary tools.”

6. Workplace Adaptation. Only at UBU and UA are measures identified that target staff with disabilities, focused on providing accessible resources for their work. For example: “Support for administrative and service staff. Ensuring equal opportunities through counseling for workplace adaptation, acquisition of assistive devices, and awareness-raising activities” (UBU)

Regarding the participation category (61 citations, represented in the pink zone in the diagram), the actions are grouped into four dimensions:

1. Awareness-raising. A common objective in diversity initiatives, especially for students with disabilities, SEN/NEAE, and gender inequality (typically with reference to LGBTIQ+), involving informational and educational activities. The UC: “Aims to inform and raise awareness among the university community about the importance of addressing the educational needs of certain students.” (UC). Some examples include the podcast “UCA Sin Armarios,” to raise awareness about gender diversity (UCA), and activities commemorating the International Day Against Homophobia, Transphobia, and Biphobia (Universitat Pompeu Fabra [UPF], Universidad de Alcalá [UAH], USAL, UZA). One example is the UCA, which celebrated “the First LGBTIQAP+ Pride Week with educational and advocacy activities.”

Likewise, safe spaces and protocols for reporting discrimination, gender-based violence, or violence against LGBTIQ+ individuals are promoted, and guides on non-sexist language are developed.

2. Promotion of volunteering and solidarity. Notably at UJA, UJI, UMU, and UNIE, with a recognized track record and specific

campaigns. As UMU explains: “The Social Outreach and Volunteer Service fosters solidarity and social participation within the university community.”

3. Creation of networks with associations and non-profit organizations linked to disability, sexual diversity, or health, such as that offered by the University of Valladolid [UVA]: “Support for organizations in awareness-raising and training initiatives.”

4. Improving student employability. Through agreements and support for external internships for students with disabilities, as shown below: “The Diversity and Inclusion Unit promotes the inclusion and skill development of students with specific educational needs to facilitate their entry into the workforce” (UNIE).

4.3. Visual elements: photographs, icons, or logos, and the combination of text and images

Finally, the graphic system at universities shows limited use of images, primarily informational carousels, logos, and posters. The images mostly depict students and faculty associated with equality, disability, and educational support. However, they lack institutional context and are often interchangeable. Diversity services are not presented as physical spaces, but rather as rhizomatic spaces with diverse scope.

The images focus on three forms of diversity:

1. Functional disability, with frequent use of wheelchairs (UAL, UAM, UCM, UJI, UMU, USAL, UZA).

2. Digital accessibility and educational support (UA, UAM, UC, UCA, UJI, UMU, International University of Valencia [VIU]).

3. Gender diversity, featuring rainbow flag logos (UA, UCA, UCM, UDC, University of Huelva [HU], Polytechnic University of Madrid [UPM], USAL, UZA). To a lesser extent, images related to mental health, women, and sign language are also included. The predominant color is purple,

referring to the concept of equality, while the colors of the rainbow symbolize gender diversity. Many of the images promote partner organizations or events, both internal

and external, such as Down Cádiz at UCA and ONCE at UI1.

In general, the images shown do not provide significant insight into diversity services.

5. Discussion

This research has analyzed the conceptualization of diversity in Spanish universities by studying the websites of their institutional services, focusing on the interactive, verbal, and graphic systems. This methodological approach constitutes a novel contribution to the field of studies on diversity in higher education, especially in the Spanish context, where the discursive, representational, and performative potential of institutional websites has barely been explored. There are well-established studies on university diversity in contexts such as the United States and the United Kingdom (Ford & Patterson, 2019; Soysal & Baltaru, 2021; Wilson & Meyer, 2009). Our study, however, offers a first critical mapping of how Spanish universities project their meanings of diversity through their digital environments.

Through an analysis of interactive features, we observe that the term “diversity” is relatively widespread in the identification of university services or structures (40%, 36 out of 90 universities). However, only 4% include it in more than one service (UJA, UMH, USAL, and UDC). However, its placement within the website architecture is not very accessible, as in most cases a specific search is required, and in some cases external search engines are even necessary. This difficulty in accessing information supports Olssen et al.’s (2006) assertion that homepages are not neutral spaces but ideological devices that prioritize institutional values. Thus, the low digital visibility of these services suggests that diversity does not occupy a central place in institutional identity. Along these lines, Wilson and Meyer (2009) demonstrated, in the U.S. context, that web accessibility influences perceptions and choices of a university, reinforcing the relevance of the analysis proposed here.

The results also reveal the absence of a definition of the term “diversity,” which is understood through reference to specific conditions, a finding consistent with previous studies in the U.S. context, such as those by Foste et al. (2022) and Wilson et al. (2022). Analysis of the verbal system reveals a notable omission of forms of diversity beyond disability. This category appears to be prioritized, particularly in relation to the student body. As Ford and Patterson (2016) point out, this phenomenon of aggregation and omission reduces diversity to disability and SEN/NEAE, hindering the inclusion of other realities. While references to gender diversity are detected—with more specific mention of LGBTQ+ groups—these appear fragmented, and more structural concepts such as inequality or discrimination are avoided.

Regarding functions, the area of learning (especially curricular adaptations and educational supports) is the most common, in line with research on inclusion in higher education (Moriña, 2022; Sanahuja et al., 2020). In turn, actions related to diversity tend to focus on two areas: on the one hand, strengthening an internal culture of inclusion; on the other, outreach to society through relationships with associations or the business sector. The topic of disability dominates academic events, while commemorative or advocacy-oriented initiatives tend to focus on gender equality and the LGBTQ+ community.

These dynamics reflect the observations of Naranjo-Crespo (2024), who, despite acknowledging progress in discourse, warns that Spanish universities still reproduce a “banking” model regarding diversity, understood as limited and untransformative administrative

management. Internationally, our findings align with those of Soysal and Baltaru (2021), who, in their analysis of university websites in the United Kingdom, identified three institutional logics linked to a more rational, proactive, and socially committed university—logics that are scarcely visible in the Spanish case.

Regarding the graphic system, a lack of visual strategy is confirmed. Unlike the North American

context (Ford & Patterson, 2019), the images neither reinforce nor diversify the institutional discourse on diversity. Their function is rather symbolic, primarily representing people with disabilities and, to a lesser extent, LGBTIQ+ groups, without providing information about services or reinforcing a coherent institutional narrative.

6. Conclusions

The analysis of university websites shows that the term “diversity” is used in 36 of the 90 Spanish universities analyzed, reflecting partial institutionalization. Its use is concentrated primarily on services related to disability and SEN/EAL, while other dimensions receive little attention. Furthermore, the identified services prioritize learning, participation, and access; however, they have low visibility and are difficult to locate within the organizational website structure. Visually, the graphic representation is limited and focuses on disability and gender diversity.

From an applied perspective, these findings offer concrete guidance for designing more inclusive university policies and improving institutional communication. The limited digital accessibility and visibility of the identified services suggest that they should be integrated into institutional homepages, thereby giving them greater symbolic and functional prominence. Furthermore, the concentration of the diversity discourse on disability and SEN/AED, with the resulting invisibility of other dimensions, suggests the need

to revise the conceptual frameworks underpinning institutional inclusion plans, broadening their scope toward an intersectional approach that also addresses cultural, socioeconomic, gender, and age diversity. Another possible course of action could involve mobilizing institutions to develop policies that address the structural conditions that produce inequality, rather than solely its individual effects—an issue highlighted by the predominance of functions focused on individual learning through curricular adaptations.

Taken together, these findings not only shed light on a largely unexplored field in Spain but also highlight the fragmentation of the term “diversity” and the need to improve universities’ institutional communication strategies through their websites. At the same time, they provide information and tools to guide more coherent, inclusive policies and rethink diversity from a transformative institutional perspective. This scenario invites a critical rethinking of university governance so that diversity is not merely stated but structurally incorporated and transformed.

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Research by humanities faculty at a Peruvian university: a mixed-methods study

La investigación de docentes de humanidades de una universidad peruana: un estudio mixto

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Research by humanities faculty at a Peruvian university: a mixed-methods study

La investigación de docentes de humanidades de una universidad peruana: un estudio mixto

Abstract:

The aim of this study was to analyze the research conducted by humanities professors at a public university in Southern Peru. A mixed approach was used, following a combined qualitative and quantitative design. The sample was convenience-based and non-probabilistic, comprising 53 researchers in humanities. From a quantitative perspective, the study found that most teachers have knowledge of research methodology and the publication of scientific articles; they primarily use qualitative and mixed-methods approaches, and prefer to conduct research as co-authors. From a qualitative perspective, it was found that knowledge production is the main feature of the profile of researchers in the humanities. It is concluded that teachers in the humanities conduct research and contribute to scientific knowledge, although they face a number of disadvantages compared to other fields of human knowledge.

Keywords: humanities, research, university, professors, publication.

Resumen:

El propósito de este estudio consiste en analizar la investigación de los docentes de humanidades de una universidad pública peruana. Se utilizó un enfoque mixto. La muestra fue no probabilística y por conveniencia, conformada por 53 docentes del área de Humanidades. Desde el enfoque cuantitativo, se encontró la mayoría de docentes poseen conocimientos sobre metodología de investigación y publicación de artículos científicos; utilizan mayormente enfoques metodológicos cualitativos y mixtos, y prefieren investigar en coautoría. Desde el enfoque cualitativo se encontró que la producción del conocimiento es el principal rasgo del perfil del investigador del área de humanidades. Se concluye que los docentes en humanidades investigan y aportan al conocimiento científico, aunque tienen que enfrentar una serie de desventajas en relación a otras áreas del saber humano.

Palabras clave: humanidades, investigación, universidad, docencia, publicación.

1. Introduction

The humanities constitute an indispensable field of human knowledge, although they have not necessarily received such recognition in the scientific sphere (Guillén-Chávez et al., 2021). For a long time, research in the humanities has been relegated relative to other areas of knowledge, especially compared to the fields of science and technology. For their part, Meza and Nascimiento (2019), with the aim of positioning research in the humanities and highlighting the value of such studies, analyzed the research gap in the humanities in theses and scientific articles, and found that the latter have a constructive nature, as they advance humanistic knowledge by identifying and filling existing gaps; unlike research presented in thesis format, which is said to have a deconstructive nature.

Despite the undeniable contribution of the humanities to the field of knowledge—such as the significance of ethics as part of philosophy and critical analysis in science, which should be present in all areas of life (Rodríguez, 2021)—questions have been raised about humanities research. Thus, López-Cantos (2022) notes that there is a perception of a lack of scientific rigor and limited benefit and productivity of the humanities for science and society, unlike other fields of knowledge, such as STEM, biomedicine, and the health sciences. Similarly, Geschwind (2010) found in his study that the propensity for publication in humanities departments worldwide is not significant; therefore, it is suggested that research in the humanities be interdisciplinary or multidisciplinary. Another study found that 42% of the articles analyzed concluded that the humanities do not generate economic profits; however, 11% highlighted their social value despite the lack of attention they receive. This value is related to and extends to social value, as it involves the formation of critical and well-rounded citizens for a democratic society within universities, which primarily seek to develop commercial skills in accordance with the existing market economy (Knudsen, 2017).

In a bibliometric study by Scholkmann et al. (2025) on research in the social sciences and humanities in Europe over the past fifty years, it was found that there is fragmentation in the work of researchers in these fields. According to this study, publications are scattered across a wide range of journals, which are connected through the citation system, albeit unevenly across national contexts. Another important finding was the consolidation of the social sciences and humanities as an independent research field, in line with European research policies.

Regarding the profile of researchers in the humanities, it is important to recognize that they possess advanced research skills. Therefore, it is important to investigate training in these skills during university education, and especially at the graduate level. Another issue to consider regarding humanities researchers concerns their motivations, interests, efforts, benefits, and strategies. Xu (2013) explains that whether faculty in this field identify as researchers depends on their research interests, knowledge dissemination, micro-academic environments, and the stages of their professional lives. Furthermore, this author explains that research is a commitment rooted in personal interest, meaning that neither appropriate policies nor institutional incentives alone are sufficient; rather, there must be a dynamic of negotiation and collaboration among all parties involved. On a more general level, Pérez Pulido (2024) found that researchers have positive predispositions toward publishing their work, but their attitudes are complex, shaped by emotional, contextual, and institutional factors.

When considering the strategies employed by researchers in the humanities, factors such as time management, the rigor of the research process, and the importance of teamwork must be taken into account (Guillén-Chávez et al., 2021; Estrada & Mateos, 2024). Along the same lines, Ortuño-Soriano et al. (2013) mention the following as

part of strategies to promote research: financial incentives, time allocated during the workday for research, and teaching positions that foster research and scientific output. Regarding the difficulties faced by researchers in the humanities, Reyes-Cruz et al. (2018) found, in their study of research conducted by foreign language teachers, that although participants reported being highly motivated to conduct research, institutional and personal difficulties persisted. On the institutional side, these challenges are primarily related to a lack of time for research, followed by limited flexibility in the allocation of teaching duties, a lack of recognition for their work, and a lack of guidance. On a personal level, they cited a lack of training, limited knowledge of how to write articles and develop projects, and fear of peer review.

Likewise, it is important to note that research in the humanities is not conducted equitably when

variables such as gender are taken into account, thereby creating a long-standing gap. Kim (2025) found that academic fields foster inequality, as there is a complex relationship between gender and research specialization strategies.

In Peru, research in the humanities is not insignificant, given the presence of several humanities faculties across the country; however, a certain invisibility of studies in this area can be observed. In this regard, the general objective of this research is to analyze the humanities faculty's research at a Peruvian public university. This leads us to set the following specific objectives: a) to establish a profile of researchers in the humanities at a university in southern Peru; b) to determine the institutional support received by researchers in the humanities and their perceptions regarding publication in indexed journals in the field; c) to analyze the issues and causes of the deficit of indexed publications in the humanities.

2. Materials and Methods

A mixed-methods approach was chosen, with a concurrent design (quantitative and qualitative). On the one hand, descriptive statistical analyses were conducted, as well as content analysis (CAQDAS NVivo 12 PLUS) for the analyses related to the open-ended questions, using an inductive approach, understanding the context and the individuals from a holistic perspective, being sensitive to the effects the researcher has on the study subjects, and understanding the study participants within their frame of reference, in which all perspectives are valid. It is a humanistic method that emphasizes the validity of the research and the potential of all contexts and individuals as subjects of study (Quecedo & Castaño, 2002). The constant comparative method of Strauss and Corbin (1994) was used as a reference. This model allows for three essential actions: open, axial, and selective coding to identify relevant categories from participants' comments, which were grouped into metacategories to construct the theory-generating conceptual map. Throughout the research, the quality parameters and ethical principles inherent to the qualitative approach were taken into account (Fernández-Bringas

& Bardales-Mendoza, 2022). For this reason, coding was performed by the research team to ensure credibility, that is, internal validity.

The qualitative content analysis procedure began with an examination of the data and the application of a structure to identify several specific themes, which were later grouped into general categories or metacategories. Within these categories, subcategories were created based on existing themes (Cabanillas-García et al., 2022). To test the reliability of the category system, an explanatory codebook was developed. Finally, the objectivity (confirmability) of the results is substantiated through verbatim excerpts from the participants' texts. Additionally, non-probability and convenience sampling were used; 53 researchers in the Humanities from a public university in southern Peru voluntarily participated and provided their informed consent before completing the questionnaire. Among the participants' main characteristics, it is worth noting that 100% were from the Humanities, with 33 men (62.3%) and 20 women (37.7%). For data collection, a questionnaire with closed-ended,

multiple-choice, and open-ended questions was used. Of 21 items, 11 were closed-ended, 1 was multiple-choice, and 10 were open-ended. The questionnaire was distributed to faculty members electronically via Google Forms.

Table 1 below shows the 21 items, which were divided into three macro-categories (MC):

- MC1: Profile of the Humanities Researcher (14 items): gender (1), affiliation (2), field (3), rank (6), employment status (7), level of teaching experience (8), academic degree (9), administrative position (10),

training in methodology and publication (11), type of authorship (12), methodological approach (13), subfield (4), teaching experience (5), RENACYT status and affiliation (12).

- MC2: Institutional support for the Humanities (3 items): promotion of research (17), publication opportunities (18), and support for publication (19).

- MC3: Publishing in the Humanities (4 items): problems (15), cause of lower publication volume (16), influence of the environment (20), and appropriateness of impact factors (21).

Table 1: Questionnaire items
Source: Prepared by the author (2024)

Closed-ended questions	Multiple-choice questions	Open-ended questions
1. Gender	4. Please indicate which subfield of the Humanities you research:	5. How many years of experience do you have in university teaching?
2. Are you a faculty member in the humanities?		14. Are you currently a RENACYT researcher? What affiliation do you use in your publications?
3. Do you conduct research related to the humanities?		15. What challenges do you think arise when trying to publish in a scientific journal?
6. What is your professional teaching rank?		16. In your opinion, why are there fewer articles published in high-impact journals in the Humanities?
7. What is your employment status at the university?		17. Does your institution promote research? How? What does it depend on?
8. Your teaching experience corresponds to the level of:		18. Do you believe there are currently more opportunities for research in the Humanities?
9. What is your highest academic degree?		19. Has your institution provided you with support for publishing? In what way?
10. Have you held administrative management positions while conducting research?		20. Do you believe that the family environment influences the research activities of scholars in the humanities? Are there differences between men and women?
11. Have you received training in research methodology and article publication?		21. Do you consider criteria such as the H-index and/or the number of citations of a scientific article to be appropriate for evaluating impact in the Humanities? Why?
12. Do you prefer to publish as a sole author or as a co-author?		
13. What methodological approach do you use in your research?		

3. Results

First, with regard to the quantitative data, Table 2 presents a descriptive analysis of the frequencies of the nominal variables under study. It is worth noting that 100% of the participants teach in the Humanities, which ensures that they possess in-depth knowledge of the field, and a large percentage of them (92.5%) are also engaged in research related to the Humanities. Among the subfields of research in the Humanities, the highest number of respondents to the questionnaire were

from the subfield of Languages, Literature, and Linguistics (54%), followed by Arts (Visual Arts and Music) at 16% and Philosophy, Ethics, and Religion at 15%; Additionally, 15% reported conducting research in other subfields of the humanities. Within the professional category of faculty members, those with the rank of assistant professor stand out most frequently (47.2%), and the majority hold tenured positions (83%). Additionally, they teach primarily at the

undergraduate level (67.9%), and nearly half of them hold administrative positions (47.2%).

Regarding their training, they have received instruction in both research methodologies and the publication of articles (54.7%). In terms of their academic degrees, the majority hold a master's degree (67.9%), which may not ensure a deep understanding of the methodological foundations of research, since only 32.1% hold a doctoral degree and only 7.5% hold the status of RENACYT Researcher, which is the National Registry of Science, Technology, and Technological Innovation for individuals—Peruvian or foreign—who carry out science, technology, and innovation activities in Peru. It also includes Peruvians who carry out these activities abroad, and foreigners who do not reside in Peru but have a commitment to a Peruvian entity to carry out such activities in the country. On the other hand, regarding their preferences for authorship when publishing articles, it has been observed that they prefer to publish as co-authors (56.6%), which shows that they have a clear preference for teamwork and primarily use qualitative (41.5%) and mixed (34%) methodological approaches.

Second, the inferential analyses performed are detailed below. The analysis was conducted at

the 95% confidence level with a 5% error margin. Table 3 shows the chi-square values and p-values for the comparison of the nominal variables analyzed in relation to gender, as well as the correlation coefficient (Phi) for the dichotomous variable of gender and the contingency coefficient for the polytomous variable of teaching experience. The values of these coefficients range from 0 to 1, with values close to 0 indicating a low association and values close to 1 indicating a high association.

No relationship was found between gender and professional teaching category ($p=0.669$), employment status ($p=0.860$), teaching experience ($p=0.183$), level of teaching experience ($p=0.723$), holding management positions ($p=0.167$), training in research methodologies and/or publication of articles ($p=0.263$), academic degree ($p=0.723$), RENACYT researcher status ($p=0.287$), or authorship preference ($p=0.730$). However, a relationship was found with the methodological approach used ($p=0.007$), with a moderate correlation ($\Phi=0.485$). Humanities researchers preferentially use qualitative and mixed-methods approaches, given that their subject of study is cultural.

Table 3: Results of the comparison of the variables under study by gender
Source: Author's own work (2024)

Variable	Chi	p-Value
Teaching profession category	0,803	0,669
Employment status	0,302	0,860
Teaching experience	3,400	0,183
Level of teaching experience	0,126	0,723
Holding management positions	1,909	0,167
Training in research methodologies and/or publication of articles	2,643	0,263
Academic degree	0,126	0,723
RENACYT researcher	1,133	0,287
Author preference	0,628	0,730
Methodological approach	12,240	0,007

Note: Data are presented based on the Chi-square value. *: $p < 0.05$ between gender (male and female; $n = 53$) and the nominal study variables.

Table 2: Descriptive analysis of the frequencies of the nominal variables under study
Source: Author's own work (2024)

Variable ranges	Frequency (n)	Percentage (%)
Teaching in the Humanities		
Yes	53	100%
No	0	0%
Research related to the Humanities		
Yes	49	92.5%
No	4	7.5%
Research subfields: Arts, visual arts, and music		
Arts (Visual Arts and Music)	9	16%
Languages, Literature, and Linguistics	28	54%
Philosophy, Ethics, and Religion	8	15%
Other	8	15%
Teaching profession		
Assistant	25	47,2%
Associate	16	30.2%
Primary	12	22,6%
Employment status		
Guest	4	7,5%
Appointed	44	83%
Contract	5	9,4%
Years of teaching experience		
Between 1 and 10 years	16	30,2%
Between 11 and 24 years	18	34%
25 or older	19	35,8%
Level of teaching experience		
Undergraduate	36	67,9%
Graduate	17	32,1%
Hold management positions		
Yes	25	47,2%
No	28	52,8%
Training in research methodologies and/or publication of articles		
Research methodology	16	30,2%
Publication of scientific articles	8	15,1%
Both	29	54,7%
Academic degree		
Teacher	36	67,9%
Ph.D.	17	32,1%
RENACYT Researcher		
(verified by CONCYTEC as of December 2022)		
*Female researchers were not included in the sample		
Yes	3	5,66%
No	50	94,34%
Authorship preference		
Single author	19	35,8%
Co-author	30	56,6%
Both	4	7,5%
Methodological approach		
Quantitative	8	15,1%
Qualitative	22	41,5%
Mixed	18	34%
Depends on the study	5	9,4%

Note: Descriptive results: frequency (n=53) and percentage (%).

Table 4 shows the results of the comparison of teaching experience with the different nominal variables. No relationship was found between teaching experience and holding management positions ($p=0.307$), training in research methodologies and/or publication of articles ($p=0.706$), being a RENACYT researcher ($p=0.992$), authoring preference ($p=0.762$), and methodological approach ($p=0.637$). However, a relationship was found between teaching experience and the teacher's professional category ($p=0.000$) with a strong relationship (contingency coefficient=0.642), with employment status ($p=0.001$) with a moderate correlation (contingency coefficient = 0.512), with teaching experience ($p = 0.001$) with a moderate correlation (contingency coefficient = 0.447), and with academic degree ($p = 0.001$) with a moderate correlation (contingency coefficient = 0.447).

Regarding the qualitative data, the hierarchical map (Figure 1) below visually organizes the categories in the codebook by coding frequency. It can be observed that MC1 (38.97%) and MC3 (35.09%) are most frequently referenced, and finally, MC2 (25.94%). Analyzing each of them individually, participants considered MC1 the most important factor in shaping the profile of humanities researchers. With respect to MC2, concerning institutional support in the humanities, both the promotion of research and the promotion of publishing in the humanities were highlighted (28.22%). Finally, within MC3, which analyzes the characteristics of publishing in the humanities, the problems (26.64%) and the causes of the lower volume of publications (25.7%) stood out.

Table 4: Results of the comparison of the variables under study based on teaching experience
Source: Author's own work (2024)

Variable	Chi	p-Value
Teaching professional category	37,215	0,000
Employment status	18,796	0,001
Level of teaching experience	13,201	0,001
Hold management positions	2,363	0,307
Training in research methodologies and/or publication of articles	2,163	0,706
Academic degree	13,201	0,001
RENACYT researcher	0,016	0,992
Author preference	1,858	0,762
Methodological approach	4,295	0,637

Note: Data are presented based on the Chi-square value. *: $p < 0.05$ between teaching experience (10 years or less, 11–20 years, and more than 20 years; $n = 53$) and the nominal study variables.

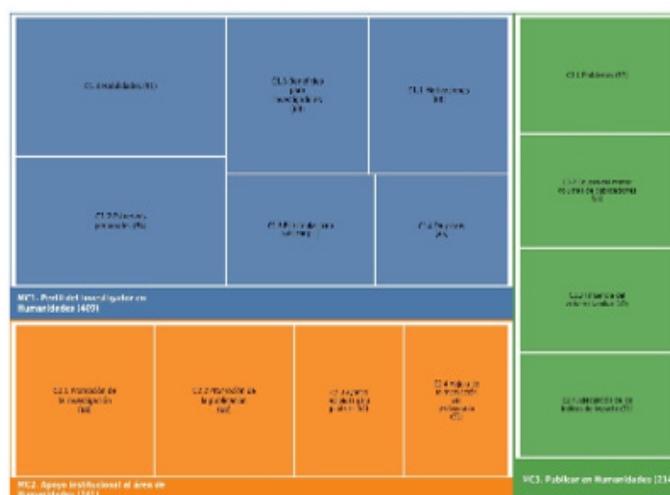


Figure 1: Hierarchical map of the codebook.
Source: Author's own work (2024).

The results show that within the construction of the humanities researcher profile (MC1), participants indicated that conducting research in the humanities requires a significant investment of time. Participant 44 noted: “a great deal of time spent reading a large number of texts on the research topic,” while a significant financial investment is also necessary for research in the humanities (28.57%).

Delving deeper into the analysis of the institutional support offered to the Humanities (MC2), it has been observed that, predominantly, researchers have indicated that research is indeed promoted at their institution (76.47%), compared to 14.71% indicating that it is not. Among the former, financial aid (37.5%) stands out, along with the training offered (22.5%) through courses, specializations, and lectures, provided on an ongoing basis and with predominantly technical content. However, 17.5% of the responses indicated that such promotion is very limited. Regarding the reasons for not promoting research, faculty members cited the following: it is necessary to reduce the teaching load to dedicate time to research; there is inequality in promotion; and a change in policies in the Humanities is necessary.

On the other hand, a higher percentage of respondents indicated that publication in the Humanities is indeed promoted at their institution (67.65%), compared to 16.18% who stated that it is not. Among the former, financial aid stood out (35.29%), as indicated by participant 15: “Yes, through calls for proposals for publicly funded research projects. Also through the budget allocated to each program, provided that the funds are credited to the university,” along with promotion carried out by research departments (17.65%), notably the University’s Vice-Rectorate for Research. However, as in the previous point, researchers note that there is very little promotion of publication in the Humanities (17.65%). Regarding the reasons for not promoting publication, they highlight the lack of indexed journals, insufficient outreach to encourage publication, and the need to reduce teaching loads to allow for research.

When analyzing the support researchers actually receive, the majority of faculty members indicate that they have not received support (51.85%), compared to those who indicate that they have (42.59%), suggesting that the reality regarding support for publishing is worse than participants’ perception of the promotion of research and publishing in the humanities at their institution. It has been observed that the support received is primarily financial (43.48%), courses (26.09%), and the university press (13.04%).

Regarding publication in the humanities (MC3), the problems were examined, among which the long review, acceptance, and publication times of journals stood out (36.84%), implying a long period of time from when authors complete their research until publication actually takes place, as mentioned by participant 14: “the waiting time regarding whether or not the submitted article is accepted,” and participant 7: “the turnaround times for article submissions are excessively long because, in most cases, the reviewers receive no financial incentive, and the same reviewers evaluate for several journals,” along with the fact that journals have a high number of publication requirements (19.3%), and to a lesser extent, respondents cited that publication fees for a large number of journals are high (12.28%). Along these lines, regarding the causes of the lower volume of publications, it has been observed that the most frequently cited reason was a lack of interest in the humanities (30.91%), both on the part of the community and of the journals, which place greater value on research linked to the pure sciences, as highlighted by participant 4 “perhaps because there isn’t much interest in research from non-scientific fields,” while also highlighting the time required for humanities research (12.73%), which demands space for reflection, the design of theoretical frameworks, the study of sources, and the preparation of articles—a process that is much more extensive in the humanities than in other fields, the scarcity of indexed journals, coupled with a lack of recognition in the humanities (10.91%).

Regarding the influence of the family environment on research, 80.39% of respondents affirm that family does influence it, while 19.61% indicate that it does not. Among the former, family burdens and responsibilities stand out (47.83%), requiring the use of available time for family or personal matters rather than for research. Thus, Participant 13 states: “Yes, sometimes family responsibilities arise that limit the time available for research,” while noting that this has a greater influence on women than on men (26.09%), as women must assume greater family responsibilities, as highlighted by Participant 15: “Gender does influence it; women have to compete for time with household chores.”

Finally, when analyzing the appropriateness of impact indices, such as the H-index and/or the number of citations of an article in the Humanities, respondents believe they are appropriate (66.67%) compared to those who indicate they are not (27.45%). In the former case, these indices confer quality and prestige on publications in the humanities (45.45%), as they are internationally recognized (22.73%). However, the disadvantages pointed out by the participants are: very low citation rates in the humanities due to factors such as a lack of interest and the very nature of humanities texts; and the publication of high-quality articles in non-indexed journals, which hinders improving impact factors in the field.

4. Discussion

In this study, one objective focused on investigating the profiles of humanities faculty members, taking into account not only their academic training but also the conditions under which they conduct their research. The profile of the researchers in this study is characterized by the fact that they teach in the humanities, with a higher representation in the research subfields of languages and literature and linguistics; they hold the rank of tenured assistant professor and have a higher volume of undergraduate teaching; however, it is worth noting that, although they identify as researchers—given that they publish academic texts—in reality, very few are RENACYT researchers. According to the regulations, RENACYT researchers must submit the information required for evaluation in accordance with established criteria. Thus, the publications that receive the highest scores are articles published in journals indexed in quartile 1 (5 points), to the detriment of books (2 points) or book chapters (1 point). In other similar studies, participants are research professors who belong to Mexico’s National System of Researchers (López-López et al., 2024; Estrada & Mateos, 2024) and research group directors (Giménez-Toledo et al., 2019) with greater experience publishing in indexed journals.

At the university where this study was conducted, the majority of humanities faculty hold master’s degrees, underscoring the importance of graduate education among the faculty. Furthermore, nearly one-third hold a doctoral degree, and a small group are researchers recognized by the national research agency. These results confirm the direct and indirect relationship between doctoral studies and scientific output (Barros & Turpo, 2020). Doctoral studies equip researchers with more advanced methodological tools that enhance their research skills, thereby increasing the likelihood of publishing their work in high-impact journals. Regarding authorship type, most humanities faculty members indicated a preference for co-authorship, which aligns with the recent trend toward multiple scientific authorship to create networks of scientific cooperation (Meza et al., 2017).

Another aspect worth highlighting is the time available for conducting research, as reported by other studies (Ortuño-Soriano et al., 2013; Rodas-Brosam et al., 2021), which mention the importance of personal time dedicated to research and the need for the institution to consider it part of teaching activity. In many university contexts, teaching loads and administrative responsibilities

significantly reduce the time allocated to research, creating tensions between teaching and scholarly output. Consequently, institutions need to formally recognize research time as an integral part of teaching, allocate specific hours within the workday, and promote academic support policies.

For humanities faculty, reading and writing practices are central, as they underpin knowledge creation, theoretical reflection, critical analysis, and specialized writing, as the researchers in this study noted. Another study with Ecuadorian faculty researchers highlights writing groups that “create spaces where this activity not only has dedicated time but also a protected space to begin practicing, alongside others, the literate practices related to scholarly writing” (Rodas-Brosam et al., 2021, p.12). Along the same lines, López-López et al. (2024) focused on the competencies required to write scientific articles among male and female researchers in the social sciences and humanities at Mexican universities. They concluded that methodology, research experience, and being male are predictors of article publication; therefore, they recommend greater support for female researchers and increased methodological training to promote educational and professional equity in research.

Regarding the second objective on the perception of institutional support, in our study, three-quarters of the total indicate that the university promotes research through courses. Regarding financial support, a low percentage reported that the university provides funding for research. This funding is obtained through competitive grants offered by the university. In general, these results are similar to those obtained in Mexico with researchers from diverse fields, including the Humanities and Behavioral Sciences. These researchers highlight the lack of funding for data collection, access to databases, and the creation of meaningful samples; added to this problem are the high costs of publishing in Gold Open Access journals, which they have sometimes had to cover out of their own salaries (Estrada & Mateos, 2024). In this regard, it is necessary to emphasize the importance of negotiation and collaboration among the parties involved in

research (Xu, 2013) in order to improve research practices at universities.

Regarding the third objective, this study found that publishing challenges are diverse; participants noted lengthy review, acceptance, and publication timelines in journals, the high number of publication requirements, high publication fees in some journals, and the lack of interest in the humanities compared to the pure sciences. Aguado-López and Becerril-García (2021) found that peer review times in humanities journals are longer than in natural science journals. Overall, these results are consistent with the findings of Giménez-Toledo et al. (2019), who surveyed Brazilian research group directors. One question focused on the importance of different document types for disseminating research results. Most considered the peer-reviewed journal article to be the most important, followed by the book format, such as a book chapter; regarding this response, they note that the lack of transparency in editorial processes, funding, and distribution is one of the weaknesses of the Brazilian academic sector; this could lead to frustration or situations of stress and anxiety (Pérez Pulido, 2024).

This study aligns with the work of Geschwind (2010), who suggests that, given the scarcity or low visibility of publications in the humanities compared to other scientific fields, research in the humanities should be interdisciplinary or multidisciplinary. This would make it possible to expand lines of humanities research even further if linked to processes of technological innovation, as is currently happening with the so-called digital humanities. Núñez-Núñez et al. (2023) reaffirm the need to work in an interdisciplinary and transdisciplinary manner within the field of literary studies, for example, through discourse analysis, cultural studies, postcolonial studies, and comparative studies. It should also be noted that research in the social sciences and humanities has become a central focus of research policies in Europe (Scholkmann et al., 2025), a trend that could be replicated in other parts of the world, given their significance.

Finally, the opinions expressed by the interviewees in this study are the product of their

experience, which is likely shared by humanities researchers in other geographical contexts. Gregorio-Chaviano et al. (2021), in their research on Dialnet Metrics, reach promising conclusions regarding the Humanities and Social Sciences. For the authors, the tendency to publish research results in Spanish national journals and to cite these journals adds strategic value to the indexing

of disciplines with lower visibility in international citation indices. Another forward-looking contribution is to incorporate Latin American journals in the field, creating a shared space with Spain. At the same time, an expansion of bibliographic reference indexing is anticipated, to include references from book chapters, books, or doctoral theses.

5. Conclusions

This article analyzes and reflects on the research conducted by the humanities faculty at a Peruvian university. From a quantitative perspective, this study primarily reveals that humanities faculty acknowledge that they possess training in research methodologies and in publishing articles. Furthermore, a low percentage of faculty researchers are classified as RENACYT and hold a doctoral degree; similarly, the majority of faculty surveyed state that they use qualitative and mixed-methods approaches.

From a qualitative perspective, this research found that the profile of researchers in the humanities at the university studied is primarily focused on producing knowledge, as evidenced by the publication of articles and books, despite the challenges that may arise along the way. Likewise, communication skills, especially those related to academic reading and writing, strengthen the humanities faculty's research skills, though this does not necessarily guarantee publication in an indexed journal, which can take considerable time.

This study reveals that, in humanities research, criteria and conditions differ from those used in other fields of knowledge. The institutions responsible for evaluating scientific output seek to standardize knowledge according to the parameters of the hard sciences. It must be

considered that the value of the humanities does not lie in the quantity of research conducted, but in their capacity to generate critical and ethical thinking.

One limitation of this research stems from the non-probabilistic, convenience-based sample selection. This meant the research had to adapt to the sample's conditions. Given that there is only one humanities faculty in the southern region of Peru, it is necessary to investigate the profile of the faculty members working there and the challenges they face when conducting research. Another limitation of this study is that the results apply specifically to one particular university. It would be necessary to undertake a broader study encompassing all humanities faculties in the country.

Finally, research in the humanities by university faculty is a field that needs to continue to be explored and promoted in order to contribute to the development of a society with ethical values and critical thinking. Humanities research is crucial in the current era, which is heavily dominated by technology and lacks parameters to control or redirect it in the service of humanity. Future studies will analyze in greater depth the differences identified in this study by researchers' gender.

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The Radical Populist Right and the SDGs: The Vox Electorate in Spain (2024–2025)

Derecha radical populista y los ODS: el electorado de Vox en España (2024–2025)

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The Radical Populist Right and the SDGs: The Vox Electorate in Spain (2024–2025)

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Abstract:

Europe is experiencing the rise and consolidation of the radical populist right. This article analyzes the extent to which the attitudes and characteristics of the Vox electorate—considered in the literature as representative of the radical populist right in Spain—may generate tensions regarding the fulfillment of the 2030 Agenda, comparing them with those of the Partido Popular electorate in areas such as immigration, climate change, gender equality, and democratic attitudes. A mixed-methods approach was applied, based on a literature review and bivariate analysis of eight CIS surveys (2024–2025), using cross-tabulations and chi-square and Cramer's V tests. The results show that Vox voters exhibit higher levels of nativism, climate skepticism, and critical stances toward feminism, as well as lower adherence to certain democratic principles than the Popular Party electorate, forming a set of attitudes that may conflict with several SDGs. These differences could hinder the building of the social and institutional consensus necessary to advance the 2030 Agenda.

Keywords: Sustainable Development Goals, political right, electoral behavior, democracy, populism

Resumen:

Europa experimenta el auge y consolidación de la derecha radical populista. El artículo analiza en qué medida las actitudes y características del electorado de Vox, considerado en la literatura como representante de la derecha radical populista en España, pueden generar tensiones en relación con el cumplimiento de la Agenda 2030, comparándolas con las del electorado del Partido Popular en ámbitos como inmigración, cambio climático, igualdad de género y actitudes democráticas. Se aplicó un método mixto basado en revisión bibliográfica y análisis bivariado de ocho encuestas del CIS (2024–2025), mediante tablas cruzadas y pruebas de chi-cuadrado y V de Cramer. Los resultados muestran que el electorado de Vox presenta mayores niveles de nativismo, escepticismo climático, posiciones críticas con el feminismo y menor adhesión a determinados principios democráticos que el electorado del Partido Popular, configurando un sistema de actitudes que puede entrar en tensión con varios ODS. Estas diferencias podrían dificultar la construcción de consensos sociales e institucionales necesarios para avanzar en la Agenda 2030.

Palabras clave: Objetivos de Desarrollo Sostenible, derecha política, comportamiento electoral, democracia, populismo

1. Introduction

Europe is witnessing the rise and political and electoral consolidation of radical populist right-wing parties (García Escribano et al., 2025). Their expansion has impacted areas such as the protection of minority rights, judicial independence, and various fundamental freedoms (Valencia Sáiz & Fernández García, 2022). These groups, defined by Mudde (2007) as radical right-wing populist, have experienced sustained growth in recent years. Unlike the traditional far right, these parties formally accept liberal democracy, although they seek to transform it from within (Mudde, 2021). This process has been linked, among other factors, to rising institutional distrust, especially among young people, who are more inclined toward illiberal options (Foa & Mounk, 2016).

Radical right-wing populist parties exhibit substantial differences across countries, depending on each country's social and political context (Fernández-Vilas, 2022). Nevertheless, the literature agrees on identifying a series of common ideological traits, among which authoritarianism, populism, and nativism stand out (Antón-Mellón & Seijo Boado, 2023). These pillars are frequently supplemented by scientific denialism, anti-feminism, and opposition to European integration (Seijo Boado & Antón-Mellón, 2024; Valencia Sáiz & Fernández García, 2022). In the Spanish case, Vox has established itself as the leading exponent of this movement, articulating a discourse that combines authoritarianism, populism, nativism, disinformation, anti-elitism, anti-feminism, and climate denial (Pablos Romero et al., 2024).

Various studies have analyzed the profile of the radical right-wing populist electorate in Europe, all noting an overrepresentation of young men (Simón, 2022). In contexts of economic precariousness and institutional distrust, this group has been described as a breeding ground for adopting radical right-wing positions (Díaz, 2023), as they are particularly affected by low wages, inequality, and difficulties in accessing housing. Electoral support for these parties has

been explained by factors such as the economic crisis and unemployment, increased immigration, and the loss of credibility of traditional parties (Rama et al., 2022).

Anti-immigration rhetoric constitutes one of the main mechanisms of political mobilization for the radical populist right, as it associates ethnic minorities with insecurity, unemployment, and the misuse of public resources. Populism, a central component of these parties (Mudde, 2007), is typically articulated through an exclusionary nationalism that appeals to the defense of a “people” conceived as a homogeneous community against external threats (Valencia Sáiz & Fernández García, 2022). This logic is particularly appealing to men with lower socioeconomic or educational capital, who tend to identify with discourses that channel experiences of vulnerability stemming from globalization, immigration, or the advances of feminism (Sendra & Plaza-Colodro, 2022).

The rise of the radical populist right has sparked growing concern about potential effects on human rights and public policies aimed at social cohesion, particularly regarding the welfare state and the inclusion of vulnerable groups (Valmorisco Pizzaro, 2023; Crespo, 2023). In this context, the 2030 Agenda, adopted by the United Nations in 2015, is structured around 17 Sustainable Development Goals and 169 universal targets and constitutes a normative framework to guide public action in areas such as reducing inequalities, gender equality, climate action, and the strengthening of democratic and inclusive institutions (Gómez Gil, 2018; United Nations, 2015).

The ideological framework of the radical populist right helps explain its tension with the SDGs, which are often perceived as a globalist agenda that threatens traditional values and national sovereignty (Herrera Letona, 2024). Based on this approach, the study posits as its main hypothesis that individuals who report having voted for Vox in the 2023 general election tend to exhibit

attitudes further removed from the values and principles associated with the 2030 Agenda than those who report having voted for the People’s Party on issues of immigration, climate change, gender equality, and democratic attitudes.

Consistent with this hypothesis, the present study examines the extent to which those who report voting for Vox show less alignment with the

values and principles of the 2030 Agenda than those who report voting for the Partido Popular. Using a mixed-methods approach based on a literature review and statistical analysis of surveys from the Center for Sociological Research (CIS) covering the 2024–2025 period, their positions on immigration, climate change, gender equality, and democratic attitudes are compared

2. Materials and Methods

The study employs a mixed-methods approach that combines a specialized literature review—used to define the theoretical framework and guide variable selection—with a non-experimental, cross-sectional, and comparative quantitative design based on the secondary analysis of representative CIS surveys from the 2024–2025 period. After reviewing all surveys published by the CIS during those years, eight studies were selected that incorporate homogeneous and comparable indicators in the areas analyzed, allowing for their joint use in an expanded cross-sectional analysis. All of them feature representative samples of the adult population in Spain, confidence levels above 95%, and narrow margins of error (Table 1).

The bivariate statistical analysis was performed using SPSS, with those who voted in the general elections of July 23, 2023, as the reference group. Two groups were compared: the Vox electorate, representative of the radical populist right, and

that of the Partido Popular, understood as an expression of the traditional right. Using cross-tabulations and the Chi-square and Cramer’s V tests (García Ferrer, 2016), associations between variables and the strength of these relationships were examined to determine whether the observed differences were statistically significant.

The main independent variable is voting recall in the general elections of July 23, 2023, recoded into two categories: Vox voters and Partido Popular voters. The dependent variables correspond to attitudes linked to various Sustainable Development Goals, operationalized using CIS indicators in the areas of immigration, climate change, gender equality, and democratic attitudes.

To ensure consistent results, the database was cleaned by excluding “don’t know/no answer” responses, which were treated as missing values. On the agreement and disagreement scales, the

Table 1: CIS studies analyzed in the article (2024 and 2025).
Source: Author’s own compilation (2026) based on data from the technical specifications of CIS studies 3466, 3480, 3486, 3489, 3490, 3497, 3522, and 3524

Study	Publication date	Number of cases	Confidence level	Margin of error	Recall of PP vote	I remember voting for Vox
3466 Social inequalities and trends	06/06/2024	4006	95.5%	±1.6%	660	306
3,480 Ideology and Polarization	10/11/2024	3928	95.5%	±1.6%	843	346
3486 Survey on Social Trends (IV)	11/08/2024	3,800	95.5%	±1.6%	707	290
3,489 December 2024 Barometer	12/02/2024	4621	95.5%	±1.5%	894	340
3,490 Political participation	12/12/2024	2562	95.5%	±2%	447	208
3497 Quality of Democracy (III)	04/08/2025	4010	95.5%	±1.6%	740	415
3522 Study on Social Inequalities	06/12/2025	4004	95.5%	±1.6%	659	269
3,524 September 2025 Barometer	09/25/2025	4122	95.5%	±1.6%	771	390

extreme categories were recoded into two main groups: an agreement category comprising “strongly agree” and “agree,” and a disagreement category comprising “strongly disagree” and “disagree.” The intermediate options were

discarded due to their low frequency and because they are not read aloud by interviewers, which reduces their reliability. This recoding helped avoid distortions and ensure consistent results.

3. Results

Vox voters place immigration high on the public agenda. Although in the CIS Barometer 3524 from September 2025, the main problem they identify is the current government, immigration ranks second, cited by 14.9% of respondents. When considering Spain’s three main problems together, immigration becomes the most frequently cited issue among Vox voters (Figure 1). In contrast, among Partido Popular voters, its prominence is notably lower: only 5.2% cite it as the country’s main problem. As Figure 1 shows, while mentions of immigration and the current government predominate among Vox voters, the Popular Party electorate spreads its concerns more evenly across the economy, housing, and job quality.

CIS Study 3489 shows that Vox voters are more pessimistic about crime. 76.8% believe it will increase, compared to 60% of the Popular Party electorate. The difference is statistically significant (χ^2 (2, N = 994) = 32.969, $p < .001$) and of moderate magnitude (Cramer’s $V =$

0.182). Public safety also ranks tenth among the top three problems mentioned by Vox voters.

The CIS 3480 survey shows that 97.4% of Vox voters believe that immigrants should adopt the country’s customs and values, compared to 83% of Popular Party voters. This statistically significant difference, of moderate intensity, is consistent with the nativist framework of the radical populist right, which views immigration as a threat to national identity and sovereignty (Valencia Sáiz & Fernández García, 2022).

Skepticism toward climate change and environmental policies is one of the main pillars of disinformation in the discourse of the radical right, which, in the Spanish case, translates into downplaying the climate threat and questioning ecological transition measures (Poch-Butler et al., 2025; Fernández et al., 2020). Compared to the general electorate (Table 2), Vox voters are less likely to recognize climate change as a real threat and do not rank it among the country’s main

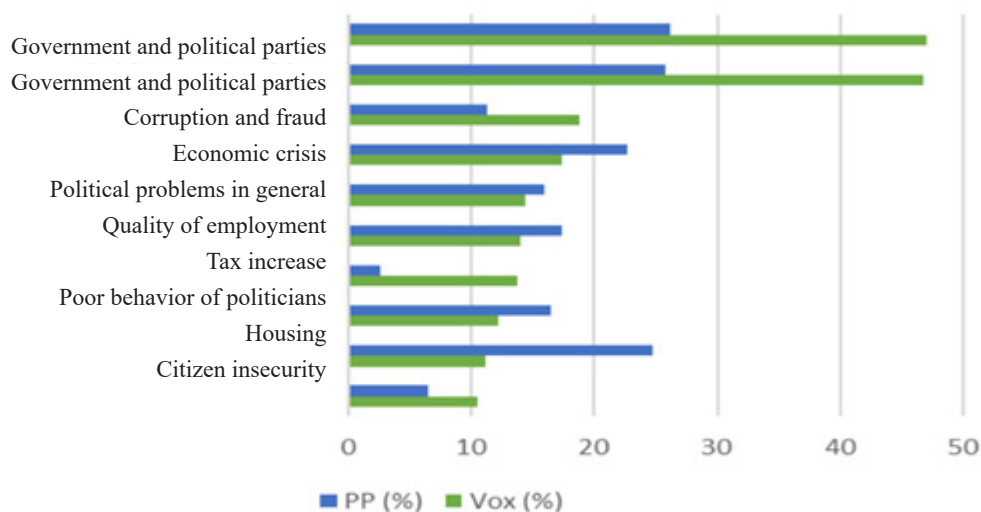


Figure 1: Top ten problems perceived by Vox voters (comparison with the PP) (2025).
Source: Author’s own analysis (2026) based on data from CIS Study 3524.

problems. They also express a lower willingness to prioritize environmental protection if it conflicts with economic growth and employment.

In the area of gender equality, the gap between the two voter bases is also evident. According to CIS Study 3480, 84.5% of Vox voters do not consider the feminist movement necessary to achieve equality between men and women, compared to 49.3% of PP voters. The association between the two variables is statistically significant and of moderate strength (Cramer's $V = 0.326$).

This gap is reflected in perceptions of inequality between men and women. The results of Study 3522 show that 41.6% of Vox voters consider such inequality nonexistent or minimal, while among PP voters, the perception of significant inequality is more prevalent (38.8%). The difference is statistically significant and of moderate-to-low intensity (Cramer's $V = 0.212$).

Data from various CIS studies reveal significant democratic disengagement among Vox voters. While 73.9% of PP voters reject living in a less democratic country, even if it would improve their quality of life, this stance drops to 55.4% among Vox supporters. In contrast, 44.6% of the latter would accept a less democratic system in exchange for greater well-being, compared to 26.1% of the PP electorate. This difference is statistically significant and shows a moderate association (Cramer's $V = 0.180$).

Study 3466 reinforces this pattern of disaffection by analyzing the relationship between democracy and social justice. Among PP voters, 55.4% believe that the democratic system promotes an equitable distribution of wealth. In contrast, 68.6% of Vox voters believe that democracy contributes to an unfair distribution of wealth. The difference between the two voter bases is statistically significant, with a moderate association (Cramer's $V = 0.236$).

The CIS 3490 study shows that 8.7% of Vox voters strongly disagree with the statement "Democracy may have problems, but it is always preferable to any other form of government," compared to 1% of the PP electorate who hold this view. Likewise, nearly half of PP voters strongly agree with this statement, while fewer than 30% of supporters of the party led by Santiago Abascal do so.

Table 3 delves into this disaffection among Vox supporters toward democracy and its representative institutions. Only 61.8% of its voters prefer democracy as a form of government, compared to 86.3% of PP voters. Likewise, 56.3% of Vox supporters agree with the statement that "without parties there is no democracy," compared to 84.6% of the general electorate. Although satisfaction with democracy in Spain is low in both cases, Vox voters are even more dissatisfied, with a statistically significant difference.

Table 2: Comparison of attitudes toward climate change and the environment based on votes for Vox and the PP (2024 and 2025).

Source: Author's own analysis (2026) based on CIS surveys 3480, 3486, 3490, and 3524.

Indicator	Vox (%)	PP (%)	χ^2	p	Cramer's V
Considers climate change to be a real threat to human well-being and the health of the planet	38.2	80.2	112.414	< 0.001	0.437
Mentions climate change among the main problems	8.3	30.6	55.513	< 0.001	0.236
Prioritize environmental protection, even if it reduces economic growth and employment	33.9	51.4	29.437	< 0.001	0.160
Mentions climate change, the environment, or drought among the top three problems	1.3	3.8	5.615	0.018	0.070

Table 3: Attitudes toward democracy and the political system based on voting for the PP and Vox (2025)

Source: Author's own analysis (2026) based on CIS study 3497

Indicator	Vox (%)	PP (%)	χ^2	p	Cramer's V
Prefers democracy as a form of government	61,8	86,3	116,03	< 0,001	0,321
Do you agree that without political parties there is no democracy?	56,3	84,6	110,07	< 0,001	0,312
Satisfied with democracy in Spain	11,4	16,3	4,49	0,034	0,068

The results of CIS Study 3480 show an authoritarian orientation among Vox voters regarding immigration. 96.5% of its voters agree that the government should employ more forceful measures to prevent the irregular entry

of immigrants, compared to 81.5% of the Popular Party's electorate. The difference is statistically significant and of moderate magnitude, highlighting greater support among Vox voters for restrictive policies and border control.

4. Discussion

The 2030 Agenda provides a useful framework for interpreting the political and social implications of the results obtained. Although its implementation is formally the responsibility of governments and public institutions, its success also depends on public support for the policies needed to make it effective. In this regard, the beliefs and perceptions of the electorate are relevant, as they can facilitate or hinder the acceptance of measures related to social inclusion, gender equality, climate action, or institutional strengthening. From this perspective, the discussion examines the main areas in which the attitudes of the Vox electorate come into conflict with the principles of the 2030 Agenda.

The issue of immigration occupies a central place in the campaigns and narrative of the radical populist right, serving as a powerful tool of political communication to attract voters dissatisfied with globalization, elites, the economic situation, and social change (Dancygier et al., 2025). The contrast between Spain's two main right-wing parties regarding the importance they attach to immigration can be explained by the fact that radical right-wing populist parties consistently resort to highly emotionally charged messages that associate immigration with negative perceptions to a greater extent than do traditional right-wing parties (Klein, 2024).

Concerns regarding public insecurity are not unrelated to anti-immigrant sentiment. According to the tetralogy of xenophobia formulated by Rodríguez Soler (2013), the feeling of insecurity is directly related to xenophobic attitudes, as the symbolic association between immigration and threat constitutes a discursive device that the far right uses to reinforce rejection of foreigners. Likewise, the radical populist right reflects

an exclusionary conception of the national community, which, as Antón-Mellón and Seijo Boado (2023) point out, seeks to preserve a homogeneous identity amid cultural diversity.

Measure 121 of the program presented for the general elections of July 23, 2023, establishes that immigrants in an irregular administrative status will have access to the healthcare system only in life-threatening situations or in cases of infectious diseases. Similarly, measures 125 and 126 prioritize the Spanish population in access to housing and social assistance, with the stated aim of assisting all Spaniards in need (Vox, 2023) exclusively. As a result, immigrants—a group numbering seven million people in Spain (National Institute of Statistics, 2026)—are excluded from policies aimed at ending poverty for the entire population living in Spain. Likewise, the party led by Santiago Abascal claims to prioritize those from the Iberian sphere and, in measure 214, launches a direct attack on Islam by proposing the closure of mosques or places of worship that propagate ideas contrary to Spanish culture and identity. This initiative constitutes a direct threat to target 16.10, which requires ensuring access to information and protecting fundamental freedoms.

SDG 10, which aims to reduce inequalities, is unattainable in a globalized world, as these parties aspire to build an ethnically homogeneous community and reject migration from what they call “non-assimilable cultures,” referring to those originating from Islam (Antón-Mellón & Seijo Boado, 2023).

The results show that immigration constitutes the central axis of Vox's discourse and the perceptions of its electorate, positioning it among

the country's main problems and associating it with insecurity and the loss of national identity. This discursive framework, based on a logic of exclusion and cultural confrontation, predisposes its voters to adopt nativist attitudes that hinder the achievement of SDGs 10 and 16 (Peace, Justice, and Strong Institutions) of the 2030 Agenda, which aim to promote social inclusion, reduce inequalities, and strengthen peaceful and cohesive societies.

Attitudes toward climate change align with the findings of Ortega Giménez et al. (2025), who explore fear-based policies regarding immigration and the rejection of environmental initiatives. The authors conclude that the political movement led by Santiago Abascal addresses climate issues infrequently and often uses them to establish a dichotomy between economic well-being and environmental protection. Such framing helps explain why its voters tend to perceive climate change as a secondary issue compared to the economy and as two spheres that are difficult to reconcile. Along these lines, Moreno and Thornton (2022) describe Vox's strategy as "obstructionist" toward climate action. According to these authors, the party, like other radical populist right-wing groups in Europe and the United States, does not openly deny the existence of climate change. However, it discredits policies aimed at combating it and downplays its impact. To do so, it relies on economic and sovereignty-based arguments that portray the ecological transition as a threat to employment, growth, and national sovereignty.

SDG 13, under the heading "Climate Action," focuses on combating climate change and its effects—a goal that, in the words of Vox MP Arias Moreno, is considered "climate religion" (López Frías, 2024). Along these lines, in its electoral platform for the July 23, 2023, elections, it asserts that "Sánchez has embraced the radical environmentalist agenda" and has flooded the field with "green taxes" (Vox, 2023, p. 107). This same platform prioritizes the interests of Spaniards over the effects of climate change, harshly criticizes the climate change law, and opposes a common policy against climate change. The spokesperson for the Vox parliamentary group in the Aragon Regional Parliament,

Santiago Morón, explained in May 2024 that the claim that we are facing a climate emergency is questionable, while asserting, in reference to the scientific consensus on climate change, that "science is not based on consensus, and being in the majority does not make one right" (Vox, 2024, para. 5).

This discourse, which downplays climate risk, also frames the ecological transition as an economic, territorial, and cultural threat against which a defense of national interests, the rural world, and productive sectors is articulated—a logic that has demonstrated a considerable capacity for political mobilization and can be interpreted in terms of identity-based sovereignty (López Ortega, 2025). Likewise, the environmental issue is also often framed from a perspective of confrontation with European institutions and rejection of international cooperation (Ortega Giménez et al., 2025), a position that undermines SDG 17 (Partnerships for the Goals) and could hinder the achievement of the principle of multilateral cooperation promoted by the 2030 Agenda.

The results obtained regarding the feminist movement can be explained by the fact that Vox's electorate is composed mainly of men (71.8% of voters who stated they supported the party led by Santiago Abascal in Barometer 3524 of September 2025 were male) who frequently display a masculine self-identification associated with sexist attitudes (Coffé et al., 2023). Furthermore, Vox employs hate speech critical of equality policies and the feminist movement, which reinforces the conservative collective imagination regarding women's roles in society (Díaz-Bajo Rodríguez et al., 2024). The high percentage of Vox voters who perceive significant inequality between men and women may be related to the party's discourse, which promotes a narrative of male victimization, framing feminism's advances as a loss of rights for men (Brandariz Portela & Del Pino, 2025). However, to confirm this hypothesis, more specific research would be needed to delve deeper into perceptions of gender inequality within the Vox electorate.

Vox shares with other radical right-wing populist parties an outright rejection of the 2030 Agenda, which it accuses of promoting the destruction of the

traditional family and ideological indoctrination (Velasco Páez, 2025). These ideological orientations pose a risk to achieving several Sustainable Development Goals, especially SDG 5, which aims to achieve gender equality and the empowerment of women. Vox's rhetoric denies the structural existence of inequality. It discredits public policies aimed at correcting it, promoting a traditional view of the family and gender roles instead, thereby legitimizing inequality between men and women. Likewise, SDG 10, which aims to reduce inequalities within countries, is compromised by the party's opposition to redistribution policies and affirmative action measures designed to address gender gaps.

The certain democratic disengagement exhibited by voters of the radical populist right in Spain supports the observations of Arroyo Ménéndez (2020), who identifies authoritarianism as the distinctive trait that sets Vox apart within the Spanish right-wing spectrum, which translates into greater tolerance for forms of authority and a political culture that prioritizes security, national homogeneity, and strong leadership. In this regard, voters on the radical right show a predisposition to accept less democratic and more

authoritarian regimes, provided these guarantee security and the defense of national identity (Aktas, 2024). Likewise, support for measures aimed at intensifying border control suggests an authoritarian disposition linked to the association between immigration and crime and to the idea that reducing immigration requires strengthening internal and external security through more punitive legislation (Fernández-Villas, 2022).

Vox voters display clear disaffection with the democratic system and a penchant for authoritarian approaches that hinder achieving SDG 16, which aims to promote strong institutions and peaceful, inclusive societies. This trend can be situated within the framework of the “fourth wave” of the far right, marked by the de-marginalization and progressive institutional normalization of nativist, authoritarian, and populist frameworks (Mudde, 2021). From this perspective, distrust of Parliament, the Government, and political parties, along with the legitimization of strong leadership and the rejection of pluralism, reveal a political culture opposed to institutional strengthening and democratic dialogue—essential pillars of the 2030 Agenda.

Table 4: Summary of the profile of Vox voters regarding the 2030 Agenda compared to the PP (2024 and 2025).
Source: Author's own analysis (2026) based on CIS studies 3466, 3480, 3489, 3490, 3497, 3522, and 3524.

Dimension	Trend observed in Vox compared to the PP	Main evidence (Vox vs. PP)	SDGs involved
Immigration	Greater focus on the issue and tolerance for more restrictive measures	Vox voters support tougher measures against illegal immigration, and 47% rank the issue as one of the country's top three problems	SDGs 10, 16
Climate change	Lower perception of climate risk and environmental priority	Only 38.2% of Vox voters consider climate change a real threat, compared to 80.2% of PP voters	SDGs 13, 17
Gender equality	Greater rejection of feminism and lower recognition of inequality	84.5% of Vox voters do not consider feminism necessary, compared to 49.3% of PP voters	SDGs 5, 10
Democracy	Greater institutional disaffection and tolerance of authoritarianism	Only 61.8% of Vox voters prefer democracy as a form of government, compared to 86.3% of PP voters	SDG 16

5. Conclusions

The results obtained in this study are consistent with the conclusions of recent literature on the European radical populist right, showing that the Spanish case reproduces the same patterns of nativism, populism, authoritarianism, and Euroscepticism described by other researchers. However, this research offers a novel perspective by empirically linking these ideological orientations to the alignment of the Vox electorate on the SDGs, allowing us to assess how its belief system may hinder the social and political consensus necessary for achieving the 2030 Agenda.

This article demonstrates that Vox's ideology constitutes a system of attitudes and perceptions that hinders the fulfillment of the SDGs in Spain. The empirical results from the CIS (2024–2025) in this study show that the positions of its electorate appear to be linked to the social translation of a discourse that articulates exclusionary nationalism, climate denial, anti-feminism, Euroscepticism, and authoritarianism.

Nativism, which constructs a narrative portraying immigration as a threat to national identity, social order, and access to public resources, is the central pillar of Vox's discourse. This framing, which relies on strong emotional appeal and is systematically repeated in the speeches of the party led by Santiago Abascal, associates immigration with negative perceptions and serves to mobilize voters dissatisfied with globalization, elites, the economic situation, and social change. This view, widely echoed by its supporters, questions cultural diversity as a democratic value and promotes an exclusionary logic that impedes the implementation of SDGs 10 and 16. It is, moreover, particularly problematic because it undermines the universality of human rights, a cross-cutting principle of the 2030 Agenda (United Nations, n.d.).

Vox's anti-feminist narrative and climate skepticism can be understood through the "cultural backlash" thesis, which holds that

part of the support for the far right stems from a reaction against cosmopolitan, post-materialist, and egalitarian values perceived as threatening (Norris & Inglehart, 2019). From this perspective, Vox voters' rejection of SDGs 5 and 13 is closely linked to cultural opposition to normative frameworks associated with gender equality, the ecological transition, and supranational governance. In the case of SDG 5, this reaction manifests as opposition to equality policies, denial of gender-based violence, and the defense of a traditional and hierarchical view of the family and gender roles (Arranz Sánchez, 2022). In the case of SDG 13, this translates into denialist, hostile discourse toward the ecological transition, which downplays the climate threat and discredits environmental policies by framing them as an economic cost or a surrender of sovereignty. In both cases, these are discursive frameworks that reinforce the Vox electorate's distancing from two of the 2030 Agenda's central normative pillars.

CIS data show that Vox's electorate exhibits less adherence to liberal democracy, greater tolerance for authoritarian arrangements, and distrust toward Parliament, the Government, and political parties. These attitudes embody a trend characteristic of 21st-century radical populist right-wing movements, in which segments of the electorate accept the erosion of liberal values in the name of national identity, efficiency, and security. All of this can undermine the principles enshrined in SDG 16 by weakening pluralism, deliberation, and democratic oversight.

Vox's ideology, which embodies a model of society that may hinder the achievement of the 2030 Agenda, along with the global spread of radical right-wing populist ideologies, poses challenges to the SDGs. It is important to promote public and institutional communication strategies capable of competing in the symbolic realm with the proposals of radical right-wing populists, grounded in scientific evidence and discourses that reduce political disaffection and polarization

to foster a more just, inclusive, and sustainable future.

This study is based on secondary data from the CIS; therefore, the analysis depends on the available questions and does not allow for the control of all relevant variables. Furthermore, its cross-sectional design prevents the analysis of temporal changes in attitudes or the establishment of firm causal relationships. The recoding of scales and the use of bivariate analyses introduce certain limitations by simplifying part of the complexity of the perceptions examined. Finally, as it focuses exclusively on the Spanish case, the results should be interpreted with caution, since their validity cannot be directly extrapolated to other European contexts due, among other reasons, to the heterogeneity of radical right-wing parties in Europe, with very different argumentation depending on cultural and social factors (Oliván Navarro, 2021).

Based on the results obtained and the study's limitations, it is recommended that future research delve deeper into the discursive strategies that hinder consensus on sustainability, human rights, and the 2030 Agenda, as well as into the communicative mechanisms that can strengthen institutional trust and citizen engagement with these frameworks. To overcome the limitations inherent in cross-sectional and secondary data, longitudinal studies, systematic discourse analyses, and ethnographic approaches to the electorate would be particularly useful. Likewise, it would be pertinent to develop comparisons across European countries to assess similarities and differences in how other radical-right populist electorates relate to the SDGs. All of this is particularly relevant in a scenario where polarization around the 2030 Agenda may challenge social cohesion and multilateral cooperation frameworks aimed at defending human rights.

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Measurement of technological maturity: empirical studies in a public treasury

Medición de madurez de tecnología: estudios empíricos en la tesorería pública

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Measurement of technological maturity: empirical studies in a public treasury

Medición de madurez de tecnología: estudios empíricos en la tesorería pública

Abstract:

Digital transformation in the public sector requires measuring internal capabilities through a multidimensional approach to guide institutional improvement strategies. A quantitative, cross-sectional, descriptive-analytical study was conducted with a sample of 125 officials from the Treasury Subsecretariat of the Medellín Mayor's Office; maturity was operationalized through ten dichotomous dimensions aggregated on a [0,1] scale, estimating a composite index and a structural equation model with a unidimensional confirmatory factor analysis using robust estimation (MLR, Yuan–Bentler). The index indicated an intermediate maturity level of 50.32 points with high dispersion and heterogeneity. The CFA showed significant loadings and high reliability ($\alpha=0.829$; $\omega=0.835$), with innovation and cybersecurity showing the strongest associations. Conclusions: The index is communicable and converges with latent maturity ($r=0.986$), but alternative models should be evaluated before asserting full unidimensionality of the model.

Keywords: technological maturity, digital transformation, confirmatory factor analysis, structural equation modeling, public sector.

Resumen:

La transformación digital en el sector público exige medir capacidades internas con enfoque multidimensional para orientar estrategias de mejoramiento institucional. Se contempló un estudio cuantitativo, transversal y descriptivo-analítico, con una muestra de 125 funcionarios en la Subsecretaría de Tesorería de la Alcaldía de Medellín; se operacionalizó la madurez con diez dimensiones dicotómicas agregadas a escala [0,1], estimando un índice compuesto y un modelo de ecuaciones estructurales con análisis factorial confirmatorio unidimensional con estimación robusta (MLR, Yuan–Bentler). El índice evidenció madurez intermedia de 50.32 puntos con alta dispersión y heterogeneidad. El AFC mostró cargas significativas y alta confiabilidad ($\alpha=0.829$; $\omega=0.835$), cuyas dimensiones con mayor asociación fueron innovación y ciberseguridad. El índice es comunicable y converge con la madurez latente ($r=0.986$), pero se recomienda evaluar modelos alternativos antes de afirmar unidimensionalidad plena en el modelo.

Palabras clave: madurez tecnológica, transformación digital, análisis factorial confirmatorio, modelo de ecuaciones estructurales, sector público.

1. Introduction

In the contemporary era, marked by the Fourth Industrial Revolution, society is immersed in a digital network where interconnection is the norm rather than the exception (Xiao et al., 2023). The rapid advancement of technologies such as artificial intelligence, the Internet of Things, blockchain, cloud computing, and 5G networks has reshaped not only the global economy but also the foundations of public governance (Xiao et al., 2023). In this context, digital transformation (DT) has ceased to be a strategic option and has become an imperative necessity for governments seeking to maintain their relevance, efficiency, and responsiveness to citizen demands (Eom & Lee, 2022; Xiao et al., 2023).

However, DT in the public sector, often referred to as Digital Government Transformation (DGT), is a substantially more complex phenomenon

than the mere adoption of technological tools (Eom & Lee, 2022; Tangi et al., 2021). While “digitization” involves converting analog information into digital form and “digitalization” focuses on integrating these technologies into existing processes, true digital transformation represents a second-order change: a profound reengineering of organizational structures, culture, and relationships to generate public value (Al Maazmi et al., 2025; Magnusson, Päiväranta, et al., 2021; Tangi et al., 2021). This process requires public administrations to operate with digital ambidexterity, balancing the exploitation of current capabilities to improve operational efficiency with the exploration of disruptive innovations that transform service models (Magnusson, Päiväranta, et al., 2021; Magnusson, Khisro, et al., 2021).

2. The Concept of Digital Transformation in Public Organizations

Academic and scientific literature defines DT as a process that seeks to improve an entity by triggering significant changes in its properties through combinations of information, computing, communication, and connectivity technologies (Eom & Lee, 2022; van Roekel et al., 2025). In the governmental sphere, this translates into modernizing national management systems to promote innovative effectiveness, though not without challenges, dilemmas, and ethical paradoxes (Eom & Lee, 2022).

The urgency of this transformation process was drastically accelerated by the COVID-19 pandemic, which acted as a global catalyst forcing governments to implement emergency digital solutions to ensure the continuity of essential services and public safety (Eom & Lee, 2022; Elmatsani et al., 2024). This period of crisis underscored that government responsiveness

is intrinsically dependent on its level of technological Maturity and its organizational agility to integrate internal and external resources (Xiao et al., 2023; Ly, 2024).

2.1. Studies on measuring the level of technological maturity

To effectively manage the digital transition, it is essential that organizations be able to determine their current state and define improvement trajectories. This is where maturity models take center stage. A maturity model is defined as a diagnostic tool that allows for the assessment of an organization’s level of readiness across various areas and its classification within an evolutionary scale, typically consisting of five or six levels (Rytova et al., 2020; Zoubek & Simon, 2021).

The measurement of technological maturity in the public sector has evolved from purely infrastructural approaches toward multidimensional models that consider the entire socio-technical system (Rytova et al., 2020; Hawrysz et al., 2025). Recent research by various authors highlights that maturity is not a static state, but a dynamic trajectory that passes through stages such as: (1) Initial or Ad hoc: undefined processes or those managed in isolation (Rytova et al., 2020; Zoubek & Simon, 2021); (2) Managed or Defined: introduction of standards and certified processes (Rytova et al., 2020; Zoubek & Simon, 2021); (3) Integrated: cross-departmental collaboration and use of shared platforms (Zoubek and Simon, 2021; Wahyuni et al., 2024); and (4) Optimized or Smart: proactive use of data, advanced automation, and a focus on sustainability (Rytova et al., 2020; Zoubek & Simon, 2021).

There are various global assessment tools, such as the United Nations e-Government Development Index (EGDI), which measures maturity based on online services, telecommunications infrastructure, and human capital (Ilieva et al., 2024; Rytova et al., 2020). Other approaches, such as the use of fuzzy logic, allow for the integration of quantitative statistical indicators with qualitative expert assessments to obtain a more accurate view of maturity in specific regional contexts (Rytova et al., 2020). However, despite the abundance of models, a gap persists between available digital infrastructure and the maturity of internal processes, often resulting in “information silos” and platforms that are poorly functional for citizens (Rytova et al., 2020).

In the Latin American context, empirical research on digital maturity in the public sector has gained greater visibility in recent years, although it remains limited compared to European and Asian research. Juárez-Merino (2025) conducts a multidimensional comparative analysis of digital governance in Mexico City, Buenos Aires, and Santiago, Chile, identifying uneven progress in citizen participation, interoperability, digitization of procedures, cybersecurity, digital education, and innovation in public administration. Likewise, Cancino-Cancino et al. (2023) used structural equation modeling to analyze the

factors influencing the digital maturity of 490 organizations in Argentina, Costa Rica, Ecuador, Mexico, and Uruguay, demonstrating that a commitment to digital maturity does not directly impact the level of organizational development but rather requires the mediating effect of digital skills training. In the realm of urban digital platforms, Aguerre and Bonina (2024) document the case of Montevideo, showing how open technological architecture and institutional agreements with non-state actors constitute key mechanisms for sustaining digital transformation in Latin American local governments. These studies argue that digital maturity trajectories in the region are shaped by specific institutional, cultural, and economic configurations, which justifies the need for empirical research situated within this context.

2.2. Common Dimensions in Measuring Digital Maturity

Identifying common factors or variables is essential for public leaders to prioritize their transformation efforts (Al Maazmi et al., 2025). The literature has consolidated these factors primarily through the TOE (Technology, Organization, Environment) framework, which offers a comprehensive lens for understanding innovation adoption (Ninčević Pašalić & Čukušić, 2024).

First, the TD establishes a technological context in which technological variables are not limited to hardware or software. Information and communication technology infrastructure serves as the foundation. However, factors such as interoperability, data quality, and data usage—that is, the ability to manage and share information seamlessly across organizations—are critical to achieving high levels of Maturity (Wahyuni et al., 2024). Likewise, cybersecurity, information security, and perceived privacy are critical variables; if citizens do not trust that their data is protected, the adoption of digital services stagnates (Nookhao & Kiattisin, 2023; Palos-Sánchez et al., 2023). In this same context, the protection of assets and creations related to technologies takes on importance; answering the question “what do we protect and how do we protect it” becomes relevant from the perspective

of intellectual property, a critical variable for establishing a solid and meaningful structure in light of digital transformation (Zhang et al., 2025; Li & Hu, 2024). A counterintuitive finding in some studies suggests that “perceived benefits” are not always the primary driver of adoption in local governments; rather, regulatory pressure or operational necessity act as more powerful drivers (Ninčević Pašalić & Ćukušić, 2024).

Additionally, DT must be established within the organizational context; this is perhaps the most critical—and often the most neglected—domain. Support from senior management is the variable most strongly correlated with DT success (Ninčević Pašalić & Ćukušić, 2024). Leadership in the digital age must be transformational, capable of communicating a clear vision and fostering a culture of innovation that reduces resistance to change (Elmatsani et al., 2024). On the other hand, organizational strategy and its communication to users and employees have become increasingly important as a main factor in the structure of digital transformation (Kringelum et al., 2025; Ortner et al., 2025; Paul et al., 2024).

Another fundamental variable is the workforce’s expertise. Digital Maturity requires not only IT experts but also widespread digital literacy across the entire administrative staff (Ninčević Pašalić & Ćukušić, 2024; Rytova et al., 2020). This involves, among other things, understanding and developing the agile capabilities required for transformative processes in public organizations (Ciancarini et al., 2024). The presence of mid-level leaders who act as mediators between strategy and operations is vital for institutionalizing change (Kusmaryanto & Santoso, 2025; Ratan et al., 2025). Furthermore, factors such as organizational commitment and job satisfaction are positively influenced by digital Maturity, creating a virtuous cycle of productivity and loyalty (Ly, 2024; Hawrysz et al., 2025).

Finally, public organizations operate under constant pressure from citizens and other stakeholders, such as the business sector and international organizations (Ninčević Pašalić & Ćukušić, 2024); therefore, DT must be studied in the context of the environment. The

public’s readiness or preparedness in terms of digital skills and internet access determines the success of digital transformation; a sophisticated platform is useless if the population cannot or does not know how to use it (Ninčević Pašalić & Ćukušić, 2024). Finally, trust in the government emerges as the most important mediating factor in citizens’ behavioral intent to use electronic services (Nookhao & Kiattisin, 2023).

Beyond identifying dimensions, the specialized literature emphasizes that maturity models are not limited to a diagnostic function but also play a prescriptive role by mapping typical trajectories of digital transformation. In this vein, Berghaus and Back (2016) demonstrate empirically, based on a sample of 547 individuals from 417 organizations, that digital maturity models allow for the derivation of evolutionary stages that guide organizational leaders on how to approach their transformation, providing a structured roadmap of the paths organizations typically follow as they advance toward higher stages of Maturity. This perspective is particularly relevant for the public sector, where institutional complexity and heterogeneity of capabilities require tools that combine diagnosis with practical guidance for strategists and senior management.

Despite the wealth of knowledge and research on technology adoption, there is a lack of quantitative empirical studies that examine digital Maturity from the perspective of internal capacity within local and regional public organizations, rather than focusing solely on citizens’ needs (Toleikienė et al., 2025). Most research has been conducted in developed economies, leaving a significant gap in understanding how these factors operate in contexts with resource constraints or different institutional frameworks (Feleke & Lessa, 2024). Furthermore, the digital government literature has tended to prioritize citizen-centered approaches, thereby shifting the focus from the internal capabilities of public organizations to the user (Sundberg & Holmström, 2024).

This research article seeks to help fill this gap by analyzing the relationship between organizations’ dynamic capabilities and their government performance, mediated by agility in collaboration. By integrating a maturity model

with an adaptive governance framework, this study provides not only a diagnostic tool but also a roadmap for strategic decision-makers. The main objective is to identify the level of technological Maturity and the configuration of key factors that can be optimized to transform public servants' commitment into superior institutional performance in the era of the digital "new normal."

In line with the above, this research study is guided by the following question: What is the level of technological Maturity of the Treasury Undersecretariat of the Medellín Mayor's Office, and which dimensions best explain its

configuration as a unidimensional construct? Based on this question and the reviewed theoretical framework, the following working hypothesis (H1) is formulated: the ten proposed dimensions (strategy, agility, digital competencies, innovation, leadership, cybersecurity, collaboration, digital relationships, data, and intellectual property) significantly converge into a single latent factor of technological Maturity, which can be validated through confirmatory factor analysis. This hypothesis is evaluated using conventional criteria for goodness-of-fit, factor loadings, composite reliability, and convergent validity, the development of which is described in the following section.

3. Methodology

A quantitative, cross-sectional study with a descriptive-analytical scope was conducted to operationalize and estimate a maturity level based on 10 dimensions associated with the Treasury Undersecretariat of the Medellín Mayor's Office's organizational and digital capabilities. The analytical strategy was based on a structural equation modeling (SEM) approach, specifically using confirmatory factor analysis (CFA), complemented by the construction of a composite maturity index for comparative and applied purposes.

The unit of analysis comprised 125 officials from the Treasury Undersecretariat who were surveyed. The sample was used to estimate a factorial model of a single latent construct (Maturity) measured by ten observed variables. The maturity level was conceptualized based on the following dimensions: strategy, agility, digital competencies, innovation, leadership, cybersecurity, collaboration, digital relationships, data, and intellectual property. Each dimension was measured using a set of dichotomous (Yes/No) questions. For each participant and dimension, an aggregate score was calculated as a proportion of compliance, as indicated in Equation 1:

$$X_{ij} = \#Si_{ij} / \#Items_j \quad Eq.(1)$$

where X_{ij} is the value of person i in dimension j , $\#Yes_{ij}$ represents the number of affirmative responses, and $\#Items_j$ represents the total number of questions in the dimension. This procedure generated 10 observed variables on a continuous scale bounded by $[0,1]$ that served as indicators of the overall maturity construct.

For the strategy to measure the level of Maturity, two complementary approaches were estimated:

Composite index: an overall maturity score was calculated as the simple average of the ten dimensions, maintaining the $[0,1]$ scale, as shown in Equation 2, and additionally rescaled to $[0,100]$ to facilitate its interpretation in public administration organizational contexts, as shown in Equation 3:

$$M_i = (1/10) \sum_{j=1}^{10} X_{ij} \quad Eq. (2)$$

$$M_i^{100} = 100 M_i \quad Eq. (3)$$

Latent maturity: a latent factor η (Maturity) was modeled, measured by the ten dimensions aggregated via a unidimensional AFC, as shown in Equation 4:

$$X_j = \lambda_j \eta + \epsilon_j \quad ec.(4)$$

where X_j represents each observed dimension, λ_j its factor loading, and ϵ_j the specific error term.

To estimate the SEM/FAC model and its evaluation criteria, the R software was used; the code is available in the appendix of this study. Since the indicators are bounded in $[0,1]$ and may exhibit departures from normality, maximum likelihood estimation was employed with robust standard errors (the sandwich method) and the Yuan–Bentler scaling correction. The evaluation of model fit considered: (i) the chi-square test, (ii) the Comparative Fit Index (CFI) and Tucker–Lewis Index (TLI), (iii) the root mean square error of approximation (RMSEA with a 90% confidence interval), and (iv) standardized residuals (SRMR). In addition, the standardized

factor loadings, their statistical significance, and the variance explained by each indicator (R^2) were examined as evidence of the measurement model's consistency.

Finally, the reliability and convergent validity of the Maturity construct were assessed using Cronbach's alpha and omega coefficients (ω , ω_2 , ω_3) derived from the model to obtain less restrictive estimators than α in the face of possible differences in factor loadings. Convergent validity was examined using the average variance extracted (AVE), interpreting the average percentage of variance in the indicators explained by the latent factor.

4. Results

The main results obtained were: (i) the individual-level maturity score via the composite index and (ii) the latent maturity score derived from the factor scores of the AFC model. Additionally, the model's overall fit indices, standardized factor loadings, and R^2 per indicator are presented, along with the reliability coefficients (α and ω) and AVE.

4.1. Composite maturity index

As an initial operational estimate of the level of Maturity, an overall index was constructed by averaging the ten dimensions on a 0–1 scale and subsequently rescaling it to 0–100 to facilitate interpretation. The descriptive summary of this index shows a wide range among participants (minimum = 13.40; maximum = 96.00), with a central value close to 50 (median = 49.70) and a similar average (mean = 50.32), suggesting an overall intermediate level of Maturity in the sample. Additionally, the quartiles ($Q_1 = 35.40$; $Q_3 = 63.60$) indicate that the central 50% of the observations are concentrated within a range of approximately 28 points, reflecting significant heterogeneity in the assessed capabilities and providing empirical support for subsequent latent structure analyses and comparisons across dimensions.

4.2. Latent Maturity of the Model

The model converged after 67 iterations and 30 estimated parameters, using maximum likelihood with robust sandwich errors (Yuan–Bentler correction). This approach is appropriate given that the variables, being bounded (0–1), may exhibit deviations from normality and heteroscedasticity. The evaluation criteria for the iterated model are shown in Table 1.

Table 1. SEM/AFC model results.
Source: Authors (2026)

Metric	Value (standard)	Robust/scaled value
χ^2 (df)	90.360 (35)	88.841 (35)
p-value (χ^2)	< 0.001	< 0.001
CFI	0.857	0.858
TLI	0.817	0.817
RMSEA	0.112	0.113
90% CI for RMSEA	[0.084, 0.141]	[0.084, 0.141]
$p(\text{RMSEA} \leq 0.05)$	0.000	0.000
$p(\text{RMSEA} \geq 0.08)$	0.969	0.970
SRMR	0.071	0.071
AIC / BIC	217,445 / 302,295	---

In terms of overall fit, the unidimensional model shows a mixed pattern, as assessed using Yuan–Bentler robust estimation with a sample of 125 civil servants. The chi-square test was significant ($\chi^2(35) = 90.36$; $p < 0.001$; robust $\chi^2 = 88.84$), suggesting discrepancies between the observed and implied covariance matrices; however, given its sensitivity to model complexity and sample size, the assessment was supplemented with approximate fit indices. The incremental indices fell within a moderate range (robust CFI = 0.858; robust TLI = 0.817), indicating that the single-factor specification captures a significant proportion of the covariance among the indicators, although there is room for improvement. The cutoff points for the CFI and TLI fit indices should be interpreted as guidelines rather than universal rules, as their performance varies depending on the model's complexity, the data distribution, and the sample size; therefore, a combined assessment of multiple indices within the model is prioritized (Bentler, 1990; Hu & Bentler, 1999; Bentler & Bonett, 1980; Marsh et al., 2004; Feinman et al., 2008). The robust RMSEA was 0.113 (90% CI: 0.084–0.141), reflecting a less precise fit under the assumption of strict unidimensionality; in contrast, the SRMR = 0.071 remained within a generally acceptable range, suggesting contained average residual discrepancies. Taken together, these results support the operational utility of the unidimensional model as a global, interpretable measure of the construct, while suggesting that alternative specifications may improve fit.

At the parameter level, Table 2 shows that all factor loadings were positive and statistically significant.

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In terms of standardized loadings, the dimensions most strongly associated with Maturity were innovation ($\lambda = 0.788$), cybersecurity ($\lambda = 0.726$), digital relationships ($\lambda = 0.659$), and agility ($\lambda = 0.638$), suggesting that these areas best “represent” the common variance of the construct in this sample. At a second level, digital competencies ($\lambda = 0.585$), intellectual property ($\lambda = 0.551$), collaboration ($\lambda = 0.563$),

Table 2. Loadings and significance of model parameters.
Source: Authors (2026).

Indicator	Standardized loading	z	p	R ²
Strategy	0.360	3.275	0.001	0.129
Agility	0.638	8.843	<0.001	0.407
Digital skills	0.585	6.395	<0.001	0.342
Innovation	0.788	11.741	<0.001	0.620
Leadership	0.539	6.346	<0.001	0.290
Cybersecurity	0.726	8.460	<0.001	0.527
Collaboration	0.563	7.171	<0.001	0.316
Digital relationships	0.659	8.626	<0.001	0.434
Data	0.518	6.428	<0.001	0.268
Intellectual property	0.551	6.162	<0.001	0.304

and leadership ($\lambda = 0.539$) make moderate contributions. Meanwhile, data ($\lambda = 0.518$) also shows a moderate relationship. At the same time, strategy exhibits the lowest loading ($\lambda = 0.360$), indicating that, as operationalized, it shares less variance with “overall maturity” than the other dimensions; this may reflect conceptual heterogeneity (strategy as a more normative/planning-oriented dimension) or differences in how it manifests in the 0–1 aggregate measure.

The coefficients of determination (R^2) corroborate this pattern by quantifying the variance of each dimension and the extent to which the Maturity construct explains it. The largest proportion of variance explained corresponds to innovation ($R^2 = 0.620$), followed by cybersecurity ($R^2 = 0.527$), digital relationships ($R^2 = 0.434$), and agility ($R^2 = 0.407$), reinforcing their role as central indicators of the factor. In contrast, strategy has a low R^2 (0.129), and data (0.268) and leadership (0.290) remain in the low-to-medium range, suggesting that a significant portion of their variability stems from specific components not captured by the general factor—for example, particular practices among staff, differences by area or role, or other subcomponents of Maturity. Consequently, although the model supports the existence of a common component interpretable as Maturity, the fit statistics and heterogeneous R^2 values suggest caution in asserting strong unidimensionality.

4.3. Model Reliability

The reliability indices for the Maturity construct are estimated, indicating high internal consistency and supporting the stability of the overall score derived from the unifactorial model. This is shown in Table 3.

Table 3. Model reliability indices.
Source: Authors (2026)

Metric	Value
Alpha	0.8290901
Omega	0.8345178
Omega2	0.8345178
Omega3	0.8439948
AVE	0.3406263

In particular, Cronbach's alpha ($\alpha = 0.829$) indicates that the ten dimensions exhibit sufficient covariation to be interpreted as indicators of a single underlying domain, exceeding the commonly accepted threshold of 0.70 for applied research (Taber, 2018; Tavakol & Dennick, 2011). However, since α depends on the number of indicators and essentially assumes tau-equivalence (similar loadings), it is necessary to supplement this evidence with factor-model-based coefficients.

In this regard, the omega coefficients show very high and close values ($\omega = 0.835$; $\omega_2 = 0.835$; $\omega_3 = 0.844$), indicating that a substantial proportion of the variance in the composite score attributable to the dimensions is explained by the common factor. Unlike α , ω is less restrictive regarding the equality of loadings and is therefore particularly informative in contexts such as the present one, where the observed standardized loadings for the indicators were heterogeneous. The convergence between α and ω (small differences) suggests that, despite this heterogeneity, the set of dimensions behaves consistently as an aggregate measure of Maturity, providing evidence of robust construct reliability in the analyzed sample.

In contrast, the average variance extracted ($AVE = 0.341$) is relatively low, indicating that, on average, the Maturity factor explains about 34% of the variance in its indicators, with the remaining variance attributable to specific

variance and error. This result is consistent with a scenario of moderate convergent validity: although the dimensions share a common component sufficient to produce a reliable score, the overall construct does not fully capture the specificity of each domain (e.g., strategy, data, or leadership), which may reflect that "maturity" is a phenomenon with subcomponents or that the dimensions contain distinctive elements not reducible to a single factor.

Finally, when comparing the composite maturity index (average of the ten dimensions on a 0–1 scale) with the latent score estimated using the confirmatory factor model, Figure 1 shows an extremely high correlation ($r = 0.986$) and a high coefficient of determination ($R^2 = 0.973$). This result indicates substantial convergence between both measurement approaches. Although the SEM approach explicitly incorporates measurement error and weights indicators by their loadings, the simple index almost completely reproduces the ranking of individuals obtained from latent estimation. From a practical perspective, this supports the use of the 0–100 index as an operational and communicable metric for organizational monitoring. In contrast, from a research perspective, it confirms that the latent construct captured by the unifactorial model is consistent with the aggregation of the ten dimensions into an overall score.

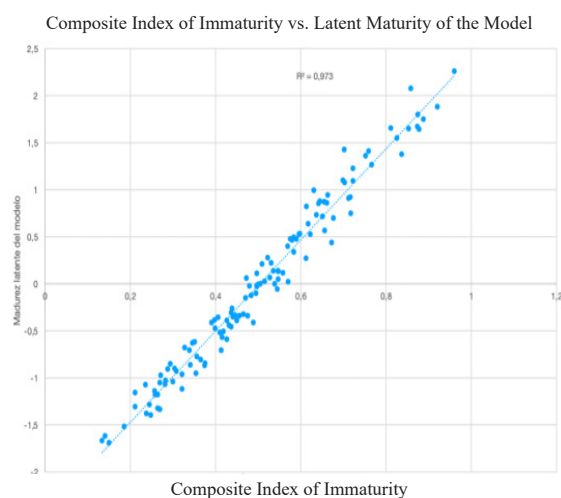


Figure 1. Relationship between indices.
Source: Authors (2026).

5. Discussion

The results of this research allow for an interpretation of the state of technological Maturity of the Treasury Undersecretariat of the Medellín Mayor's Office in relation to the available scientific evidence and the stated objectives. The identified intermediate maturity level (50.32 points on a 0–100 scale) is consistent with findings from similar studies in public organizations in developing economies, where heterogeneity among staff and departments is a recurring finding (Rytova et al., 2020; Feleke & Lessa, 2024). This result confirms the hypothesis that the internal digital capabilities of local public entities are in a transitional phase, which is consistent with the notion that government digital transformation is not limited to the adoption of tools but involves a profound reengineering of organizational structures and culture (Eom & Lee, 2022; Al Maazmi et al., 2025).

The factor loadings pattern reveals that innovation ($\lambda = 0.788$) and cybersecurity ($\lambda = 0.726$) are the dimensions that best represent the common variance of the maturity construct. This finding aligns with the reviewed literature, which positions cybersecurity and innovation capacity as central pillars of digital transformation in the public sector (Nookhao & Kiattisin, 2023; Palos-Sánchez et al., 2023). In contrast, the strategy dimension has the lowest factor loading ($\lambda = 0.360$), which differs from the findings of Ninčević Pašalić and Ćukušić (2024), who identified senior management support and strategic planning as the factors most strongly correlated with the success of digital transformation. This discrepancy may be explained by the operationalization adopted in the present study, where the strategy dimension captures more normative and planning-related aspects that may manifest differently in an aggregated dichotomous measurement, or by the particularities of the regional and Colombian context, where digital strategic planning may be more formalized in documents than internalized in the daily practices of public officials.

To investigate this discrepancy, it is important to consider three possible causes to help

understand and interpret the difference between this study's findings and those presented in the international literature. First, a methodological cause: dichotomous operationalization (Yes/No) tends to compress the variability of more abstract constructs such as strategy, whereas studies such as those by Berghaus and Back (2016) or Ninčević Pašalić and Ćukušić (2024) employ Likert scales that allow for the capture of gradual levels of strategic Maturity. Second, an institutional cause: in Latin American contexts, and particularly in Colombian local governments, the digital transformation strategy is typically formulated in national regulatory instruments (e.g., CONPES, Digital Government Policy) that are transmitted to the municipal level without necessarily translating into internal strategic ownership by operational units, which is reflected in a low factor loading when measured from the perspective of frontline staff. Third, a sectoral cause: the Undersecretariat of the Treasury, due to the transactional nature of its processes, prioritizes daily technological operations (incremental innovation, cybersecurity, data management) over long-term strategic formulation, which is consistent with the findings of Cancino-Cancino et al. (2023), who document that in Latin American organizations, strategic commitment to digital Maturity must be mediated by previously developed operational capabilities. These three causes, far from invalidating the findings, contextualize their value and suggest specific paths for future comparative research.

The model's reliability ($\alpha = 0.829$; $\omega = 0.835$) is comparable to that obtained in validated instruments in the field of digital government (Taber, 2018; Tavakol & Dennick, 2011). However, the average variance extracted (AVE = 0.341) is relatively low and falls below the conventional threshold of 0.50, indicating moderate convergent validity. This result is a finding that deserves attention: although the dimensions share a common component sufficient to produce a reliable score, each domain retains a substantial proportion of specific variance. This suggests that technological Maturity, as

measured in this study, is a phenomenon with distinct subcomponents, a finding consistent with the multidimensional models proposed by Zoubek and Simon (2021) and Wahyuni et al. (2024), who argue that digital Maturity spans stages and domains that do not necessarily evolve uniformly.

One anomalous result that should be transparently noted is the overall fit of the unidimensional model. The incremental indices ($CFI = 0.858$; $TLI = 0.817$) fall below the conventional thresholds of 0.90, and the RMSEA (0.113) exceeds the commonly recommended limit of 0.08. Although these cutoff points should be interpreted as guidelines rather than universal rules (Marsh et al., 2004; Feinian et al., 2008), the data indicate that the single-factor specification, while operationally useful, does not capture the full covariance structure among the ten dimensions. This misfit is acceptable in a first-order model with 10 heterogeneous indicators. However, it invites exploration of alternative specifications, such as bifactor or second-order models, that may better represent the construct's architecture. Bentler (1990) and Hu and Bentler (1999) caution against mechanically interpreting fit indices, recommending a comprehensive interpretation that, in this case, supports the model's utility as a diagnostic tool even when its factor structure warrants refinement.

Regarding the convergence between the composite index and the latent score ($r = 0.986$), this result constitutes a relevant practical contribution. The near-perfect correlation indicates that the simple average of the ten dimensions reproduces with high fidelity the ranking of individuals derived from the factor model, which supports its use as an operational metric for institutional monitoring. This finding is particularly significant for public organizations that, as noted by Toleikienė et al. (2025) and Sundberg and Holmström (2024), require accessible and communicable diagnostic tools to guide their digital transformation strategies without relying on advanced analytical infrastructure.

This proposed convergence is particularly relevant when considering the profile of Latin American local governments. Most municipal

administrations do not have teams specialized in tools such as advanced statistical modeling nor robust budgets to commission periodic SEM analyses; in this scenario, the composite index on a 0–100 scale proposed in this study becomes an accessible instrument that can be administered by the planning or information technology departments themselves without requiring specialized software, replicated annually as a monitoring and feedback mechanism, and disaggregated by department to identify internal gaps and prioritize technological investments. In terms of its utility for public management, the index fulfills three complementary functions: diagnostic, by offering a comprehensible snapshot of the current state of Maturity; comparative, by enabling benchmarking between departments or among similar municipal entities; and guiding, by identifying the dimensions with the lowest scores as priority areas for intervention. This threefold function makes the index a suitable tool for integration into results-based management systems and municipal development plans, helping to bridge the gap between academic rigor and public management practice that Feleke and Lessa (2024) identified as a main shortcoming of the digital government literature in developing economies.

The novelty of this research lies in three aspects. First, it proposes an empirical measurement of technological Maturity from the internal perspective of a Latin American local public organization, a context that is underrepresented in the literature (Feleke & Lessa, 2024). Second, it integrates the dimension of intellectual property as a component of the maturity construct, an aspect that, according to Zhang et al. (2025) and Li and Hu (2024), is critical for protecting digital assets and consolidating a robust digital transformation framework within organizations. Third, the dual measurement strategy, based on the composite index and latent construct, bridges the gap between practical utility for organizational management and the methodological rigor of confirmatory factor analysis, addressing the need identified by Xiao et al. (2023) to link organizations' dynamic capabilities with their governmental performance.

Based on the results obtained, and following the approach of Berghaus and Back (2016), according to which Maturity models not only diagnose but also chart typical paths of transformation, this study allows for the delineation of a guiding roadmap for strategists at the Undersecretariat of the Treasury and, by extension, for local public administrations with similar maturity profiles. This roadmap is structured according to the hierarchy of priorities derived from the factor loadings and scores in each dimension. At the priority level is the strategy dimension, which had the lowest factor loading and constitutes the main bottleneck for the consolidation of the construct; strengthening it requires coordination with leadership, given that strategic formulation without managerial sponsorship tends to remain confined to the documentary level (Elmatsani et al., 2024; Kringelum et al., 2025). At a second level is the data dimension as a foundational element of digital transformation, since without consolidated data governance, the other capabilities lose their effectiveness (Wahyuni et al., 2024). At a third level, the dimensions with

the highest weights (innovation, cybersecurity, digital relationships, and agility) function as enabling capabilities that can sustain and amplify progress in the two preceding priorities. This sequential architecture—from Strategy to Leadership to Data and finally to enabling capabilities—allows the quantitative diagnosis to be translated into an actionable plan, the specific operationalization of which is developed in the Conclusions.

Finally, future research should consider expanding the sample, including Likert-type scales to capture greater gradation, and evaluating alternative bifactorial or second-order models that allow for testing the hypothesis of unidimensionality against more complex structures. Likewise, it would be appropriate to replicate the study in other public entities and regional contexts to assess the generalizability of the findings and move toward explanatory models that link technological Maturity to concrete organizational outcomes.

6. Conclusions

This research applied a dual strategy for measuring technological Maturity: a composite index and a latent construct estimated via AFC, with a simultaneous operational interpretation of the composite maturity index and an analytical interpretation of the model's latent construct. This dual strategy facilitated the transfer of results to practical applied contexts within the public organization without sacrificing methodological or academic rigor.

When considering the applied perspective on the results of the maturity level, two compatible findings emerge: the first indicates the construction of an overall maturity score, which is statistically defensible because all dimensions load significantly on a common factor; this assumption is particularly useful for diagnostic and comparative purposes within the organization; and the second finding, from a strictly academic perspective, justifies exploring

theoretically plausible alternative models before asserting that Maturity is fully unidimensional. The results show that it is possible to estimate an overall technological maturity score in a public organization; thus, in applied terms, the index provides an interpretable summary of the sample's status and reveals intermediate Maturity with wide variation among the evaluated officials, suggesting internal gaps that are useful for prioritization and change management.

The unidimensional AFC shows a common factor (all loadings are positive and significant) and high reliability (Cronbach's alpha and omega coefficients); however, it shows overall misfit and moderate convergent validity. Consequently, technological Maturity appears to be shared, though not fully explained by a single latent dimension, suggesting that the construct may be multicomponent.

In interpretive terms, the pattern of loadings and R^2 suggests that, in this sample, Maturity is most strongly expressed in practices of innovation, cybersecurity, digital relationships, and agility. At the same time, strategy operates as a dimension that is less well integrated into the overall factor, possibly requiring conceptual refinement or treatment as a complementary component of the professional index.

Four practical recommendations emerge from the study's findings, aimed at public managers responsible for digital transformation in municipal administrations with intermediate maturity profiles. First, it is recommended to institutionalize the periodic measurement of the technological maturity index as a permanent monitoring tool, integrating it into institutional planning systems and management dashboards on an annual or semi-annual basis. Second, it is recommended to disaggregate the index by departments, occupational profiles, and functional areas to identify internal gaps and design differentiated interventions, avoiding uniform approaches that dilute the impact of technology investments. Third, it is recommended to align the index results with information technology investment budgets, prioritizing resources toward the dimensions with the lowest scores and making the relationship between technology spending and progress in Maturity explicit. Fourth, it is recommended to communicate the index results in an accessible manner to officials at all levels, transforming the assessment into a change management tool that fosters collective ownership of digital transformation priorities, in line with the arguments put forth by Elmatsani et al. (2024) regarding the importance of transformational leadership in reducing resistance to change.

Likewise, building on the conceptual roadmap outlined in the Discussion, an operational action plan is proposed that translates the sequence of Strategy, Leadership, Data, and Enabling Capabilities into specific actions that can be implemented in the short and medium term.

For the Strategy dimension, the following actions are proposed: formulating a strategic digital transformation plan with measurable goals, a three- to five-year horizon, and indicators for monitoring; aligning this plan with existing municipal planning instruments; and disseminating it across all hierarchical levels to ensure internal ownership. For the Leadership dimension, the following actions are proposed: appointing a formal head of digital transformation with authority and an allocated budget (e.g., a Chief Digital Officer); forming a digital steering committee with representation from all key departments; and incorporating digital competencies into executive-level job profiles. For the Data dimension, proposed actions include: implementing a data governance policy with an institutional catalog, quality standards, and domain-specific leads; advancing interoperability architectures that enable information sharing among departments in accordance with the framework proposed by Wahyuni et al. (2024); and developing internal analytical capabilities for the strategic use of data. Finally, to sustain progress in capabilities such as innovation, cybersecurity, digital relations, and agility, it is recommended to sustain progress through ongoing training programs, controlled experimentation spaces, and periodic evaluation mechanisms that feed into the improvement cycle. This action plan, coordinated with periodic measurement of the index, offers an operational management tool that goes beyond diagnosis and is oriented toward the effective transformation of the public organization.

As future work, it is recommended to refine dimensions with lower integration and review their operationalization; furthermore, to expand the sample and evaluate by profiles for valid comparisons; and to evolve from a diagnosis to explanatory models that link Maturity with organizational outcomes, while maintaining the observed practical advantage: the near-total convergence between the index and the latent indicator ($r=0.986$) allows for institutional monitoring without sacrificing advanced analysis.

7. Ethical Considerations

Participation by public officials was voluntary and anonymous, and the data were analyzed in aggregate form for research purposes.

8. Conflict of Interest

The authors have no conflict of interest.

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10. Anexo

```
install.packages(c("readxl","dplyr","lavaan","semTools"))
library(readxl)
library(dplyr)
library(lavaan)
library(semTools)
df <- read_excel("datos.xlsx")
vars <- c("estrategia","agilismo","competencias_digitales","innovacion","liderazgo",
  "ciberseguridad","colaboracion","relaciones_digitales","datos","propiedad_intelectual")
df <- df %>% mutate(across(all_of(vars), ~ as.numeric()))
df$madurez_indice_0_1 <- rowMeans(df[, vars], na.rm = TRUE)
df$madurez_indice_0_100 <- 100 * df$madurez_indice_0_1
summary(df$madurez_indice_0_100)
model_1f <- '
  Madurez =~ estrategia + agilismo + competencias_digitales + innovacion + liderazgo +
  ciberseguridad + colaboracion + relaciones_digitales + datos + propiedad_intelectual
'
fit_1f <- cfa(model_1f, data = df, estimator = "MLR", std.lv = TRUE, missing = "fml")
summary(fit_1f, fit.measures = TRUE, standardized = TRUE, rsquare = TRUE)
semTools::reliability(fit_1f)
fs <- lavPredict(fit_1f, method = "regression")
df$madurez_latente <- as.numeric(fs)
cor(df$madurez_indice_0_1, df$madurez_latente, use = "pairwise.complete.obs")
```


Desafíos en la enseñanza del inglés como lengua extranjera en Ecuador: una revisión sistemática PRISMA

Challenges in Teaching English as a Foreign Language in Ecuador: A PRISMA Systematic Review

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Desafíos en la enseñanza del inglés como lengua extranjera en Ecuador: una revisión sistemática PRISMA

Challenges in Teaching English as a Foreign Language in Ecuador: A PRISMA Systematic Review

Resumen:

Este estudio tuvo como objetivo identificar los principales desafíos que afectan la enseñanza del inglés como lengua extranjera (EFL) en Ecuador. Se realizó una revisión sistemática de la literatura siguiendo la metodología PRISMA, analizando 20 estudios revisados por pares publicados entre 2020 y 2025 en bases de datos como Scopus, ERIC, Latindex 2.0 y SciELO. Los hallazgos revelaron dificultades persistentes, incluyendo formación docente insuficiente, escasez de recursos, limitada integración tecnológica y baja motivación estudiantil. Otros problemas identificados fueron la escasa exposición al uso auténtico del inglés, contradicciones en las políticas lingüísticas nacionales y desigualdades entre contextos rurales y urbanos. La revisión también evidenció la falta de diseños longitudinales y experimentales, lo que limita la aplicabilidad de los resultados disponibles. Se concluyó que superar estos desafíos requiere fortalecer las políticas de desarrollo docente, mejorar la infraestructura, aplicar políticas sensibles al contexto y promover investigaciones más rigurosas para mejorar la calidad y sostenibilidad de la enseñanza del inglés en Ecuador.

Palabras clave: Enseñanza del inglés como lengua extranjera, desafíos educativos, política lingüística, metodología PRISMA, limitaciones de recursos.

Abstract:

This study aimed to identify the main challenges affecting the teaching of English as a foreign language (EFL) in Ecuador. A systematic literature review was conducted following the PRISMA methodology, analyzing 20 peer-reviewed studies published between 2020 and 2025 in databases such as Scopus, ERIC, Latindex 2.0, and SciELO. The findings revealed persistent difficulties, including inadequate teacher training, limited resources, insufficient technological integration, and low student motivation. Additional issues included minimal exposure to authentic English use, contradictions in national language policies, and disparities between rural and urban contexts. The review also found a lack of longitudinal and experimental research designs, which limits the applicability of existing findings. It was concluded that addressing these challenges requires stronger policies for teacher development programs, improved infrastructure, context-sensitive policy reforms, and more rigorous research to enhance the quality and sustainability of EFL education in Ecuador.

Keywords: EFL teaching, educational challenges, language policy, PRISMA methodology, resource limitations.

1. Introducción

La enseñanza del inglés como lengua extranjera (TEFL) se ha convertido en una prioridad educativa significativa en muchos países donde el inglés no es la lengua materna. Hernández y Rojas (2018) afirmaron que, al igual que en otros países de América Latina, en Ecuador se reconoce que el inglés desempeña un papel estratégico en la educación, la movilidad internacional y el mercado laboral. Por ello, el Ministerio de Educación de Ecuador (MINEDUC, 2016) introdujo el inglés como asignatura obligatoria en los niveles de primaria, secundaria y terciario, tanto en instituciones públicas como privadas. Además, el Currículo de Inglés como Lengua Extranjera (EFL) de Ecuador se integró como guía para que los docentes desarrollen las habilidades comunicativas, la conciencia cultural y las capacidades de aprendizaje permanente de los estudiantes, haciendo hincapié en la aplicación de un enfoque centrado en el alumno, la Enseñanza Comunicativa de las Lenguas y el Aprendizaje Integrado de Contenidos y Lengua (Barre y Villafuerte, 2021; Ministerio de Educación de Ecuador, 2016). Con estas iniciativas, se espera que los alumnos alcancen el nivel B1 al finalizar la educación secundaria, de acuerdo con el Marco Común Europeo de Referencia para las Lenguas (Consejo de Europa, 2018; Villafuerte y Mosquera, 2020).

A pesar de estas reestructuraciones políticas, la implementación efectiva del plan de estudios nacional ecuatoriano se ha topado con diversos obstáculos que dificultan la enseñanza eficaz del inglés como lengua extranjera (EFL), principalmente en términos de calidad, acceso y resultados de aprendizaje. Según Education First (2024), una organización que evalúa el dominio del inglés en todo el mundo, los estudiantes ecuatorianos ocuparon el puesto 82. Esto indica que el aprendizaje del inglés como lengua extranjera en Ecuador sigue siendo limitado. Además, Álvarez et al. (2025b) afirmaron que una de las razones principales es la falta de contextualización del currículo y su aplicación inconsistente en todo Ecuador.

Varios estudios han señalado diferentes factores que dificultan la aplicación adecuada de los principios fundamentales establecidos en el plan de estudios. Por ejemplo, Álvarez et al. (2025b) afirmaron que el apoyo institucional insuficiente y la formación limitada del profesorado dejan a los docentes sin la preparación necesaria para atender las diversas necesidades del aula, integrar nuevas tecnologías y aplicar estrategias pedagógicas modernas. Además, factores relacionados con la pedagogía, como la aplicación de metodologías obsoletas, la falta de prácticas docentes innovadoras y la incapacidad de integrar estrategias eficaces para desarrollar las competencias comunicativas de los estudiantes, son factores relevantes que impiden la conexión efectiva entre los principios curriculares establecidos y las prácticas docentes reales (Preciado et al., 2024; Sevy-Biloon et al., 2020).

Otro desafío relevante radica en la accesibilidad y disponibilidad de los recursos educativos. Lăpădat (2023) señaló que las limitaciones de recursos, particularmente en zonas desfavorecidas, pueden restringir el proceso de aprendizaje del inglés. Álvarez y Guevara (2021) sostuvieron que los módulos pedagógicos y los libros de texto proporcionados por el MINEDUC a las escuelas públicas de primaria y secundaria en Ecuador están descontextualizados y no se ajustan a las necesidades de los alumnos, centrándose principalmente en la gramática, el vocabulario y las habilidades de lectura. Además, la falta de materiales auténticos, herramientas interactivas y recursos digitales que apoyen la mejora de las habilidades en inglés de los estudiantes es un aspecto negativo de la enseñanza de idiomas (Checa, 2021; Sevy-Biloon et al., 2020). En este sentido, Barre y Villafuerte (2021) sugirieron que las políticas institucionales deben abordar la falta de recursos prestando mayor atención a la enseñanza del inglés como lengua extranjera.

La infraestructura limitada y los entornos de aprendizaje inadecuados son factores importantes que dificultan la adquisición eficiente de una

lengua. Checa (2021), por ejemplo, señaló que el espacio insuficiente en las aulas, la falta de herramientas tecnológicas y la conectividad limitada a Internet pueden impedir la integración de enfoques modernos e innovadores de enseñanza comunicativa de idiomas. Toro et al. (2019) también hicieron hincapié en que las aulas ecuatorianas tienen un gran número de alumnos, lo que impide a los docentes implementar estrategias comunicativas e interactivas y utilizar recursos auténticos. Estos factores llevan a los docentes a brindar un apoyo inadecuado a cada alumno, lo que reduce su motivación para aprender y hace que se sientan incómodos al participar en clase. Por lo tanto, una infraestructura adecuada y un tamaño de clase manejable son cruciales para lograr un impacto positivo en la enseñanza del inglés (Guzmán et al., 2022).

Checa (2021) señaló que la falta de Tecnologías de la Información y la Comunicación (TIC) es otro factor que dificulta la enseñanza del inglés en Ecuador. El investigador señaló que la tecnología inadecuada en las escuelas primarias y secundarias, así como el acceso limitado a las TIC, impiden aprovechar los beneficios de la tecnología en la enseñanza de idiomas. Las principales limitaciones de la infraestructura digital incluyen la falta de acceso a Internet en las instituciones, conexiones a Internet inestables y herramientas tecnológicas limitadas en el aula (Guerrero et al., 2025). Además, Proaño et al. (2025) explicaron que muchos docentes carecen de experiencia técnica en materia de alfabetización digital actual. Esto da lugar a resultados adversos que repercuten en la calidad de la enseñanza y el aprendizaje de los alumnos en el contexto ecuatoriano. Por lo tanto, la disponibilidad limitada de herramientas TIC actuales, la deficiente infraestructura digital en las instituciones públicas y la formación insuficiente de los docentes en su uso pueden afectar negativamente al proceso de enseñanza y aprendizaje, lo que repercute en la calidad de la instrucción docente y en el rendimiento lingüístico de los alumnos en Ecuador.

En última instancia, se descubrió que los factores relacionados con los alumnos también pueden influir significativamente en el éxito del plan de estudios de inglés como lengua extranjera.

Fayzulloyeva y Murzina (2022) corroboraron estos hallazgos, señalando que la mayoría de los estudiantes tienen actitudes negativas y una baja motivación hacia el aprendizaje del inglés, lo que afecta directamente a la eficacia de la enseñanza de la lengua. Orosz et al. (2021) explicaron que las desventajas socioeconómicas, la falta de aplicación auténtica del idioma, los métodos de enseñanza tradicionales, las herramientas tecnológicas inadecuadas y la exposición limitada al idioma de destino fuera del aula son factores que desmotivan a los estudiantes a la hora de aprender el idioma. Por lo tanto, Bravo et al. (2017) destacaron la importante conexión entre el aprendizaje de idiomas y la motivación, que aumenta las actitudes positivas de los estudiantes hacia el aprendizaje del idioma y los anima a participar activamente en actividades de aprendizaje tanto dentro como fuera del aula. En conjunto, estas deficiencias obstaculizan la calidad educativa y los resultados de los estudiantes.

Aunque estos estudios han abordado los principales retos de la enseñanza del inglés como lengua extranjera (EFL) en Ecuador, se echa en falta un análisis sistemático e integrador que abarque toda la gama de cuestiones de los últimos cinco años. Por lo tanto, este estudio tuvo como objetivo colmar esa laguna de conocimiento identificando los factores clave que afectan a la enseñanza del inglés y llevando a cabo una revisión sistemática utilizando la metodología PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). Page et al. (2021) afirmaron que la metodología PRISMA garantiza la coherencia de los resultados, minimiza el sesgo de la investigación y mejora la reproducibilidad, y que es aplicable tanto a estudios cualitativos como cuantitativos que examinan los retos de la enseñanza del inglés como lengua extranjera en el contexto educativo ecuatoriano. Para lograr este objetivo, las siguientes preguntas de investigación guiaron este estudio:

RQ1: ¿Cuáles son los retos más frecuentemente señalados a los que se enfrentan los profesores de inglés como lengua extranjera en Ecuador en diferentes contextos educativos?

RQ2: ¿Qué áreas requieren una mayor

investigación en la bibliografía actual en relación con los retos de la enseñanza del inglés como lengua extranjera en Ecuador?

2. Materiales y métodos

Este estudio siguió la metodología PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analyses). Según Page et al. (2021), se trata de un conjunto de normas de información diseñadas para orientar y mejorar la fiabilidad de la revisión. Además, esta metodología ayuda a los autores a reducir el sesgo de investigación y a garantizar que el proceso de revisión esté bien documentado y sea reproducible (Sarkis et al., 2021). La revisión sistemática PRISMA se basó en las dos preguntas establecidas para este estudio: 1. ¿Cuáles son los retos más frecuentemente señalados a los que se enfrentan los profesores de inglés como lengua extranjera (EFL) en Ecuador en diferentes contextos educativos? y 2. ¿Qué áreas requieren una mayor investigación en la bibliografía actual en relación con los retos de la enseñanza del inglés como lengua extranjera (EFL) en Ecuador? Además, en esta revisión sistemática, la evaluación de la calidad de los estudios seleccionados se llevó a cabo mediante un proceso de selección estructurado alineado con las directrices PRISMA, lo que garantizó el rigor metodológico, la transparencia y la relevancia, excluyendo actas de congresos, tesis y publicaciones no indexadas.

Se llevó a cabo una revisión bibliográfica exhaustiva en las siguientes bases de datos electrónicas: Scopus, Web of Science, ERIC, Google Scholar, Latindex y SciELO. La búsqueda incluyó artículos publicados entre 2020 y 2025 en revistas revisadas por pares sobre la enseñanza del inglés como lengua extranjera en Ecuador, en escuelas de primaria y secundaria. Se combinaron palabras clave y operadores booleanos para formar consultas como «profesores de EFL» Y «desafíos» Y «enseñanza de idiomas en Ecuador» Y «problemas» Y «educación en Ecuador» Y «cuestiones». Además, se revisaron cuidadosamente las listas de los artículos seleccionados para identificar los estudios que cumplían los criterios de inclusión.

En cuanto a las consideraciones éticas, este estudio siguió las recomendaciones de Beauchemin et al. (2022). En primer lugar, los artículos se seleccionaron de revistas de acceso abierto revisadas por pares para garantizar el cumplimiento de los principios de derechos de autor. Además, se definieron claramente los criterios de selección y exclusión de los estudios, y se aplicó el protocolo PRISMA para mejorar el rigor y la transparencia de la revisión bibliográfica. Por último, para garantizar la transparencia, este estudio ofrece una metodología sencilla, aborda abiertamente sus limitaciones e informa de los resultados positivos y negativos de los estudios revisados.

El primer paso del proceso de revisión consistió en utilizar Litmaps, una aplicación web que ayuda a los investigadores a encontrar y visualizar artículos académicos a través de mapas bibliográficos interactivos (Sulisworo, 2023). Como se muestra en la Figura 1, se utilizó un conjunto básico de documentos clave relacionados con los retos de la enseñanza del inglés como lengua extranjera en Ecuador para generar un mapa de citas, con el año de publicación en el eje horizontal y el impacto de las citas en el eje vertical.

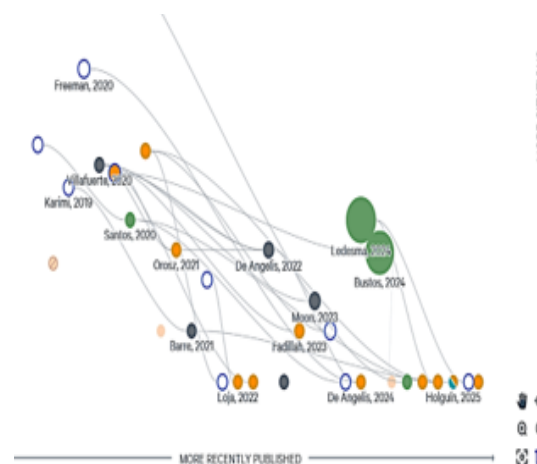


Figura 1: Mapa de citas antes de aplicar los criterios de inclusión/exclusión

Fuente: Elaboración propia

A partir de los grupos revelados por Litmaps (Tabla 1), los investigadores identificaron artículos fundamentales para un análisis más profundo y definieron los criterios de inclusión y exclusión. Los criterios de inclusión dieron prioridad a los artículos revisados por pares publicados entre 2020 y 2025 que se centraban en retos específicos de la enseñanza del inglés en Ecuador.

Tabla 1: Criterios de inclusión y exclusión
Fuente: Elaboración propia

Criterios de inclusión	Criterios de exclusión
Estudios que abordan directamente los retos a los que se enfrentan los profesores de inglés como lengua extranjera en Ecuador.	Estudios publicados antes de 2020. Actas de congresos. Tesis de máster y doctorado.
Artículos de revistas revisados por pares. Publicación: 2020-2025.	Estudios que no abordan los retos relacionados con la enseñanza del inglés como lengua extranjera en Ecuador.
Diseño de investigación cuantitativo, cualitativo y de métodos mixtos.	

Con la información proporcionada y basándose en la alineación de las preguntas de investigación de este estudio, los investigadores pudieron seguir el marco de revisión sistemática de la literatura PRISMA para garantizar una búsqueda exhaustiva y fiable de la bibliografía actual (Page et al., 2021). Los registros identificados mediante la búsqueda en bases de datos utilizando las palabras clave y los operadores booleanos en las cinco bases de datos ascendieron a 207 artículos. Debe contener información precisa y suficiente para que el lector pueda repetir la investigación si fuera necesario. La sección de materiales y métodos puede organizarse de la siguiente manera: (i) describir el diseño metodológico de la investigación; (ii) indicar la población en la que se llevó a cabo el estudio, describiendo el contexto de la muestra y cómo se seleccionó; (iii) indicar el entorno en el que se llevó a cabo el estudio; (iv) describir las intervenciones técnicas, los tratamientos (utilizar siempre nombres genéricos), las mediciones, las unidades, las pruebas piloto, los aparatos y la tecnología, etc.; y (v) indicar los análisis estadísticos utilizados y cómo se procesaron los datos.

2. Materiales y métodos

Para presentar los principales hallazgos de esta investigación, la Figura 2 ofrece una visión general descriptiva del proceso de selección de artículos, siguiendo el protocolo PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). Tras consultar las bases de datos electrónicas mencionadas para la búsqueda bibliográfica, se identificaron un total de 207 registros. Tras eliminar los artículos duplicados entre las bases de datos, quedaron 107 estudios. De estas investigaciones, se seleccionaron 57 artículos en función de sus títulos y resúmenes, y se pasó a la siguiente fase de selección. Los otros 20 artículos se excluyeron porque no cumplían los criterios de inclusión. De los 37 artículos restantes, se excluyeron 17 porque no se ajustaban adecuadamente al objetivo del estudio. Finalmente, se seleccionaron 20 artículos para el análisis en este estudio, ya que cumplían los criterios de inclusión, abordaban las preguntas de investigación establecidas en este trabajo y respondían al propósito del estudio.

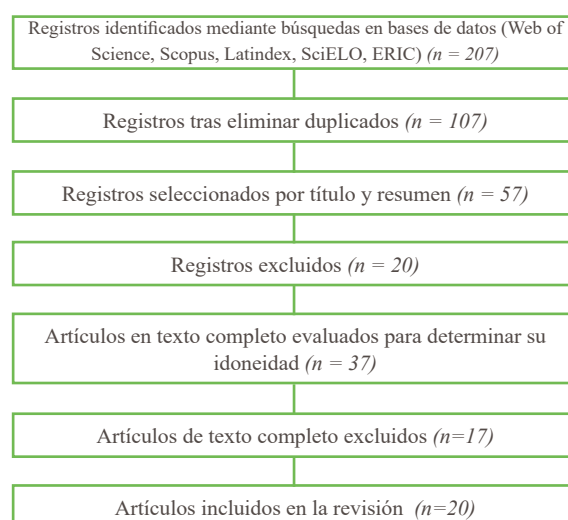


Figura 2: Diagrama de flujo PRISMA del proceso de selección de estudios
Fuente: Elaboración propia

En consecuencia, en la Tabla 2 se seleccionaron los siguientes artículos para este estudio, ya que abordan temas destacados de gran importancia para su desarrollo.

Tabla 2: Artículos seleccionados para este estudio
Fuente: Elaboración propia

Autores	Tema	Retos	Base de datos
1. Sevy-Biloon et al. (2020)	<i>Factores que afectan a la enseñanza del inglés en las escuelas públicas de Ecuador.</i>	Infraestructura inadecuada Escasa exposición al inglés Recursos descontextualizados Aulas con exceso de alumnos Horas de inglés limitadas Carga de trabajo excesiva de los profesores	Scopus
2. Tamayo y Cajas (2020)	<i>Identificación de los retos en la enseñanza de la escritura a estudiantes ecuatorianos de inglés como lengua extranjera</i>	Los estudiantes tienen un dominio limitado del inglés Interferencia del español Falta de motivación de los estudiantes Número insuficiente de horas lectivas en todas las habilidades lingüísticas	Latindex 2.0
3. Barre y Villafuerte (2021)	<i>La enseñanza del inglés como lengua extranjera en Ecuador: Implementación del Aprendizaje Integrado de Contenidos y Lengua durante 2019-2021</i>	Escasa conectividad e insuficiencia de dispositivos Dificultades con las metodologías a distancia Baja inversión Infraestructura inadecuada Aulas con exceso de alumnos	ERIC
4. Burgin et al. (2021)	<i>Estudio exploratorio sobre la comprensión del aprendizaje socioemocional por parte de los docentes ecuatorianos: un análisis de los maestros de primaria</i>	Brecha entre la teoría y la práctica en el plan de estudios Problemas de comportamiento y motivación de los alumnos Bienestar emocional del profesor Participación limitada de los padres Falta de recursos	Web of Science
5. Espinar (2021)	<i>Mejora del inglés en Ecuador: análisis de las innovaciones en la política educativa coreana sobre el inglés</i>	Dificultades con las habilidades productivas Formación docente poco desarrollada Falta de una estrategia nacional coherente Dependencia excesiva de los métodos de traducción gramatical Falta de motivación y escasa participación de los alumnos	Latindex 2.0
6. Orosz et al. (2021)	<i>Percepciones de los docentes ecuatorianos sobre la enseñanza del inglés: retos en el sector de la educación pública</i>	Baja motivación de los alumnos Presión del plan de estudios Escasa formación docente Falta de metodologías de pensamiento crítico	Scopus
7. Hidalgo e Intriago (2022)	<i>Factores que motivan a los profesores de inglés de las escuelas públicas ecuatorianas a cambiar de código en el aula de inglés como lengua extranjera</i>	Bajo nivel de competencia y exposición de los alumnos Clases numerosas Baja motivación y actitudes de los alumnos Limitaciones del plan de estudios Gran énfasis en la enseñanza de la gramática	Latindex 2.0
8. Acosta et al. (2023)	<i>Relación entre los perfiles de los profesores y su capacidad para implementar el plan de estudios: Análisis de los factores que configuran e influyen en las clases de inglés como lengua extranjera</i>	Apoyo institucional y recursos insuficientes Clases con un número elevado de alumnos Enseñanza tradicional y no comunicativa	Scopus
9. Burgin y Daniel (2023)	<i>Los futuros docentes debaten sobre su preparación para enseñar inglés como lengua extranjera en Ecuador</i>	Desconexión entre los objetivos del programa y las necesidades de los alumnos Tiempo limitado para la enseñanza diferenciada Entornos con escasos recursos Escasa participación de los padres	ERIC
10. Álvarez et al. (2024)	<i>Factores que influyen en el desarrollo de las habilidades orales</i>	Baja motivación Clases con un gran número de alumnos Falta de recursos y materiales auténticos Clases con un número excesivo de alumnos	Scopus
11. Bravo (2024)	<i>entre los estudiantes ecuatorianos de inglés como lengua extranjera: perspectivas de los docentes.</i>	Complejidad del plan de estudios Baja motivación de los alumnos Ausencia de evaluación diagnóstica	Scopus
12. Cajas y Cherres (2024)	<i>De primaria a secundaria: retos y estrategias en la enseñanza del inglés en una escuela pública de Guayaquil</i>	Políticas escolares rígidas Gran carga de papeleo administrativo Escasa capacidad para la práctica reflexiva Dificultad para seguir los planes de colaboración	Scopus
13. Álvarez et al. (2025a)	<i>Retos y oportunidades del uso del estudio de lecciones en la enseñanza del inglés entre</i>	Desajuste entre el plan de estudios y la realidad del aula Escasa implicación de los padres Falta de formación y experiencia de los docentes con alumnos de corta edad Aulas masificadas	Scopus
14. Galeas et al. (2025)	<i>profesores de inglés como lengua extranjera en Ecuador</i>	Ausencia de un plan de estudios nacional para la educación preescolar Profesores sin experiencia Tiempo de exposición limitado Diferentes contextos socioeconómicos Falta de participación de los padres	Scopus
15. Guerrero et al. (2025)	<i>La enseñanza del inglés en las escuelas primarias ecuatorianas: las creencias de los docentes en el contexto de la reforma curricular frente a las prácticas reales</i>	Barreras tecnológicas Falta de motivación y percepción de la relevancia Acceso desigual a clases particulares Limitaciones curriculares y pedagógicas Ausencia de un grupo de control en el diseño de la investigación	Scopus
16. Guerrero y Moreira (2025)	<i>Un programa de inglés como lengua extranjera para niños muy pequeños en la educación pública ecuatoriana: un estudio preliminar</i>	Tiempo de enseñanza limitado Planes de estudios con gran énfasis en la gramática y la expresión escrita Baja motivación de los alumnos Acceso desigual a la tecnología	Latindex
17. Guzmán (2025)	<i>Tutoría académica en línea para el aprendizaje del inglés: un estudio de caso sobre el desarrollo de las habilidades receptivas en estudiantes ecuatorianos</i>	Pedagogía tradicional centrada en la gramática Limitaciones estructurales y de recursos Lagunas en el desarrollo oral Falta de prácticas centradas en el alumno	SciELO
18. Proaño et al. (2025)	<i>Experiencias de los profesores de inglés como lengua extranjera en Ecuador en el fomento de las habilidades de expresión oral de los alumnos: perspectivas sobre estrategias y retos en escuelas públicas y privadas.</i>	Acceso limitado a la tecnología Clases con un número elevado de alumnos Formación insuficiente del profesorado Presión por la carga de trabajo Limitaciones de tiempo	Scopus
19. Soto et al. (2025)	<i>Retos y experiencias en la enseñanza del inglés como lengua extranjera: Reflexiones a partir de experiencias didácticas en Ecuador</i>	Integración de recursos complementarios Algunos estudios de investigación a largo plazo o longitudinales Baja motivación de los estudiantes para aprender inglés Falta de prácticas centradas en el alumno	SciELO
20. Yunga et al. (2025)	<i>Perspectivas y retos de la integración tecnológica en la enseñanza del inglés: un enfoque académico</i>	Falta de motivación de los alumnos Conocimientos insuficientes de inglés por parte de los profesores Dependencia de los métodos de enseñanza tradicionales Competencia digital e infraestructura deficientes	Latindex 2.0

Nota: Esta tabla muestra los resultados según los criterios PRISMA.

La Figura 3 muestra una nube de palabras con los factores más frecuentemente discutidos en la investigación académica sobre la enseñanza del inglés en Ecuador entre 2020 y 2025, apareciendo las palabras más grandes como las que más se repiten en los estudios. Según los estudios seleccionados, los factores más destacados que obstaculizan la enseñanza eficaz de idiomas en Ecuador fueron la motivación, la formación del profesorado, las aulas con exceso de alumnos, la falta de recursos didácticos, el acceso a la tecnología y las deficiencias del plan de estudios. Los retos moderados fueron el tiempo lectivo, la falta de métodos centrados en el alumno, la implicación de los padres y la aplicación frecuente de métodos centrados en la gramática. Por último, las variables menos discutidas fueron la competencia digital, las deficiencias en la evaluación, la práctica reflexiva y la falta de investigación en la enseñanza del inglés como lengua extranjera (EFL). Este resumen visual destaca la importancia de abordar los factores pedagógicos, estructurales y motivacionales, al tiempo que reconoce la necesidad de investigar más a fondo áreas menos discutidas en la enseñanza del inglés como lengua extranjera (ELT), como las reflexiones de los docentes y las investigaciones sobre el impacto a largo plazo.

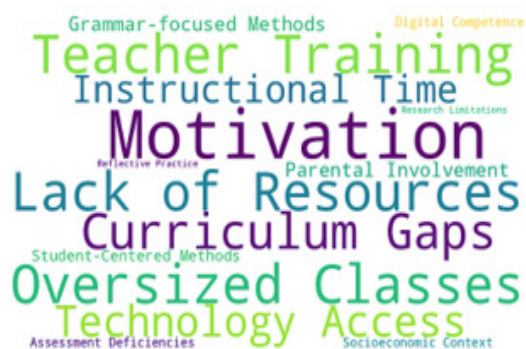


Figura 3: Variables más mencionadas en los retos de la enseñanza del inglés como lengua extranjera en la literatura ecuatoriana (2020-2025).

Fuente: Elaboración propia.

Además, la figura 4 muestra los porcentajes de los retos en la enseñanza del inglés como lengua extranjera (EFL) identificados en la bibliografía seleccionada entre 2020 y 2025. En este sentido, la motivación se reveló como el reto más destacado, citado en el 45 % de los

artículos de revisión, lo que pone de relieve la dificultad para motivar a los alumnos a aprender inglés. Además, la formación del profesorado se mencionó en el 30 % de los estudios revisados, lo que pone de relieve las deficiencias en el desarrollo profesional. Del mismo modo, las clases numerosas y las limitaciones de recursos se señalaron en el 30 % de los estudios seleccionados, lo que destaca las limitaciones infraestructurales que dificultan el acceso a materiales didácticos de alta calidad y a una enseñanza personalizada. La falta de correspondencia entre los estándares del plan de estudios nacional y la realidad de las aulas, así como los retos para *acceder a la tecnología*, se mencionaron en el 25 % de los estudios, en referencia a las barreras entre lo estipulado y esperado en la enseñanza de idiomas y la realidad en las aulas de las escuelas públicas. El tiempo lectivo dedicado a la enseñanza del inglés, la enseñanza centrada en la gramática y la participación de los padres se señalaron en el 15 % de los artículos seleccionados, lo que contribuyó a una escasa fluidez lingüística y a oportunidades limitadas para la práctica del idioma. Por último, otros factores, como los retos socioeconómicos, la escasez de investigación longitudinal y la falta de prácticas reflexivas, se identificaron como barreras subyacentes que aún deben abordarse en futuras investigaciones, ya que estaban representados en menos del 15 % de los estudios.

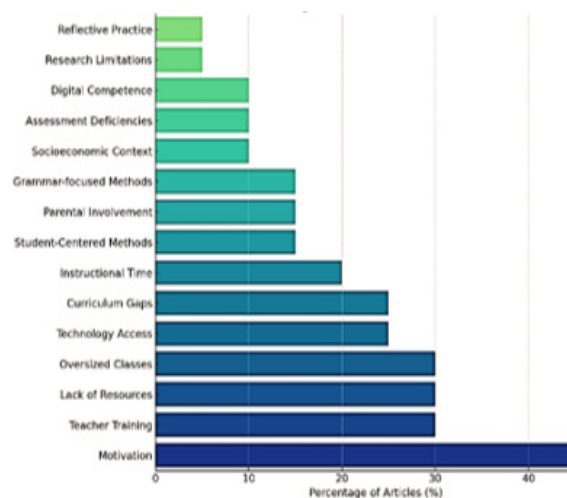


Figura 4: Prevalencia de las variables relacionadas con los retos del inglés como lengua extranjera en Ecuador.

Fuente: Elaboración propia.

4. Discusión

Esta revisión sistemática analizó los retos más frecuentemente señalados en la enseñanza del inglés como lengua extranjera (EFL) en Ecuador y las áreas que requieren una mayor investigación entre 2020 y 2025. Las variables se agruparon en las siguientes dimensiones: factores relacionados con el profesorado, factores relacionados con el alumnado, currículo y enfoques pedagógicos, limitaciones institucionales y contextuales, y limitaciones de investigación y evaluación. Estas dimensiones proporcionan un marco para interpretar y profundizar en los obstáculos recurrentes documentados en los niveles de primaria y secundaria en Ecuador.

Los retos relacionados con el profesorado se revelaron como una de las dimensiones más significativas. Un número considerable de los artículos seleccionados (15/20) destacaron la formación del profesorado, la preparación limitada en metodologías comunicativas y adecuadas a la edad, y las escasas competencias digitales para satisfacer las exigencias de la enseñanza del inglés como lengua extranjera en las escuelas públicas ecuatorianas. Espinar (2021) y Orosz et al. (2021) señalaron que muchos profesores de inglés como lengua extranjera tenían un acceso limitado a oportunidades de desarrollo profesional, lo que daba lugar a prácticas docentes repetitivas basadas exclusivamente en enfoques centrados en los libros de texto y la gramática. De este modo, persiste la dependencia de métodos de traducción gramatical obsoletos, lo que contribuye a un bajo nivel de desarrollo de la calidad de la enseñanza (Guerrero y Moreira, 2025; Guzmán, 2025). Además, estudios como los de Álvarez et al. (2025a), Galeas et al. (2025) y Proaño et al. (2025) pusieron de relieve una brecha constante en la preparación de los docentes para la aplicación práctica de metodologías comunicativas, estrategias de enseñanza específicas para cada edad y experiencia en educación infantil.

En cuanto a las escasas competencias digitales, Yunga et al. (2025) afirmaron que la mayoría de los docentes carecen de una preparación formal suficiente en el uso de herramientas digitales. Esto

conduce a una baja confianza e incertidumbre a la hora de incorporar metodologías basadas en las TIC en la planificación de sus clases o en las actividades del aula, perdiéndose así las ventajas pedagógicas de la tecnología para mejorar los resultados del aprendizaje del inglés. Estas deficiencias en la formación del profesorado, la preparación pedagógica y la competencia digital podrían ser factores cruciales para la eficacia de la enseñanza del inglés como lengua extranjera, lo que subraya la necesidad de programas de formación especializados y de desarrollo profesional continuo. Estos programas hacen hincapié en la enseñanza comunicativa de idiomas, los enfoques centrados en el alumno, las pedagogías específicas para cada edad y el desarrollo de la competencia digital para potenciar la participación de los alumnos y mejorar los resultados del aprendizaje del inglés (Acosta et al., 2023; Burgin y Daniel, 2023; Galeas et al., 2025).

En cuanto a los factores relacionados con los alumnos, doce estudios (12/20) abordaron explícitamente las principales limitaciones en el proceso de enseñanza del inglés como lengua extranjera en Ecuador, incluyendo la motivación de los alumnos, su comportamiento, sus conocimientos previos y el entorno educativo, todos los cuales pueden afectar al aprendizaje de la lengua. Un problema recurrente es la escasa motivación de los estudiantes para aprender inglés. Esto puede manifestarse en una baja participación, un rendimiento deficiente en el uso del idioma en el aula y resistencia al aprendizaje (Soto et al., 2025; Tamayo y Cajas, 2020; Yunga et al., 2025). Además, los conocimientos previos y el dominio limitado del inglés son barreras importantes a las que se enfrentan los estudiantes al aprender inglés. Tal y como señalan Espinar (2021) y Tamayo y Cajas (2020), la mayoría de los estudiantes tienen dificultades para mejorar sus habilidades productivas debido a la falta de tareas auténticas y a la constante interferencia del español, lo que también dificulta el aprendizaje efectivo del inglés.

La motivación de los estudiantes fue el reto más citado en la revisión bibliográfica seleccionada, lo cual se enmarca dentro de las cuestiones relacionadas con los estudiantes. Tamayo y Cajas (2020) indicaron que la mayoría de los estudiantes ecuatorianos de inglés como lengua extranjera (EFL) suelen tener una baja motivación para aprender inglés. Del mismo modo, Bravo (2024) y Burgin et al. (2023) reforzaron esta cuestión al señalar que la baja motivación está asociada a los retos de comportamiento de los estudiantes y al apoyo emocional insuficiente en el aula. De este modo, aparte de los retos mencionados anteriormente —como la limitada implicación de los padres, las estrategias de enseñanza obsoletas y la deficiente infraestructura digital—, las percepciones de los estudiantes sobre la relevancia de aprender inglés en Ecuador debilitan su motivación intrínseca (Guerrero et al., 2025; Soto et al., 2025). Por lo tanto, la falta de motivación implica que la mayoría de los estudiantes ecuatorianos de inglés como lengua extranjera no ven un valor significativo en el aprendizaje del inglés, mostrando poco interés en las actividades de clase, un esfuerzo mínimo en la práctica y el desarrollo del idioma, y una competencia comunicativa deficiente (Álvarez et al., 2024; Guerrero y Moreira, 2025; Orosz et al., 2021; Soto et al., 2025).

En cuanto al entorno educativo, algunos estudios han abordado explícitamente las limitaciones socioeconómicas y contextuales (Galeas et al., 2025), la escasa implicación de los padres (Álvarez et al., 2025a; Burgin et al., 2021) y los problemas de comportamiento (Burgin et al., 2021). Estos retos pueden afectar negativamente a la dinámica del aula y al entorno de aprendizaje. Estos retos pueden obstaculizar la enseñanza y el aprendizaje efectivos del inglés como lengua extranjera (EFL), lo que subraya la necesidad de integrar un plan de estudios que se centre en tareas comunicativas relevantes para la realidad de los estudiantes. Del mismo modo, no se puede subestimar la importancia de adoptar un enfoque holístico basado en el aprendizaje socioemocional y la colaboración entre la escuela y la familia.

La falta de alineación entre el plan de estudios nacional ecuatoriano de inglés como lengua extranjera y las prácticas docentes reales es

otro desafío que se aborda en la mayoría de los artículos seleccionados (12/20). En primer lugar, los estudios de Hidalgo e Intriago (2022), Espinar (2021), Cajas y Cherres (2024) y Tamayo y Cajas (2020) afirman explícitamente que la falta de correspondencia entre los objetivos de la reforma curricular y su aplicación real en el aula es ineficaz. Si bien el plan de estudios promueve un enfoque comunicativo y centrado en el alumno, la enseñanza sigue basándose en métodos obsoletos de traducción gramatical (Espinar, 2021). Del mismo modo, aparte de los problemas de infraestructura y tecnológicos, las políticas rígidas y los procedimientos burocráticos siguen impidiendo a los educadores implementar las metodologías reflexivas o colaborativas descritas en el plan de estudios (Burgin y Daniel, 2023; Cajas y Cherres, 2024). En segundo lugar, la desconexión entre los principios curriculares y las prácticas docentes reales ha sido evidente en Ecuador, donde los métodos tradicionales, centrados en el profesor y enfocados en la gramática siguen predominando en las aulas de inglés como lengua extranjera (Bravo, 2024; Guzmán, 2025; Yunga et al., 2025). Según los investigadores, los retos contextuales y la falta de formación docente limitan la capacidad de los profesores para aplicar innovaciones metodológicas y pedagógicas, lo que da lugar a un escaso desarrollo de las habilidades orales y comunicativas (Tamayo y Cajas, 2020), a una baja motivación y participación de los alumnos (Yunga et al., 2025), y a la frustración de los profesores y una baja autoeficacia profesional (Burgin y Daniel, 2023).

Las limitaciones institucionales y contextuales fueron las más citadas en los artículos seleccionados, apareciendo en 18 de los 20 estudios. En cuanto a los retos institucionales, se observó que la infraestructura y los recursos inadecuados para la enseñanza del inglés (Álvarez et al., 2024; Sevy-Biloon et al., 2020), el hacinamiento en las aulas (Acosta et al., 2023; Barre y Villafuerte, 2021; Proaño et al., 2025), el tiempo lectivo limitado (Guerrero y Moreira, 2025; Tamayo y Cajas, 2020) y la carga administrativa y las políticas rígidas (Acosta et al., 2023; Cajas y Cherres, 2024) son los factores comunes que dificultan la enseñanza eficaz del inglés como lengua extranjera en Ecuador.

Además, la desigualdad socioeconómica (Galeas et al., 2025), las barreras tecnológicas (Barre y Villafuerte; Guerrero et al., 2025; Yunga et al., 2025) y la limitada participación de los padres en el proceso de aprendizaje (Álvarez et al., 2025a; Burgin et al., 2021; Burgin y Daniel, 2023) son los principales factores contextuales que impiden un impacto positivo en el proceso de enseñanza del inglés como lengua extranjera.

Por último, las categorías de práctica reflexiva y limitaciones de la investigación recibieron la menor representación en los artículos analizados (alrededor del 5 % cada una), lo que indica una escasez de estudios en la literatura reciente. En cuanto al criterio de la práctica reflexiva, solo Cajas y Cherres (2024) señalaron que los profesores a menudo tenían dificultades para identificar tareas en el aula que requirieran una mejora o una reflexión más profunda tras las clases de inglés como lengua extranjera. Esto representa una laguna en la investigación, ya que no hay suficiente evidencia empírica sobre los factores específicos que limitan la capacidad de los profesores para la práctica reflexiva. Del mismo modo, las limitaciones de la investigación

están infrarrepresentadas en los artículos analizados, lo que sugiere que rara vez se abordan en la literatura reciente. Guerrero et al. (2025) explicaron que, aunque existe investigación sobre la enseñanza del inglés como lengua extranjera, la ausencia de estudios longitudinales con grupos de control y experimentales en el diseño de la investigación limita la capacidad de establecer relaciones causales. Por lo tanto, las deficiencias metodológicas, la falta de replicabilidad, el reducido tamaño de las muestras o la limitada diversidad de contextos restringen la validez y la generalizabilidad de los resultados.

En resumen, el análisis de los 20 estudios seleccionados puso de relieve los retos que plantea la enseñanza del inglés como lengua extranjera en Ecuador en cinco ámbitos: factores relacionados con el profesorado, factores relacionados con el alumnado, limitaciones contextuales, enfoques pedagógicos y curriculares, e investigaciones longitudinales y cuasi-experimentales. Estos resultados indican la necesidad de llevar a cabo reformas sistémicas tanto en la infraestructura escolar como en la política educativa general para respaldar una enseñanza eficaz del inglés en Ecuador.

5. Conclusiones

Utilizando la metodología PRISMA, este estudio ofrece una novedosa contribución académica al campo del inglés como lengua extranjera en Ecuador, abordando numerosos retos complejos y multifacéticos que requieren intervenciones sistémicas en las escuelas públicas de primaria y secundaria. A diferencia de estudios individuales previos que se centran en variables aisladas, esta revisión sistemática integra los hallazgos de 20 investigaciones y los organiza en cinco dimensiones analíticas coherentes. Además, el estudio identifica áreas poco exploradas en la enseñanza del inglés, en particular la escasez de investigación longitudinal y experimental que podría respaldar reformas de políticas, programas de formación del profesorado y futuras investigaciones empíricas en el contexto ecuatoriano. La cuestión más apremiante está

relacionada con el profesorado, incluyendo la formación insuficiente de los docentes, la dependencia de métodos de enseñanza obsoletos y las escasas competencias digitales, lo que debilita las prácticas en el aula y los resultados de los alumnos. Además, la baja motivación para aprender inglés y las barreras contextuales, como los factores socioeconómicos y la implicación de los padres, son los principales factores relacionados con los alumnos que obstaculizan las oportunidades de aprendizaje de idiomas. Otra limitación fundamental es la falta de alineación del plan de estudios: aunque las políticas nacionales promueven un enfoque comunicativo y centrado en el alumno, esto contrasta con las prácticas en las aulas de inglés como lengua extranjera. Las aulas masificadas, la falta de herramientas tecnológicas, la infraestructura

deficiente y las políticas administrativas rígidas son las principales limitaciones institucionales que restringen la aplicación de innovaciones metodológicas. Por último, como hallazgo urgente, la revisión PRISMA reveló que la investigación empírica que utiliza diseños longitudinales y experimentales sigue sin estar suficientemente explorada, lo que pone de relieve una laguna crítica en la investigación que podría socavar la fiabilidad y la generalizabilidad de investigaciones previas realizadas en Ecuador. Por lo tanto, superar estas limitaciones requiere

reformas integradas que prioricen la formación continua del profesorado, la alineación entre el currículo y la práctica, las inversiones en infraestructura, la colaboración activa entre las familias, las escuelas y las comunidades, y la implementación de herramientas digitales en el aula. De esta manera, la enseñanza del inglés como lengua extranjera en Ecuador puede mejorarse proporcionando equidad, relevancia y sostenibilidad en la educación primaria y secundaria.

6. Limitaciones y recomendaciones

Este estudio presenta ciertas limitaciones que deben tenerse en cuenta a la hora de interpretar los resultados. En primer lugar, aunque se siguió meticulosamente la metodología PRISMA para seleccionar los artículos, el alcance y el corpus de la revisión se limitaron a las investigaciones publicadas entre 2020 y 2025, lo que podría excluir investigaciones anteriores relevantes que podrían aportar información valiosa sobre los retos de la enseñanza del inglés como lengua extranjera en Ecuador. Además, el uso de las bases de datos mencionadas puede haber limitado la exhaustividad de la búsqueda, ya que podría haber pasado por alto bibliografía publicada en otras fuentes, como actas de congresos o revistas no indexadas, que podrían contener información práctica relevante para este estudio. Por último, aunque se aplicó la

metodología PRISMA para reducir el sesgo de la investigación, la interpretación y categorización de los retos podría estar potencialmente sujeta a sesgos. La principal contribución de esta investigación radica en identificar problemas estructurales en la enseñanza del inglés como lengua extranjera y en poner de relieve las lagunas en la práctica reflexiva y el diseño de la investigación que limitan la generalización de estudios anteriores en el contexto ecuatoriano. Los desarrollos futuros deberían centrarse en la implementación de diseños de investigación longitudinales y experimentales, la evaluación de metodologías de enseñanza innovadoras y la integración del aprendizaje socioemocional y la participación familiar como estrategias para mejorar la motivación de los estudiantes para aprender inglés.

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Resilience and suicidal behavior in adolescent and youth populations: a systematic review

Resiliencia y conducta suicida en población adolescente y juvenil: una revisión sistemática

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Resilience and suicidal behavior in adolescent and youth populations: a systematic review

Resiliencia y conducta suicida en población adolescente y juvenil: una revisión sistemática

Abstract:

Suicidal behaviors in adolescents have increased significantly. Resilience is identified as a key element in prevention. The objective is to explore the empirical evidence on the protective effect of resilience against suicidal behavior in children and adolescents. Regarding methods, the PRISMA methodology was applied, reviewing PsycInfo, PsycArticles, Dialnet, Academic Search Premier, and Google Scholar. Empirical studies from the last 15 years in individuals aged 12 to 21 were included. Twelve empirical articles were selected. A moderate negative relationship (average correlation = $-.44$) was found between resilience and self-harm. In conclusion, resilience is a key protective factor for preventing suicidal behavior in adolescents. It is essential to develop preventive strategies that promote coping skills and emotional regulation.

Keywords: Adolescence, Resilience, Suicidal behavior, Protective Factors, Systematic review.

Resumen:

Las conductas suicidas en adolescentes han experimentado un notable aumento. La resiliencia se identifica como un elemento clave en la prevención. El objetivo es explorar las evidencias empíricas sobre el efecto protector de la resiliencia frente a la conducta suicida en población infanto-juvenil. En cuanto a métodos, se aplicó la metodología PRISMA revisando PsycInfo, PsycArticles, Dialnet, Academic Search Premier y Google Académico. Se incluyeron estudios empíricos de los últimos 15 años en menores de 12 a 21 años. Se seleccionaron 12 artículos empíricos. Se constató una relación negativa moderada (correlación promedio = $-.44$) entre la resiliencia y las conductas autolíticas. Como conclusiones, se advierte que la resiliencia es un factor de protección clave para prevenir la conducta suicida en adolescentes. Resulta esencial desarrollar estrategias preventivas que fomenten habilidades de afrontamiento y regulación emocional.

Palabras clave: Adolescencia, Resiliencia, Conducta suicida, Factores de Protección, Revisión sistemática.

1. Introduction

Suicide and suicidal behavior constitute a priority public health issue. According to the World Health Organization (WHO, 2024), more than 720,000 people die by suicide worldwide each year, and this cause of death remains particularly significant among adolescents and young adults. In this context, identifying variables associated with lower suicide risk is clinically and preventively relevant.

However, the relationship between resilience and suicidal behavior cannot be assumed to be linear, as the literature reveals conceptual and methodological differences in the definition of resilience, the instruments used, and the indicators of suicidality analyzed.

Many authors have attempted to define the concept of suicide. Silverman et al. (2007) sought to establish a consensus on scientific terminology based on previous studies (e.g., De Leo et al., 2006). Silverman et al. (2007) distinguish between the presence or absence of suicidal intent and self-injury. Communications are categorized according to intent (suicide threat) or the expression of a plan (suicide plan).

Likewise, they define a suicide attempt as self-inflicted, potentially harmful behavior with a non-fatal outcome, in which there is evidence of the intent to die.

In psychology, resilience has been conceptualized as a dynamic process of positive adaptation in the face of adversity, rather than as a fixed trait (Bonanno & Kaltman, 2013; Wren & Meyer, 2017). Its multidimensional nature involves considering individual, family, and contextual components, as well as the heterogeneity of its measurement methods. It is precisely this conceptual and operational diversity that justifies a critical review of how its association with suicidal ideation, risk, or behavior has been studied in adolescent and youth populations.

The main objective of this systematic literature review is to synthesize the published empirical evidence on the association between resilience and suicidal behavior in adolescents and young adults over the past 15 years. As a specific objective, we aim to identify patterns of association, the methodological characteristics of the included studies, and the main limitations of the available evidence.

2. Materials and methods

Methodological design and study setting. A Systematic Literature Review (SLR) with a descriptive and narrative synthesis orientation was conducted, following the general PRISMA structure. A 15-year time window (2010–2024) was considered in order to gather recent and comparable evidence on resilience and suicidal behavior in adolescents and young adults, a field in which empirical research has intensified particularly during this period. The review focused on studies with samples aged 12 to 21 or with a predominance of adolescents and young adults in that developmental stage.

Data collection procedure. The literature search was conducted in PsycInfo, PsycArticles, Dialnet, Academic Search Premier, and Google Scholar. The strategy combined the terms resilience/resiliency/resilient with suicide/suicidal ideation/suicide prevention/suicide intervention and adolescents/teenagers/young adults, using Boolean operators in advanced search. Priority was given to databases covering psychology and the social sciences, and Google Scholar was used as a complementary resource to enhance search sensitivity.

Inclusion and exclusion criteria. The selection was based on the criteria summarized in Table 1. Consistent with the exploratory nature of the review, empirical studies published in scientific journals and full-text academic literature were considered when they explicitly addressed the relationship between resilience and suicidality in adolescent or young adult populations.

Documents lacking sufficient methodological information, studies focused exclusively on adult

samples, and publications that did not directly analyze the variables of interest were excluded.

Data analysis and graphical presentation. The PRISMA procedure (Moher et al., 2009) was followed for document screening and selection. After removing duplicate records, a screening by title and abstract was conducted; subsequently, potentially eligible studies were reviewed in full text. Figure 1 summarizes the selection flow up to the final inclusion of 12 studies.

Tabla 1: Resumen de los criterios de inclusión y exclusión
Fuente: Elaboración propia, 2026.

Inclusion criteria	Exclusion criteria
Scientific articles and academic literature with empirical methodology and full text	Conferences, books, book chapters, monographs, or documents without sufficient academic peer review
Published in Spanish or English between 2010 and 2024	Studies that do not directly address the relationship between resilience and suicidal behavior/suicidal tendencies
Samples aged 12 to 21 or with a predominance of adolescents and young adults	Exclusively adult samples or those with insufficient methodological information

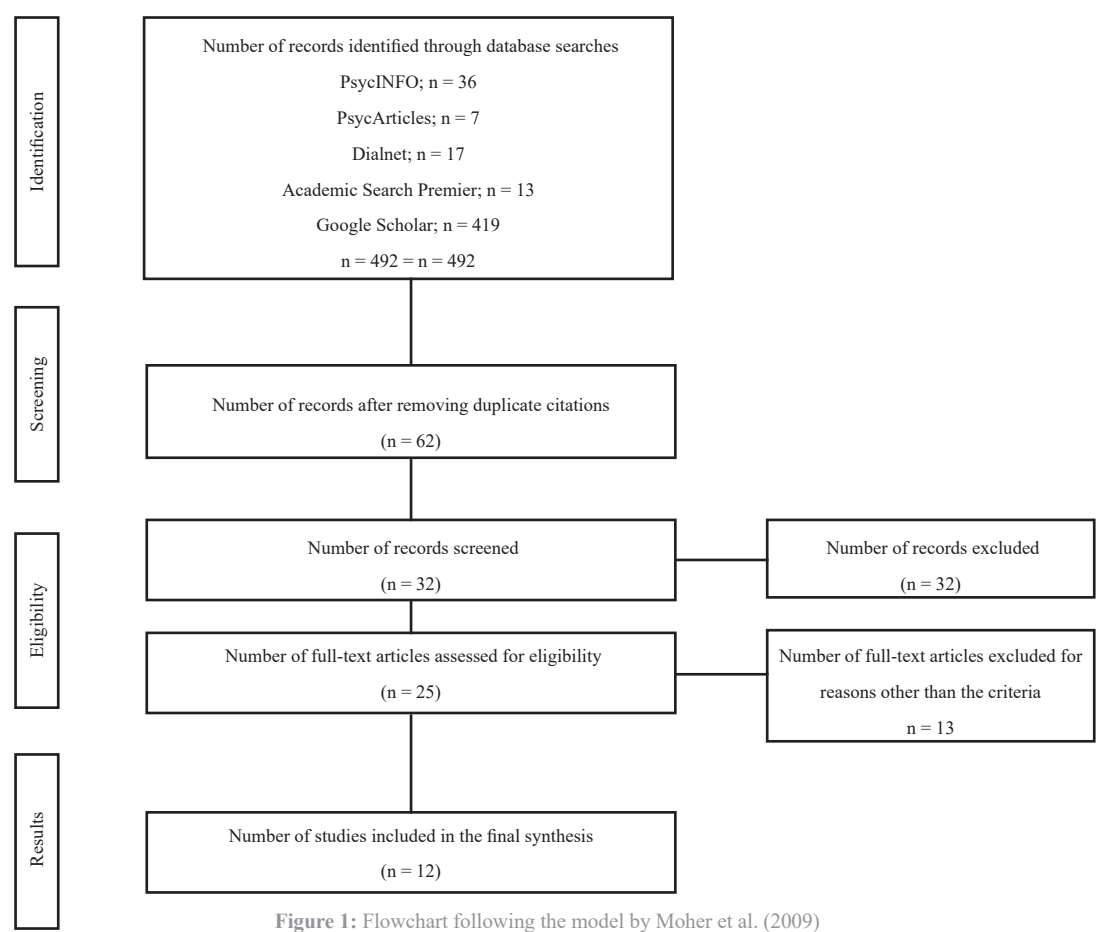


Figure 1: Flowchart following the model by Moher et al. (2009)
Source: Author's own work, 2026.

3. Results

A total of 492 records were initially identified across the various sources consulted (PsycInfo: 36, PsycArticles: 7, Dialnet: 17, Academic Search Premier: 13, and Google Scholar: 419). After removing duplicates, 62 records remained for screening based on title and abstract; 32 were excluded at this stage. Subsequently, 30 articles were evaluated in full text to determine eligibility; 18 were excluded for not meeting the established criteria. Finally, 12 studies were included in the qualitative synthesis.

Overall, the included studies mostly point to an inverse association between resilience and different manifestations of suicidal behavior

(suicidal ideation, suicide risk, suicide attempts, or self-harming behavior). However, the magnitude of this association should be interpreted with caution, given the high heterogeneity of the samples, designs, measurement instruments, and the inclusion of studies with varying levels of evidence. The main methodological and substantive characteristics of the studies are presented in Tables 2 and 3.

For transparency, this review presents a descriptive synthesis of the included studies rather than a meta-analysis; therefore, no weighted-average correlation is reported.

Table 2: Methodological characteristics of the included studies on resilience and suicidal behavior in adolescent and youth populations
Source: Prepared by the authors, 2026.

Author(s) and year	Participants	Genre	Method
Nrugham, L., Holen, A. y Sund, A.M. (2010).	N=345 adolescents and 252 young adults Mixed sample; considered for inclusion due to adolescent subsample	Adolescents: Males = 27.5% Females = 72.5% Young adults: Males = 23% Females = 77%	Quantitative: retrospective longitudinal
Arenas-Landgrave, P., Lucio-Gomez, E., y Forns, M. (2011)	N=1,084 N=106 Age: 15–17 years	Men: 41% Women: 59%	Non-experimental cross-sectional
Villalobos-Galvis et al. (2012)	N=573 Age: 10–25 years	Men: 49.7% Women: 50.3%	Instrumental
Montes-Hidalgo, J., y Tomás-Sábado, J. (2016)	N=186 Age: 18–43 years Predominantly early-stage university students	Men: 32 Women: 154 (M=22,6)	Quantitative: Cross-sectional, correlational
Sánchez, D. (2016)	N = 470 Age: 18–71 years Large sample	Men: 207, 44% Women: 263, 56%	Quantitative: Non-experimental-cross-sectional
Ayón, H. J. (2018)	N=241 Age: 12–17 years	Men: 107 Women: 134	Cuantitativo: No experimental-transversal
Cuellar, C.D. y Pallares, L.T. (2020)	N= 200 Años: 18-40 años	Hombres: 16% Mujeres: 84%	Cuantitativo: No experimental-transversal
Quispe Llanos, S. W. (2020)	N=340 Age: 12-17 years	Not specified	Quantitative: Non-experimental—cross-sectional
Vilca, C.J. (2021)	N=211 Age: 18-39 years	Men: 172 Women: 39	Cuantitativo: No experimental-transversal
Ocampos, J.M y Raymundo, K. M. (2022)	N=220 Age: 12 y 17 years	Men: 94 Women: 126	Quantitative: Non-experimental—cross-sectional
Yang et al. (2023)	N=1607 Age: 14-19 years	Men: 53,1% Women: 46,9%	Quantitative: Cross-sectional
Villaverde, J.G. (2023)	N=266 Age: 12-17 years	Men: 42,1% Women: 57,9%	Correlational, non-experimental

Table 3: Main variables and instruments of the included studies
Source: Author's own compilation, 2026.

TABLE 3

MAIN VARIABLES AND INSTRUMENTS OF THE INCLUDED STUDIES

Author(s) and year	Variables	Scales
Frugham, L., Holen, A. y Sund, A.M. (2010).	Resilience Suicide attempt Traumatic events	Connor Davidson Resilience Scale (CD-RISC-25) (2003) Kiddie-Schedule for Affective Disorders and Schizophrenia (K-SADS)
Arenas-Landgrave, P., Lucio-Gomez, E., y Forns, M. (2011)	Resilience Suicide Risk/Ideation Stress	Life Events Questionnaire for Adolescents (Lucio and Durán, 2003) IRIS (Hernández and Lucio, 2003) MMPI-A (Lucio, Ampudia, and Durán, 2004)
Villalobos-Galvis et al. (2012)	Resilience Suicidal ideation	Suicide Resilience Inventory (SRI-25). Social Support Scale (AS). Social Problem-Solving Inventory (SPSI) Beck Hopelessness Scale (BHS). Center for Epidemiological Studies Depression Scale (CES-D). Rosenberg Self-Esteem Scale (AE) Reasons for Living Inventory (RFL). Suicidal Ideation Questionnaire (SIQ).
Montes-Hidalgo, J., y Tomás-Sábado, J. (2016)	Resilience Suicide risk	Rosenberg Self-Esteem Scale (RSE) Brief Resilient Coping Scale (BRCS) Plutchik Suicide Risk Scale (ERSP) Rotter Internal-External Locus of Control Scale
Sánchez, D. (2016)	Resilience Suicide Attempt	CD-RISC25, translated by Manzano-García and Ayala (2013) Wagnild's RS-14 (2009) Osman et al.'s SRI-25 (2004), developed and validated by Villalobos-Galvis et al. (2012) Scale of Resilience in the Face of Suicide Attempts (ERATS)
Ayón, H. J. (2018)	Resilience Self-harming behavior	Resilience Scale, Wagnild, G. Young, H. adapted by Novella (2002) Shager Self-Injury Scale (2014)
Cuellar, C.D. y Pallares, L.T. (2020)	Resilience Suicidal Behavior Stress/ansiedad/ depresión	SRI-25 adapted in Colombia by Villalobos, et al. (2012) Depression, Anxiety, and Stress Scale-21 (DASS-21) (2017)
Quispe Llanos, S. W. (2020)	Resilience Suicidal Behavior	CD-RISC10, translated by Manzano-García and Ayala (2013) Adolescent Suicidal Ideation Screening Scale (2009)
Vilca, C.J. (2021)	Resilience Suicidal ideation	Walgnild and Young Resilience Scale (1993). Adapted by Águila (2003) Beck Depression and Suicidal Ideation Scale (2014). Adapted by Eugenio and Zelada (2011)
Ocampos, J.M. y Raymundo, K. M. (2022)	Resilience Self-harming behavior	CD-RISC10, translated by Manzano-García and Ayala (2013) SHAGER Self-Injury Scale (2015)
Yang et al. (2023)	Resilience Suicidal ideation Child Abuse Conectividad escolar	CD-RISC10, validated in Chinese adolescents (Yang, Y et al., 2023) Childhood Trauma Questionnaire (CTQ-SF)
Villaverde, J.G. (2023)	Resilience Suicidal ideation	Suicidal Ideation Scale by Beck et al. (1979), adapted by Bobadilla et al. (2004) "ER" Resilience Scale by Barboza (2017)

4. Discussion

The results support the conclusion that the reviewed literature consistently describes an inverse association between resilience and suicidal behavior in adolescent and youth populations. However, this trend should not be interpreted in causal or uniform terms. The included studies are predominantly observational, cross-sectional, and heterogeneous; therefore, resilience should

be understood here as a variable associated with a lower prevalence of suicidality, rather than as a protective factor demonstrated in a causal sense.

A comparison across studies also reveals significant differences in the operationalization of the construct. Resilience was measured using different instruments (e.g., CD-RISC, RS-14,

SRI-25, or adapted scales), and suicidal behavior was assessed as ideation, risk, attempts, or self-harming behavior. This variability limits direct comparison of findings and reinforces the need to move toward longitudinal designs, better-defined samples, and more robust synthesis procedures.

Among the main limitations of this review are: a) the heterogeneity of the included studies in terms of age, context, and design; b) the absence of a formal and standardized assessment of the methodological quality of the primary studies; c) the lack of a formal meta-analysis; d) potential publication bias stemming from the sources consulted; and e) the inclusion of non-indexed academic literature, a decision that broadens the

search coverage but also increases the variability of the synthesized evidence. These limitations suggest that results should be interpreted with caution.

Based on this, future research should prioritize longitudinal and comparative studies that provide a more precise understanding of resilience across different stages of adolescent development, and should incorporate standardized measurement and quality assessment procedures. Similarly, it would be advisable to expand the search to other international databases and to compare the evidence by sample type, sociocultural context, and the specific form of suicidality assessed.

5. Conclusions

In summary, the reviewed evidence suggests a consistent association between higher levels of resilience and lower levels of suicidal ideation, risk, or behavior in adolescent and youth populations. However, the scope of this conclusion is descriptive rather than causal, as the

available evidence is largely observational and heterogeneous. Therefore, rather than asserting a conclusive protective effect, the findings support the need for further research into resilience as a potentially relevant variable for prevention and intervention in adolescent mental health.

6. Recommendations

Based on these findings, it is recommended that health and educational institutions consider interventions to strengthen resilient resources, particularly emotional regulation, social support, and problem-solving. However, the implementation of preventive programs should

be supported by rigorous efficacy evaluations and longitudinal designs that allow for a more precise determination of which components yield better results in different cultural and socio-educational contexts.

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