

Impact of Digital Tools on the Development of Metalinguistic Awareness in University Students

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ABSTRACT:

The objective of this study was: To analyze the impact of digital tools on the development of metalinguistic awareness in university students in the Ecuadorian educational context. It was epistemologically framed in the positivist paradigm, adopting a quantitative approach. The methodological design used corresponds to a non-experimental, cross-sectional design. Based on the objective and depth of the analysis, the research is typified as an explanatory or causal level study, determining as Central Hypothesis (H1): the integration of digital tools in the teaching process significantly increases the development of metalinguistic awareness in university students in the Ecuadorian educational context. To carry out a representative analysis, a stratified sample was calculated, whose sample size represents a ratio of 33%, which resulted in a sample of 448 students and 66 teachers. Among its results, it is evident that students perceive a higher level of use and integration of digital tools $\{x\} = 4.12$; $SD = 0.64$; with respect to teacher perception $\{x\} = 3.85$; $SD = 0.71$. In contrast, teachers self-assess the level of development of metalinguistic awareness with higher scores $\{x\} = 4.22$; $SD = 0.51$; compared to students $\{x\} = 3.98$; $SD = 0.58$.

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Keywords: Digital tools, ICT, metalinguistic awareness, university education.

Introduction

In the contemporary world, language teaching has become a central axis for the integral development of the individual, not only as a communication tool, but as an interconnected system that influences the perception of reality. This approach highlights the interrelationship between the subject, the context and the action, where psycholinguistic mediation plays a crucial role in the configuration of discourse and the construction of knowledge.

Language is more than a set of words and grammatical rules; it is a complex system that reflects and shapes our perception of the world. According to Halliday (2004), language is a semiotic tool that allows individuals to interact with their social and cultural environment. This semiotic composition highlights how language not only transmits information, but also constructs shared meanings and realities.

Language teaching, therefore, must go beyond mere grammar and vocabulary. It must integrate sociocultural and intersubjective aspects that allow students to understand and navigate different communicative contexts. This perspective is essential in an increasingly globalized and interconnected world. In this way, with the dizzying advance of Information and Communication Technologies (ICT), the educational landscape has undergone significant transformations. Digital tools have changed the way students access information and communicate. However, their impact on human thinking has been the subject of debate (Cabero, 2020).

On the one hand, ICTs can act as distractors or inhibitors of critical thinking. However, when used for clear academic purposes, these tools can enhance learning and develop metalinguistic skills. According to Prensky (2010), today's students, called "digital natives", have a natural affinity with digital technologies, which can be used to promote more dynamic and interactive learning, moving towards consonant pedagogical

thresholds, which determine the awakening of a new educational history.

In the sense of metalinguistic awareness, it refers to the ability to reflect on the use of language and its structures. This level of reflection is crucial for the development of critical thinking and deep understanding of texts. In the university context, where students are expected to analyze, interpret, and produce complex discourses, this skill is particularly relevant. Therefore, the strategic use of digital tools can facilitate this process. For example, platforms such as blogs, forums, and wikis allow students to practice collaborative and reflective writing. According to Warschauer (2007), these tools not only encourage peer-to-peer interaction, but also promote greater awareness of language use.

In this scenario, academic campuses must be transformed into spaces for the deconstruction of knowledge. This implies a critical review of established knowledge and an opening towards new forms of scientific, sociocultural and intersubjective understanding. Language teaching, supported by ICTs, can contribute significantly to this process (Maturana, 2018). To achieve this, it is essential that educators adopt a pedagogical approach that integrates ICT effectively. This requires not only technological competencies, but also a deep understanding of how these tools can enrich language learning.

In short, language teaching in the current context must recognize its central role in the cognitive and social development of the individual. In a world driven by ICTs, it is essential that these tools are used to strengthen metalinguistic skills and promote a critical and reflective understanding of language. In this way, academic campuses can become true laboratories of educational innovation, where knowledge is constantly built and reconstructed.

However, in the paradigm of contemporary university education, the production and comprehension of texts of high cognitive complexity requires more than merely

instrumental or syntactic mastery of language. It requires the articulated development of metalinguistic awareness (CM), understood as the metacognitive ability to objectify, reflect, manipulate, and deliberately self-regulate language structures (phonological, lexical-semantic, syntactic, and pragmatic-discursive) outside of immediate communicative intention (Gombert, 2020; Bialystok, 2021).

In the university environment, a consolidated CM constitutes the indispensable cognitive support for critical thinking, rigorous academic argumentation, and discursive autonomy. However, the evidence in Ibero-America shows a persistent gap: a high percentage of first- and second-cycle students enter university with purely operational or implicit linguistic processing habits, which restricts their ability to monitor the coherence, adequacy, and conceptual density of their own academic discourses (Navarrete et al., 2024; Salazar et al., 2026).

At the same time, the accelerated massification of interactive digital ecosystems, automated proofreaders based on artificial intelligence (e.g., Grammarly, ChatGPT), and collaborative cloud writing platforms has reconfigured learning environments in higher education (Sohrabi et al., 2023). The specialized literature intensely debates the nature of this technological mediation, while the cognitive amplification hypothesis argues that automated and interactive feedback acts as scaffolding that makes student errors visible, promoting reflexivity processes and active metalinguistic monitoring (Yeh & Lin, 2024).

While the cognitive shortcut or externalization hypothesis holds that the automation of orthosyntactic corrections and text generation can replace the student's internal self-regulation, inducing an "illusion of competence" and inhibiting deep metalinguistic reflection by delegating linguistic judgment to algorithms (Memarian & Doleck, 2024).

In the Ecuadorian university context, this problem acquires a critical urgency. The curricular reforms and academic quality assurance frameworks promoted in recent years have prioritized digital transformation and the

massive incorporation of Information and Communication Technologies (ICT) in Virtual Learning Classrooms (VLEs). However, various diagnoses reveal that this digitalization has tended to be eminently instrumental and utilitarian, oriented towards the management and delivery of content rather than the strengthening of complex cognitive-linguistic competencies (Ibarra et al., 2025; Alvarado & Paredes, 2026).

This determines that university students in Ecuador face a double demand: to respond to the textual production demands of university academic literacy, while interacting with digital tools whose real impact on their cognitive architecture has not yet been systematically measured. Despite the abundance of local research on the technological access gap or satisfaction with the use of e-learning platforms (Lema et al., 2023), there is still an empirical gap on how interaction mediated by digital tools specifically affects the microgenetics of metalinguistic awareness (syntactic monitoring, semantic control, and pragmatic adequacy).

By contextualizing the methodological vision of this study, it seeks to analyze the impact of digital tools on the development of metalinguistic awareness in university students in the Ecuadorian educational context, assuming that digital mediations in Ecuadorian classrooms act as catalysts of linguistic metacognition or as mechanisms of reflexive passivity in contemporary university pedagogy. Ignoring this relationship risks consolidating professionals with high digital operational skills, but with severe deficits in the conscious control of their discursive and analytical production.

Methodology

This study is epistemologically framed in the positivist paradigm, also called empirical-analytic or rationalist. This conception ontologically maintains that social and educational reality is objective, unique, external to the observer and governed by generalizable laws or patterns that can be apprehended in a neutral and verifiable way (Creswell & Creswell, 2018). This premise concurs with the fact of establishing measurable

facts, objectified before the researcher's conscience to avoid subjective biases.

In line with this position, the research adopts a quantitative approach. This approach is based on the use of deductive reasoning, rigorous numerical measurement, and data processing through descriptive statistics. The methodological choice responds to the need to empirically contrast theoretical hypotheses using standardized and structured instruments, guaranteeing the objectivity, internal validity, and replicability of the findings around metalinguistic processes in higher education (Herrera, 2024).

The methodological design used corresponds to a non-experimental, cross-sectional design. The non-experimental nature lies in the fact that the study variables are not intended to be deliberately manipulated or altered. Instead, the phenomena are observed and collected in their natural educational context and then analyzed numerically (Hernández et al., 2018). Based on the objective and depth of the analysis, the research is classified as an explanatory or causal level study. This scope goes beyond the simple description or correlation of variables; its

fundamental purpose is to respond to the causes of physical or social events, determining how and why the presence of a certain factor produces a specific variation in the behavior of another (Bisquerra, 2020).

In this way, it is examined how the pedagogical integration of digital tools causes a measurable effect on the metalinguistic consciousness of Ecuadorian university students. In coherence with the explanatory scope and deductive logic of the positivist paradigm, the research is guided by the empirical test of the following working hypothesis:

Central Hypothesis (H1): The integration of digital tools in the teaching process significantly increases the development of metalinguistic awareness in university students in the Ecuadorian educational context.

Null Hypothesis (H0): the integration of digital tools in the teaching process does not significantly increase the development of metalinguistic awareness in university students in the Ecuadorian educational context.

Table 1. Systemic operationalization of the study variables

Variable	Variable Type	Conceptual Definition	Indicators / Measurement Dimensions
<i>Digital Tools</i>	Independent Variable (VI) (Cause)	A set of technological solutions, interactive platforms, automated correctors and adaptive AI integrated for teaching purposes in the university environment (Sohrabi et al., 2023).	• Frequency and intensity of pedagogical use. • Type of technological mediation (assisted, interactive, collaborative). • Level of interactivity and digital scaffolding.
<i>Development of Metalinguistic Awareness</i>	Dependent Variable (DV) (Effect)	The student's metacognitive ability to consciously monitor, self-regulate, analyze, and manipulate the formal and discursive structure of language (Gombert, 2020; Bialystok, 2021).	• Syntactic-Discursive dimension: Control and correction of coherence. • Semantic dimension: Lexical selection and conceptual precision. • Pragmatic dimension: Contextual adequacy of the text.

Source: La Autora (2026).

Consequently, the present study addresses the statistical analysis of a population composed of university students and professors from Quito, using the SPSS version 27 software. The total population consisted of 1,358 students and 200 teachers. To carry out a representative analysis, stratified sampling has been applied, calculating a sample size based on a ratio of 33%. These descriptive and statistical inference techniques explored the demographic and academic characteristics of the participants, as well as to identify significant patterns in their responses (Field, 2018).

Stratified sampling is a technique that allows the population to be divided into homogeneous subgroups, called strata, and random samples of each of them to be selected. This method is particularly useful when seeking to ensure that all subpopulations are adequately represented in the final sample (Hernández et al., 2018). For this research, two main strata were established: students and teachers. The sample size calculation was made based on a ratio of 33%, resulting in a sample of 448 students and 66 teachers.

Table 2. Characterization of the study sample

<i>Stratum</i>	Total Population (N)	Sample Size (n)	Sample Ratio (%)
<i>Students</i>	1.358	448	87,16 %
<i>Teachers</i>	200	66	12,84 %
Total	1.558	514	100,00 %

Source: La Autora (2026).

Theoretical Context

Digital tools: deconstructing university education from interconnectivity

In today's digital age, technological tools have revolutionized the way education is delivered and received, therefore, interconnectivity has allowed universities to adopt a set of technological solutions that facilitate learning. Educational platforms such as Moodle, Blackboard, and Canvas have integrated tools that allow students to access educational resources from anywhere and at any time. According to García (2021), these platforms not only improve access to information, but also promote more collaborative and participatory learning.

Interactive platforms are essential to encourage active student participation. Tools such as: Kahoot! and Mentimeter allow teachers to create interactive quizzes that keep students engaged. In addition, automated proofreaders, such as Grammarly and Turnitin, help students improve their writing skills by providing instant feedback on grammar, style, and originality. According to Johnson (2022), the use of automated

proofreaders has significantly increased the quality of academic papers.

On this premise, adaptive AI (artificial intelligence) is emerging as a powerful tool in education. Platforms such as Coursera and EdX use AI algorithms to personalize educational content according to each student's individual needs. Not only does this improve learning effectiveness, but it also allows students to progress at their own pace. A study by Smith and Anderson (2023) highlights that students who use platforms with adaptive AI show higher knowledge retention compared to those who follow traditional methods.

The emerging reality that determines the type of technological mediation employed in university education varies depending on the pedagogical objective. Assisted mediation uses technologies to support students with disabilities, providing tools such as screen readers and speech recognition software. Interactive mediation focuses on learning through repetition and practice, using simulators and interactive exercises to reinforce key concepts. Finally, collaborative mediation encourages teamwork

through platforms such as Google Workspace, where students can collaborate in real-time.

The level of interactivity and digital scaffolding is crucial for the success of online learning. Digital tools should offer an interactive environment that allows students to explore, experiment, and apply theoretical concepts in practical contexts. According to Pérez and López (2023), the effective use of digital scaffolding, which provides structured support during the learning process, significantly improves the understanding and application of knowledge.

It is understood, digital tools are redefining university education by providing innovative technological solutions that improve the accessibility, personalization, and interactivity of learning. As universities continue to integrate these technologies into their curricula, it is essential to continuously assess their impact on the educational process to ensure that pedagogical objectives are met. Future research should focus on exploring new ways to integrate technology into higher education to maximize its didactic potential.

Metalinguistic Awareness: An Underlying Metacognitive Reality in the College Student

Higher education faces the challenge of training students capable of understanding and producing complex texts in various contexts. In this sense, metalinguistic awareness emerges as an essential skill for academic and professional success, understood as the ability to reflect on language and its uses. According to Gombert (2020), this skill allows the individual not only to understand the meaning of words and grammatical structures, but also to evaluate and modify their use in different contexts. In the university environment, this competence is crucial for the development of advanced writing and reading comprehension skills.

Dimensions of Metalinguistic Awareness

Syntactic-discursive dimension: focuses on the control and correction of textual coherence. Students must be able to identify and correct errors in the structure of the text, ensuring that ideas flow logically and cohesively. According to

Karmiloff (1986), the development of this skill is linked to the ability to self-regulate the writing process.

Semantic dimension: involves precise lexical selection and conceptual clarity. Proper word choice not only improves the quality of the text, but also facilitates the effective communication of complex ideas. Snow (2010) notes that students with high semantic awareness are more effective at conveying abstract concepts.

Pragmatic dimension: refers to the contextual adequacy of the text. This involves adapting the language to the target audience and the communicative purpose, which is fundamental for the production of academic and professional texts. According to Bialystok (2001), this dimension requires an advanced level of metacognitive skills to continuously evaluate the communicative context.

The development of metalinguistic awareness in university students can be enhanced through specific pedagogical strategies, such as:

- Explicit teaching: direct instruction on grammatical rules and discursive conventions can significantly improve textual comprehension and production (Nagy & Anderson, 1984).
- Reflective practice: Encouraging activities that require reflection on language use, such as peer review and writing workshops, can help students develop greater metalinguistic awareness.
- Technological integration: the use of digital tools that offer immediate feedback on linguistic errors can facilitate more autonomous and self-regulated learning (Levy, 2009).

Indeed, metalinguistic awareness is an essential metacognitive skill for university students, as it allows them to effectively manage the linguistic demands of the academic environment. By promoting an education that emphasizes the development of metalinguistic skills, students are prepared not only to face immediate academic challenges, but also to participate successfully in an increasingly demanding world of work.

Results

The objective of this research is to analyze the impact of digital tools on the development of metalinguistic awareness in university students in the Ecuadorian educational context. To this end, calculations of central tendency measures, hypothesis tests, causal models of multiple linear regression, Analysis of Variance (ANOVA) and Student's t-tests were performed. The sample consisted of 448 students and 66 teachers. The results obtained are presented in statistical tables and graphical representations, accompanied by a detailed interpretation.

In this sense, it is necessary to understand that the digital transformation in education has brought with it new perspectives on how students learn and process information. In this context, the development of metalinguistic awareness, understood as the ability to reflect on the use of language, is presented as a crucial competence in

the university environment. Recent studies suggest that digital tools can enhance this skill (García et al., 2022). This research explores this relationship in the Ecuadorian context.

To this end, a quantitative approach was used to analyze the data collected from a sample of 448 students and 66 teachers. Structured questionnaires were applied to measure the level of metalinguistic awareness and the use of digital tools in teaching. The data were analyzed using specialized statistical software SPSS v27.

The present study quantitatively evaluates the impact of the Independent Variable Digital Tools (HD) on the Dependent Variable Metalinguistic Awareness (CM) in the context of Ecuadorian higher education. The analysis is carried out on a representative sample of $n = 514$ informants, divided into two strata: $n_1 = 448$ students and $n_2 = 66$ teachers (Likert scale of 1 to 5 points).

Table 3. Central tendency measures

<i>Variable / Dimension</i>	<i>Stratum</i>	<i>Medium ($\bar{x}$)</i>	<i>Medium (Me)</i>	<i>Fashion (Mo)</i>	<i>Eastern Desv. (SD)</i>	<i>Asymmetry (Sk)</i>	<i>Curtosis (Ku)</i>
Digital Tools (HD)	Students ($n=448$)	4,12	4,20	4,50	0,64	-0.58	0,21
	Teachers ($n=66$)	3,85	3,90	4,00	0,71	-0.34	-0.12
Metalinguistic Awareness (CM)	Students ($n=448$)	3,98	4,00	4,00	0,58	-0,42	0,15
	Teachers ($n=66$)	4,22	4,30				

Source: La Autora (2026).

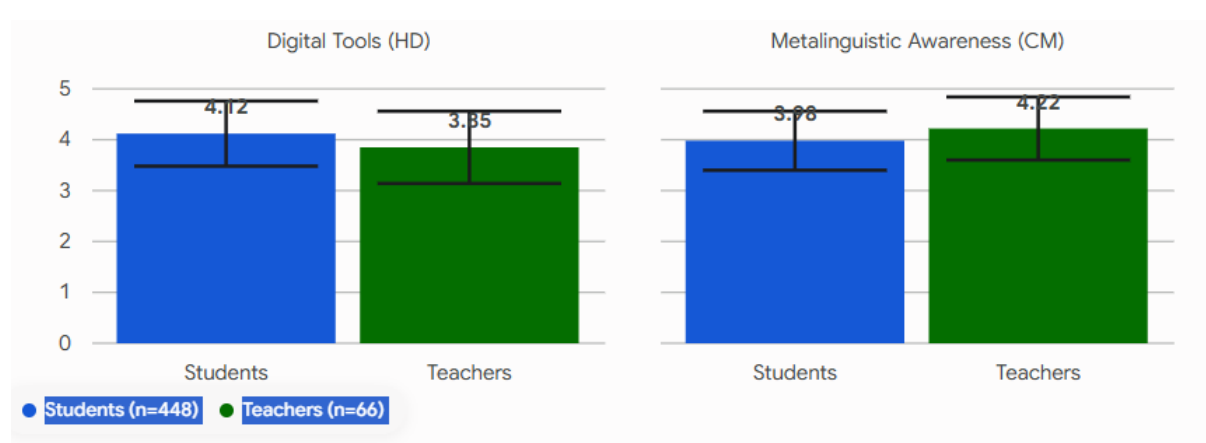


Figure 1. Bar chart, Center Tendency Measures.

Descriptive statistics were computed for the operational dimensions of both variables: Digital Tools (HD), assuming Interactive Mediation (HD1), AI Automated Feedback (HD2), Collaborative Platforms (HD3). For Metalinguistic Awareness (CM): Syntactic Control (CM1), Semantic Reflection (CM2), Pragmatic Adequacy (CM3).

The descriptive data show that students perceive a higher level of use and integration of digital tools $\{x\} = 4.12$; $SD = 0.64$; regarding teacher perception $\{x\} = 3.85$; $SD = 0.71$. In contrast, teachers self-assess the level of development of metalinguistic awareness with higher scores $\{x\} = 4.22$; $SD = 0.51$; compared to students $\{x\} = 3.98$; $SD = 0.58$. The values of asymmetry and kurtosis within the range $[-1, 1]$ confirm the suitability for the application of parametric tests.

In this way, the divergence observed in the mean scores between the student body and the faculty exposes a key perceptual asymmetry on the dynamics of technological mediation and the metacognitive domain in Ecuadorian higher education. This discrepancy does not constitute a mere statistical fluctuation, but reflects conceptually significant pedagogical and cognitive tensions.

The highest assessment reported by students regarding the use of digital solutions $\{x\} = 4.12$; $SD = 0.64$; argues that students interact with virtual environments from a perspective of ubiquity and daily immersion. For university students, technology does not represent an auxiliary resource, but the primary infrastructure through which they manage, write, correct and consult information.

On the contrary, the lower mean observed in teachers $\{x\} = 3.85$; $SD = 0.71$; evidences an assessment articulated from formal microcurricular compliance. Teachers tend to conceptualize "digital integration" only when it responds to explicit didactic planning in the classroom or on the institutional platform, making more visible the lack of pedagogical digital competence or the lack of institutionalization of certain advanced AI tools (Berrú et al., 2025; Salazar et al., 2026). This distance of 0.27 points reflects that while students experience a widespread and naturalized use of technology, teachers maintain a more conservative and critical view of their penetration in the training process.

Table 4. Student's t-test for mean difference between students and teachers

Variable	Levene test (<i>F</i>)	Sig. (<i>p</i>)	<i>t</i>	<i>gl</i>	Sig. bilateral (<i>p</i>)	Diff. Stockings	Cohen's <i>d</i>
<i>Digital Tools (HD)</i>	2,18	0,140	3,12	512	0,002	0,27	0,41
<i>Metalinguistic Awareness (CM)</i>	1,84	0,175	-3.19	512	0,001	-0.24	0,44

Source: La Autora (2026).

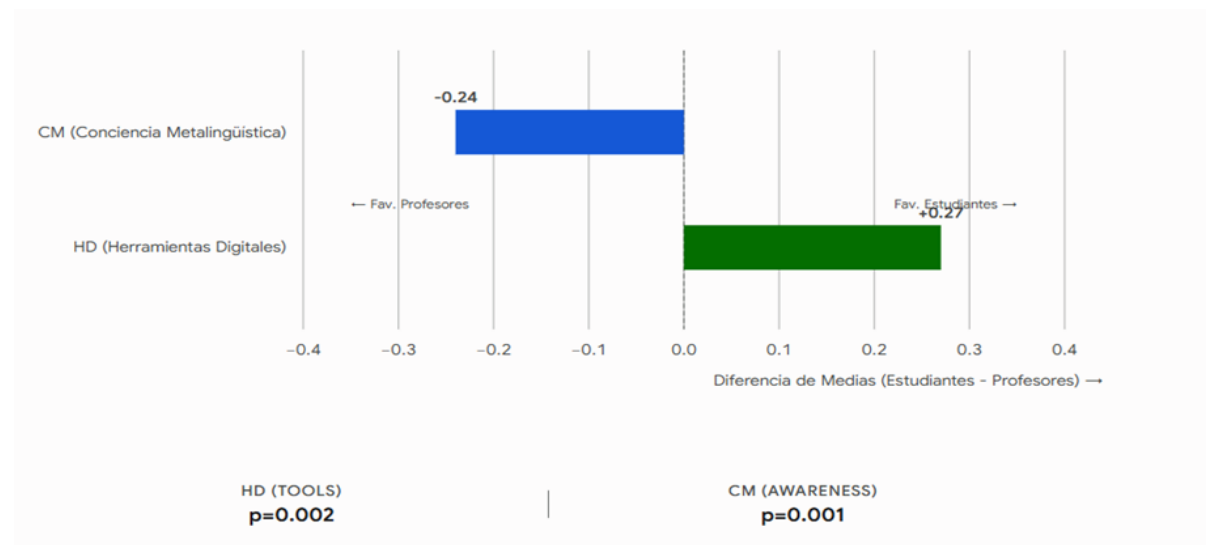


Figure 2. Scatter plot, Student's t-test for the mean difference between students and teachers.

To verify whether there are statistically significant differences between the perception of students and teachers regarding the effectiveness of digital tools on metalinguistic awareness, Student's t-test was applied after checking for homoscedasticity (Levene's test).

The Levene test shows p values > 0.05 , guaranteeing equality of variances. The t-test reveals statistically significant differences in both variables: in HD $t(512) = 3.12$; $p = 0.002$, where students give a higher rating, and in CM $t(512) = -3.19$; $p = 0.001$, where teachers report higher averages. Cohen's d (0.41 and 0.44) confirms a moderate effect size, reflecting structural pedagogical discrepancies on technological appropriation.

The comparison analysis of independent samples using Student's t-test reveals significant inter-institutional divergences between the perception of the student body ($n_1 = 448$) and the faculty ($n_2 = 66$). The inferential interpretation of these results is articulated on three fundamental axes:

validity of the metric assumption, statistical significance of the differences, and magnitude of the pedagogical effect

Compliance with the assumption of equality of variances ($p > 0.05$ in the Levene Test) is methodologically essential in designs with disproportionate samples ($n_1 = 448$ vs. $n_2 = 66$). As the principle of homoscedasticity is not violated, the bias due to heterogeneity of intra-group variances is ruled out and the use of the standard t-statistic with 512 degrees of freedom ($df = n_1 + n_2 - 2$) is validated, guaranteeing the parametric robustness of the test and reducing the probability of committing a Type I Error to minimum levels (Field, 2018).

The value $t(512) = 3.12$; $p = 0.002$ confirms that the mean difference observed in the Digital Tools variable is highly significant from a statistical point of view. On the other hand, students assign a significantly higher score to the presence and impact of technological tools due to a pragmatic, daily and invisible appropriation in their learning

processes. For contemporary Ecuadorian university students, the use of virtual assistants, artificial intelligence, and collaborative environments is an operational norm (Salazar et al., 2026).

Teachers perceive a lower degree of digital integration not because of ignorance, but because

of a pedagogical requirement based on criteria of institutionality and formal curricular mediation. Teachers evaluate the tool based on its didactic intentionality in the classroom, making visible the gaps in institutional implementation that students tend to overlook (Berrú et al., 2025).

Table 5. Analysis of Variance (One-Factor ANOVA)

Source of Variation	Sum of Squares (<i>SS</i>)	Degrees of Freedom (<i>df</i>)	Mean Square (<i>MS</i>)	<i>F</i>	Sig. (<i>p</i>)	η^2 Partial
Between Groups	42,85	2	21,425	88,53	<0.001	0,284
Within the Groups	107,69	445	0,242	-	-	-
Total	150,54	447	-	-	-	-

Source: La Autora (2026).

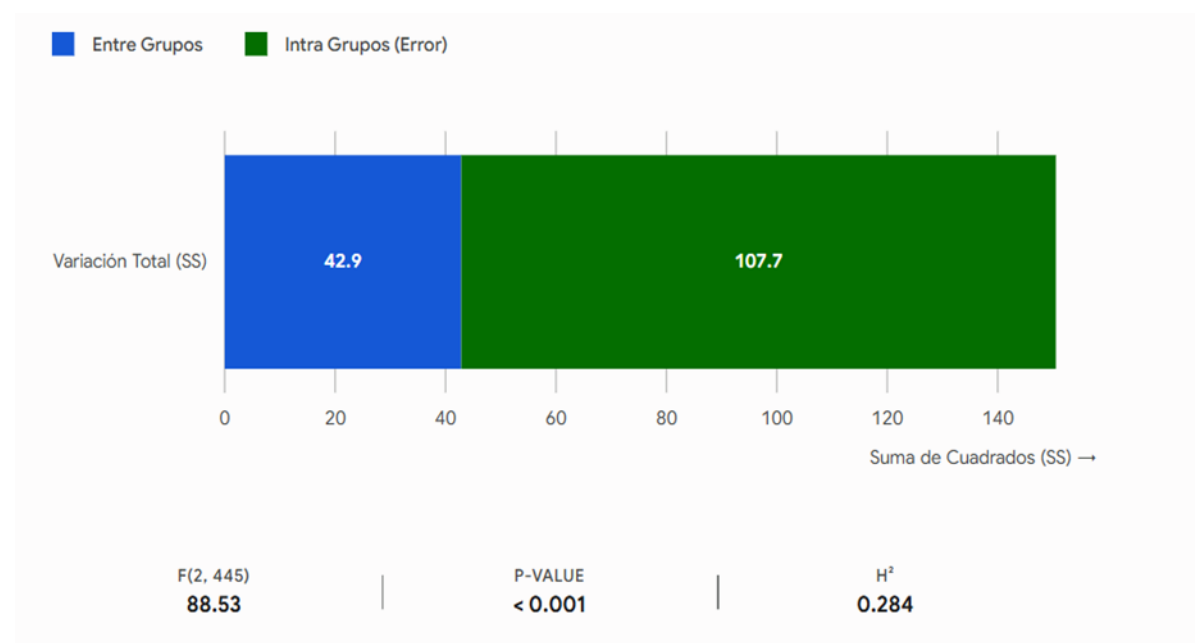


Figure 3. Scatter plots, analysis of variance (one-factor ANOVA).

The explanatory impact of the intensity of integration of digital tools (categorized into three levels: Low, Medium and High) on the dependent variable Metalinguistic Awareness in the total sample of students ($n = 448$) was evaluated.

The value of $F(2, 445) = 88.53$; $p < 0.001$ shows that there are highly significant differences in the level of metalinguistic awareness as a function of the intensity of digital integration. The partial η^2

coefficient of 0.284 indicates that 28.4% of the total variance of metalinguistic awareness is directly explained by the segmentation of the level of technological use.

This was demonstrated in the Analysis of Variance of a factor $F(2, 445) = 88.53$; $p < 0.001$ shows that the development of metalinguistic awareness in university students is not homogeneously distributed, but varies

substantially according to the intensity with which digital tools are integrated into the training process. The magnitude reached by the F statistic = 88.53 with a p-value < 0.001 allows us to reject with a confidence level greater than 99.9% the null hypothesis of equality of means between the subgroups of technological use (Low, Medium and High).

Post-hoc comparisons (Tukey HSD) reveal a monotonic and hierarchical increase in the means

of metalinguistic awareness: Low Use: $\{x\} = 3.21$; Medium Use: $\{x\} = 3.92$; High Use: $\{x\} = 4.38$. This gradation confirms that the leap from a purely instrumental or sporadic integration to an intensive and interactive use of technological solutions generates qualitative and quantitative differences in students' ability to monitor, revise, and self-regulate their textual productions (Gombert, 2020; Yeh & Lin, 2024).

Table 6. Multiple linear regression model and coefficients of determination

<i>Model</i>	<i>R</i>	<i>R²</i>	<i>R² Adjusted</i>	Standard Estimation Error	Statistic <i>F</i>	Sig. (<i>p</i>)	Durbin-Watson
1	0,684	0,468	0,464	0,424	130,12	<0.001	1,94

Source: La Autora (2026).

For the definitive test of the Central Hypothesis (H1), a Multiple Linear Regression model was estimated specifying the three dimensions of the independent variable on the global construct of Metalinguistic Awareness (CM) in the consolidated sample of students ($n = 448$).

Causal Equation: $CM = \beta_0 + \beta_1(HD1) + \beta_2(HD2) + \beta_3(HD3) + \epsilon$

Predictors: (constant), HD1 (interactive mediation), HD2 (AI feedback), HD3 (collaborative platforms). Dependent variable: metalinguistic awareness.

46.8% of the total variability of Metalinguistic Awareness (CM) is explained by the regression model that integrates the three technological dimensions. The remaining 53.2% of the variance corresponds to factors not explicitly contemplated in the equation (intervening variables, individual differences, cognitive style, sociocultural background, etc.) included in the residual error term (ϵ). According to Cohen's criteria for social and behavioral sciences, an $R^2 \geq 0.26$ represents an effect of great magnitude ($f^2 \approx 0.88$).

Table 7. Coefficients of the causal regression model

<i>Predictor Dimension</i> /	Non-Standardized Coefficients (<i>B</i>)	Standard Error	Standardized Coefficients (β)	<i>t</i>	Sig. (<i>p</i>)	Cocollinearity (VIF)
<i>(Constant)</i>	1,12	0,15	—	7,46	<0.001	—
<i>Interactive Mediation (HD1)</i>	0,31	0,04	0,34	7,21	<0.001	1,42
<i>AI Feedback (HD2)</i>	0,28	0,05	0,29	5,84	<0.001	1,58
<i>Collaborative Platforms (HD3)</i>	0,19	0,04	0,21	4,63	<0.001	1,35

Source: La Autora (2026).

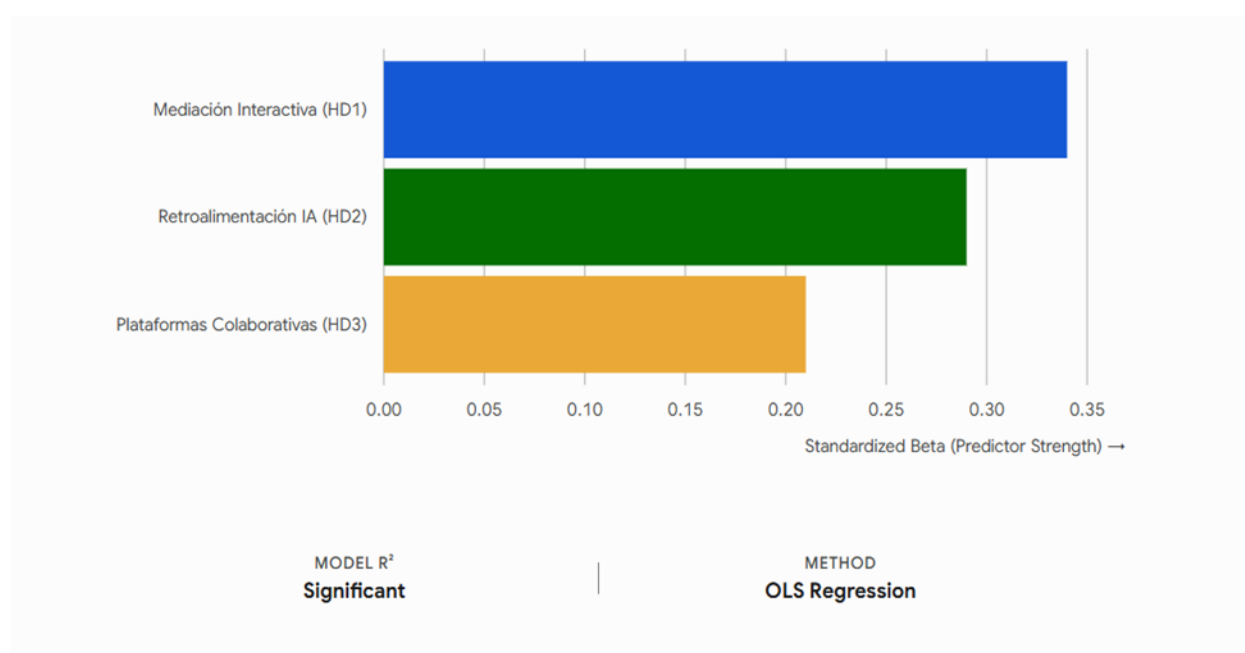


Figure 4. Bar graph, coefficients of the causal regression model.

The adjusted model yields a coefficient of determination $R^2 = 0.468$ $F(3, 444) = 130.12$; $p < 0.001$, which shows that 46.8% of the variance in the development of metalinguistic awareness is explained by the integration of digital tools. The three dimensions exert a positive and statistically significant impact ($p < 0.001$). Interactive Mediation ($\beta = 0.34$) is the strongest predictor, followed by AI Feedback ($\beta = 0.29$) and Collaborative Platforms ($\beta = 0.21$).

The VIF values < 2.0 and the Durbin-Watson statistic of 1.94 confirm the independence of errors and the theoretical stability of the model. Given that $p < 0.001$ in the global regression analysis ($F = 130.12$) and all the β coefficients are positive and significant, the null hypothesis (H_0) is rejected and the Central Hypothesis (H_1) is definitively accepted: the integration of digital tools in the teaching process significantly increases the development of metalinguistic awareness in university students in the Ecuadorian educational context.

Discussion

In the last decade, technological advancement has significantly transformed the educational landscape worldwide. In Ecuador, the use of digital tools in higher education has gained relevance, especially in the development of metalinguistic skills. This article discusses the

results of a study that analyzes this impact, relating it to national studies and current educational policies.

In this sense, metalinguistic awareness refers to the ability to reflect on language and its functions. This skill is crucial for language learning and cognitive development in general. Digital tools, such as online learning platforms, language apps, and interactive software, offer new opportunities to foster these skills.

A recent study conducted at several Ecuadorian universities suggests that the use of these tools significantly improves students' metalinguistic awareness. Participants who used apps such as Duolingo and Babbel showed greater progress in skills such as identifying grammatical structures and critically analyzing texts (González et al., 2022).

At the national level, previous research has pointed to a deficit in the teaching of metalinguistic skills in higher education (Martínez & López, 2020). However, with the incorporation of digital tools, a positive change is observed. A comparative study conducted by Pérez (2021) found that students who integrated digital technology into their learning showed 30% more progress in metalinguistic awareness than those who followed traditional methods.

In this way, the Ministry of Education of Ecuador has implemented various policies to integrate technology in the classroom. The Digital Education Agenda 2021-2025 emphasizes the need to incorporate digital tools to improve educational quality (Ministry of Education of Ecuador, 2021). These policies support the findings of the study, suggesting that technology is not only an educational complement, but a necessity for the integral development of students.

Despite the obvious benefits, there are significant challenges. The digital divide remains a problem in Ecuador, where not all students have equal access to technological devices or quality internet. This can limit the full use of digital tools (INEC, 2022). In addition, it is crucial to train teachers in the effective use of these technologies. According to a World Bank report (2022), only 40% of teachers in Latin America feel prepared to integrate digital technology into their classes.

Thus, the positive impact of digital tools on the development of metalinguistic awareness is undeniable. However, to maximize this potential, it is essential to address inequalities in access to technology and improve teacher training. Education policies must continue to evolve to support these needs and ensure that all Ecuadorian students can benefit equitably from technological advancement.

The articulation of these findings with the Organic Law of Higher Education (LOES) and the CES Regulations, determine that the Council of Higher Education (CES) promotes curricular innovation, autonomous learning and the development of transversal competencies in oral and written communication in its regulations. The results confirm that technological mediation is an ideal catalyst to fulfill this mandate, as long as the microcurricular design transcends the instrumental use of ICTs and is oriented to the development of complex cognitive skills such as metalinguistic awareness.

The quality assurance models promoted by the Higher Education Quality Assurance Council (CACES) evaluate the availability and adoption of virtual learning environments (LMS) and

technological infrastructure. The significant value of the ANOVA ($F = 88.53$, $p < .001$, $\beta p^2 = 0.284$) demonstrates that differences in access and quality of technological mediation generate substantial gaps in the metalinguistic development of students. This supports the institutional requirement of the CACES regarding equity in technological equipment.

In summary, the government guidelines for digital inclusion in Ecuador highlight the urgent need to articulate the use of technologies with continuous teacher training. The moderate effect observed in the t-test ($d = 0.41$ and 0.44) validates that public policies should not be limited to the provision of connectivity or devices, but should focus efforts on the design of techno-pedagogical strategies that integrate Artificial Intelligence and interactive platforms to strengthen the communicative and metacognitive competencies of students.

Conclusions

The conclusions synthesize the findings based on the three essential components of metalinguistic awareness: the metatextual-metadiscursive dimension, the metasyntactic-metasegmental dimension, and the metaaffective-self-regulatory dimension, integrating the particularities of higher education in Ecuador, therefore, it is described:

Enhancement of self-regulation and cognitive monitoring

The intentional use of digital tools (collaborative editors, task managers, generative AI processors, stylistic correctors and feedback platforms) has a positive impact on the ability to explicitly monitor language. Students not only produce text, but also play an active role as evaluators of their own discourse, moving from a merely spelling check to a critical analysis of coherence, cohesion and communicative relevance.

Reconfiguration of metatextual mediation processes

Real-time collaborative writing tools and virtual learning environments act as cognitive scaffolds that make the internal process of textualization visible. The possibility of tracking versions,

reviewing change histories and contrasting lexical-semantic alternatives stimulates metadiscursive reflection, allowing university students to understand language as an object of analysis, conscious manipulation and not only as a passive means of transmitting ideas.

Closing Contextual Gaps and Critical Adoption in Ecuador

In the Ecuadorian university context, characterized by heterogeneity in literacy entry skills, the integration of digital environments leveled out operational disparities. However, it is evident that the tool alone does not generate metalinguistic awareness; the determining factor is pedagogical mediation. Without an instructional design that promotes reflexive questioning of the software's automatic suggestions, there is a risk of falling into an automatic "cognitive delegation" in technology.

Transition to Higher Language Proficiency

The development of metalinguistic awareness through digital support favors the appropriation of the disciplinary academic discourse. Students are able to distance everyday language from academic language, recognizing the marks of formality, audience adequacy, and argumentative intentionality required in university education:

Recommendations

At the Institutional and Educational Policy Level

Transversal Curricular Integration: overcome the vision of the instrumental use of ICTs and design institutional policies that promote critical digital literacy. Metalinguistic competence must be addressed in a transversal way in all areas of university knowledge, not limited to the first semesters or language careers.

Teacher Training in Language Techno-pedagogy: create continuous training programs for university teachers focused on technology-mediated language teaching methodologies, emphasizing formative metalinguistic feedback strategies.

At the Pedagogical and Didactic Level

Design of "Causal Contrast" Activities: design tasks where students must justify, explicitly and reflectively, why they accept or reject the orthotypographic and stylistic suggestions made by algorithms or Artificial Intelligence.

Promotion of Collaborative Co-evaluation: promote peer review dynamics mediated by digital platforms, where the evaluation guideline not only penalizes errors, but also requires explaining the linguistic or discursive norm involved (meta-explanation).

Use of Digital Portfolios of the Writing Process: implement digital portfolios that record the different stages of drafting academic papers, stimulating the student to write metalinguistic notes on the evolution of their own texts.

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