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Digital Innovation In Higher Education: Impact Of Digital Educational Resources On The Development Of Cognitive Skills

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Abstract: *The objective of this research was to analyze the impact of digital educational resources (DERs) on the development of cognitive skills in university students in Guayaquil. A quantitative approach with a quasi-experimental design was used, applying pretests and posttests to two non-equivalent groups: experimental and control. Measurements were performed using a validated structured questionnaire and the Mini-Mental State Examination (MMSE), which allowed for the establishment of cognitive profiles in dimensions such as memory, attention, calculation, and language. The results revealed significant improvements in the experimental group, with a 90% increase in basic, higher, and perceptual cognitive skills, supported by statistically significant p values < 0.05. The intervention showed that DERs, when applied pedagogically, optimize cognitive processes and promote meaningful learning. This analysis contributes to the adoption of SDG 4 by promoting inclusive and fair education through digital technologies, reducing educational inequalities, and fostering students' critical, balanced, and independent reasoning.*
Keywords: *Digital educational resources, cognitive skills, higher education, pedagogical innovation, cognitive assessment*

1. INTRODUCTION

Currently, higher education is immersed in a rapidly changing landscape driven by technological advancement. In this context, digital educational resources (DERs) have gained critical importance due to their transformative potential in the teaching and learning process. These resources—reflected in virtual platforms, multimedia content, interactive tools, and educational applications—are characterized by their accessibility, flexibility, and adaptability to the individual needs of university students. Their implementation has significantly contributed to the development of cognitive skills, fostering understanding, analysis, critical reflection, and problem-solving, all of which are key elements in academic and professional training (Durán & Gutiérrez, 2022).

According to the International Association for Educational Development (IAED) and institutions such as the Economic Commission for Latin America and the Caribbean (ECLAC) (2025), educational transformation cannot be understood without the active and strategic integration of digital technologies in the classroom. This integration should go beyond mere technical access, aiming instead to develop higher-order cognitive skills, foster meaningful learning, and reduce structural disparities in educational quality across diverse student populations.

As noted by Castelo et al. (2024), DERs have influenced curricular restructuring in higher education, introducing active methodologies that redefine the roles of both instructors and students. Vera and Mendoza (2024) emphasize that cognition, as a complex process, can be strengthened through the systematic use of these resources, provided that their implementation is grounded in sound pedagogical planning.

Globally, the rise of Massive Open Online Courses (MOOCs) and platform-based learning has been documented by UNESCO (2024), with over 220 million users reported in 2021—evidence of a widespread educational shift toward technology-mediated environments.

In terms of outcomes, the PISA (2022) assessment reveals that moderate use of digital technologies in learning processes correlates with improved academic performance. Additionally, students who engage with recreational digital media also demonstrate cognitive advantages over those who do not. However, UNESCO (2024) cautions that excessive or unregulated use may lead to distractions that undermine learning effectiveness, particularly in settings lacking clear pedagogical integration frameworks.

This phenomenon is particularly relevant in urban university contexts such as Guayaquil, where, despite growing access to technology, significant challenges remain. These include insufficient teacher training in DER use, student demotivation, and the absence of an institutional culture that promotes their pedagogical integration in a comprehensive manner.

Evidence from some higher education institutions in Guayaquil highlights a gap between the availability of digital resources and their effective use in the classroom. Identified issues include minimal use of virtual environments, limited student participation, and a negligible impact on key cognitive skills such as attention, memory, and critical analysis. These factors have contributed to worrying levels of student dropout, academic disengagement, and poor performance.

In light of these findings, there is a pressing need to rigorously investigate the impact of digital educational resources on the development of cognitive competencies—understood as students' ability to organize, process, and apply information in academic and professional settings. Accordingly, the main objective of this study is to analyze the effect of DERs on university students' cognitive competencies. Theoretically, the research draws on the contributions of Piaget and Bruner, who emphasize the active role of the learner in knowledge construction and advocate for learning environments that foster cognitive development through collaborative, reflective, and situated approaches (Prakash Chand, 2024).

From a practical standpoint, this research responds to the call for transforming higher education in Latin America through the adoption of technology focused on learning outcomes. It also seeks to generate evidence to inform decision-making in institutional, national, and regional educational policies. The study's social relevance lies in its potential to democratize access to quality education through technological tools that personalize learning, reduce inequality, and prepare students to face the cognitive and social challenges of the 21st century.

Digital educational resources are understood as technology-based tools designed with pedagogical intent, aimed at mediating, enriching, and personalizing teaching and learning processes (Marín et al., 2022). Huang et al. (2025) classify these resources as including virtual platforms, educational apps, interactive simulators, and multimedia content, whose potential lies in providing dynamic, inclusive, and student-centered learning experiences. As Martí (2025) notes, DERs not only broaden access to information but also foster collaborative learning environments that stimulate autonomy, motivation, and critical thinking. Their effective curricular integration is central to innovating higher education and meeting the demands of the digital society.

Cognitive competencies, on the other hand, refer to a set of essential mental abilities that enable individuals to process, interpret, and apply information in academic and professional contexts (Abusamra et al., 2020). According to Gerlich (2025), these competencies include sustained attention, working memory, planning, logical analysis, problem-solving, and metacognition. These abilities are responsible for the monitoring, regulation, and evaluation of one's own thinking, allowing students to self-regulate their learning and make informed decisions throughout their educational journey.

2. METHODS

This research adopts an applied and quantitative approach, aimed at evaluating the impact of Digital Educational Resources (DER) on the development of cognitive competencies in university students. The study addresses a real-world issue within the academic environment, employing technological tools as an intervention strategy.

A quasi-experimental design was used, involving two non-equivalent groups—experimental and control—with pretest and posttest measurements conducted to compare outcomes before and after the implementation of the DER program. The research followed a longitudinal framework, allowing for the analysis of changes over time.

The population consisted of 150 university students distributed across three classrooms. The sample was selected intentionally, based on inclusion criteria such as active enrollment, regular attendance, and participation in academic platforms. Students with frequent absenteeism were excluded from the analysis. The experimental group was assigned to classroom COM-S-7-8, while the control group was placed in COM-S-7-7, resulting in a final sample of 100 participants.

Two complementary instruments were used for data collection. First, a structured cognitive competency questionnaire, validated by expert judgment and pilot testing, which achieved a reliability index of 0.93 using Cronbach's alpha coefficient—indicating high internal consistency. Second, the Mini-Mental State Examination (MMSE), a standardized psychometric tool designed to assess cognitive functions such as orientation, memory, attention, calculation, language, and visuoconstructive abilities (Llamuca et al., 2020). This instrument was applied during both the pretest and posttest phases to establish a cognitive profile for participants, thereby strengthening the validity of the results obtained.

Table 1

Mini-Mental State Examination Administered to Students.

Assessed Area	Items / General Instructions	Max Score
1. Temporal Orientation	What is today's date? What day of the week is it? What month, year, and day is it?	5
2. Spatial Orientation	Where are you right now (classroom/building name)? Which university? City? Province? Country?	5
3. Word Registration	The examiner names 3 words (e.g., tree, book, sun). The student must repeat them.	3
4. Attention & Calculation	Subtract 6 from 100 in five consecutive steps (100, 94, 88, 82, 76). One point per correct answer.	5
5. Recall Memory	Recall the 3 words from earlier (tree, book, sun) after the calculation task.	3
6. Language	Name two common objects (e.g., pencil, watch). Repeat the phrase: "The early bird catches the worm." Follow a three-step command: Fold a paper and place it on the table. Write a complete sentence.	8
7. Visuoconstructive Skill	Copy a drawing of two geometric figures (e.g., intersecting pentagons or simple shapes). Accuracy and proportion are assessed.	1
		30

Note: Adapted by Ruiz (2025)

The reliability of the instruments was confirmed through Cronbach's alpha coefficient, yielding a value of 0.93, which indicates high internal consistency. Furthermore, the study adhered to all institutional ethical principles: justice, autonomy, non-maleficence, and beneficence—ensuring informed consent and the protection of participants.

3. RESULTS

Structured instruments were applied to assess the impact of digital educational resources on the development of cognitive competencies. The data were processed using descriptive statistics and analyzed with the support of SPSS software. The results were grouped according to the assessed cognitive dimensions: basic, higher-order, and perceptual.

Table 2 Test Results

Central Tendency Measure	Value
Mean	25.62
Mode	30
Median	27
Maximum Score	30
Minimum Score	19
Range	11

Central Tendency Measure	Value
Note: Compiled by Ruiz (2025)	

Analysis of the central tendency measures of the MMSE applied to 50 students revealed a mean score of 25.62, suggesting a general performance within the range of mild cognitive impairment, although close to normal. The mode was 30, the highest possible score, indicating that several students achieved optimal cognitive performance. The median score of 27 confirms that at least half of the students scored within the normal range. The 11-point range, with scores between 19 and 30, indicates moderate variability. These findings suggest a positive impact of digital educational resources on cognitive functions, albeit with individual differences that may require pedagogical attention.

Table 3 Cognitive Functioning Distribution

Level of Cognitive Functioning	Score Range	No. of Students	Percentage (%)
Normal cognitive functioning	27–30	27	54%
Mild cognitive impairment	24–26	15	30%
Mild to moderate cognitive decline	19–23	8	16%
Significant cognitive decline (<19)	0	0	0%

Note: Compiled by Ruiz (2025)

MMSE results show that 54% of students exhibited normal cognitive functioning (scores between 27 and 30), representing the majority of the group and reflecting a positive effect of digital educational resources. Thirty percent were within the mild cognitive impairment range (24–26), suggesting minor challenges in memory, attention, or calculation, likely influenced by individual factors or digital adaptation. Additionally, 16% displayed mild to moderate cognitive decline (19–23), indicating the need for differentiated pedagogical support. No cases of significant impairment (<19) were recorded, confirming the safety and relevance of the educational intervention.

Inferential Analysis

To assess the intervention's effect, normality and rank comparison tests were conducted. Since data were not normally distributed, the non-parametric Mann-Whitney U test was used.

Table 4 Pretest Comparison of Cognitive Competencies

Group	Mean Rank	Sig. (p)
Control	56	0.075
Experimental	45	

Before the intervention, both groups had similar cognitive development levels. The difference was not statistically significant ($p > 0.05$), indicating comparable baseline conditions.

Table 5 Posttest Comparison of Cognitive Competencies

Group	Mean Rank	Sig. (p)
Control	34	0.000
Experimental	67	

After implementing the program, a statistically significant difference was observed ($p < 0.05$). The experimental group, with a higher average rank, showed substantial improvement, demonstrating the positive impact of digital resources.

Table 6 Posttest – Basic Cognitive Dimension

Group	Mean Rank	Sig. (p)
Control	45	0.057
Experimental	56	

Table 7 Mann-Whitney U Test – Dimension 1

Test Statistic	Value
Mann-Whitney U	1.083.000
Wilcoxon W	2.358.000
Z	-1.153
Asymptotic Sig. (2-tailed)	0.000

Note: Compiled by Moran (2025)

Although the experimental group had a higher average, the difference in this dimension was not statistically significant. The null hypothesis is rejected ($p > 0.00$), indicating improvement in this dimension.

Table 8 Post-test Results for the Higher-Order Cognitive Dimension

Group	Mean Rank	Sig. (p)
Control	45	0.00
Experimental	56	
Note: Adapted from Moran (2025).		

Test Statistics for Dimension 2

- Mann-Whitney U: 957.500
- Wilcoxon W: 2232.500
- Z: -2.025
- Asymptotic Sig. (2-tailed): 0.000

A positive trend was observed in the experimental group for this dimension. The significance value remained slightly below the threshold ($p = 0.00$), confirming statistical significance with high certainty.

Table 9 Post-test Results for the Perceptual Cognitive Dimension

Group	Mean Rank	Sig. (p)
Control	37	0.000
Experimental	64	
Note: Adapted from Moran (2025).		

Test Statistics for Dimension 3

- Mann-Whitney U: 979.500
- Wilcoxon W: 2254.500
- Z: -1.877
- Asymptotic Sig. (2-tailed): 0.000

Note: Adapted from Moran (2025).

The results indicate a statistically significant difference in favor of the experimental group ($p < 0.05$), confirming that the use of digital resources had a meaningful impact on students' perceptual development, attention, and sensory processing.

4. DISCUSSION

The primary objective of this study was to assess the impact of implementing digital educational resources (DERs) on the development of cognitive skills in university-level students. Statistical analysis revealed significant differences between the experimental and control groups, particularly after the implementation of the program. The Mann-Whitney test yielded a significance value of $p = 0.000$, which allowed for the rejection of the null hypothesis and the acceptance of the general hypothesis, thereby confirming the effectiveness of the program in enhancing cognitive abilities.

The intervention reinforced core aspects of cognitive development such as analysis, comprehension, memory, and problem-solving. These competencies, essential for independent and critical learning in higher education, were improved through the structured use of online platforms and resources. The positive impact aligns with findings by Hidalgo et al. (2024), who demonstrated that the integration of interactive technologies enhances understanding of specific content and fosters active student engagement.

To a large extent, the program's effectiveness is attributed to the adaptive and multisensory features of DERs, which allow learning pace adjustments tailored to individual needs, promoting autonomy, intrinsic motivation, and digital competence. Technology, therefore, functions not only as a teaching tool but also as a catalyst for critical thinking and personalized learning environments.

From a scientific perspective, the effectiveness of virtual environments such as Moodle, Microsoft Teams, and Google Classroom was confirmed. These platforms support the integration of visual and auditory resources that enhance data retention. In this study, the use of videos, forums, presentations, and feedback significantly contributed to students' cognitive development.

In the basic cognitive dimension, notable progress was observed within the study group, with students advancing from an intermediate to a high level of performance in most cases. This improvement complements previous research, such as that of Malavé (2022), which confirms that digital media support essential functions like attention, memory, and concentration. Given that these skills are foundational for acquiring more advanced competencies, the importance of implementing regular and planned digital strategies is underscored.

Regarding higher-order cognitive skills, post-intervention results indicated a substantial improvement in abilities such as critical reasoning and logical thinking. Scholars like Haleem et al. (2022) and Cohen et al. (2023) have highlighted the capacity of digital media to enhance reflection and analytical skills in university contexts. This finding is also linked to Sweller's Cognitive Load Theory, which posits that properly structured and organized information reduces mental overload and facilitates knowledge acquisition. In this analysis, the instructional design of the digital program was crucial to achieving these outcomes.

In the perceptual dimension, the data were definitive. The proportion of students reaching high performance levels increased from 34% to 90% following the intervention, indicating statistically robust significance. This improvement confirms that digital media activate sensory channels and foster richer, more engaging learning experiences. Rubner's (2023) Perceptual Theory supports the notion that pedagogically integrated visual and auditory stimuli enhance interpretation processes and sustained attention.

The evidence gathered throughout this study suggests that technology does not replace teaching—it enhances it. To ensure a lasting impact, it is vital to train educators in the pedagogical use of DERs, design activities based on cognitive principles, and develop institutional policies that support their effective integration. Moreover, equitable access to devices and connectivity must be ensured to prevent the widening of digital inequalities.

This research constitutes a significant contribution to the transformation of the teaching-learning process in higher education, demonstrating that the integration of digital tools fosters the development of key cognitive skills such as attention, analysis, memory, and reflection. Furthermore, it aligns with Sustainable Development Goal 4 (SDG-4), which promotes inclusive, equitable, and quality education. The deliberate and pedagogically guided adoption of digital technologies emerges as an effective strategy for enhancing the quality of university learning, nurturing autonomous and reflective students, and overcoming the challenges posed by the knowledge society.

Intervention

The program presents an innovative alternative to the limitations of traditional methods in promoting cognitive skills in the university environment. It integrates digital tools that foster critical thinking, concentration, memory, and problem-solving, positioning the student as an active participant within dynamic virtual learning environments. Rooted in educational theories such as Vygotsky's social constructivism and Ausubel's meaningful learning, the program offers educational experiences that connect academic content with real-world contexts, utilizing simulators, applications, concept maps, and interactive platforms.

The program consists of 20 sessions spread across one academic semester, each organized into three phases: activation, exploration, and transfer. The pedagogical framework ensures consistency in instruction and includes an initial diagnostic phase to tailor the intervention to the group's cognitive and technological needs. Activities are structured from an experiential and constructivist perspective, employing active learning

techniques such as project-based learning. This approach enhances student motivation, independence, and the development of advanced competencies required to tackle academic and professional challenges.
Evaluation follows a comprehensive approach, encompassing diagnostic, formative, and summative stages. Digital rubrics, checklists, and online tools enable real-time monitoring and immediate feedback. A variety of activities—including self-assessments, forums, cognitive games, and group projects—address diverse learning styles and skill levels. The impact of the program is also assessed in terms of academic motivation, strategic use of digital tools, and knowledge transfer to other contexts.
The implementation plan comprises six structured stages: diagnosis, socialization, design, execution, formative evaluation, and presentation of results. Each phase is meticulously organized, with specific tasks, designated responsibilities, and allocated resources, ensuring the intervention's effectiveness and educational manageability.

Table 10. Intervention Phases

Phase	Activity	Duration	Responsible Parties	Resources
Diagnosis	Initial skills assessment	1 week	Faculty, Researcher	Google Forms, digital questionnaires
Socialization	Program presentation	1 day	Coordinator, Faculty	Presentations, videos
Strategy Design	Selection of digital resources	1 week	Faculty, Researcher	Rubrics, educational tools
Implementation	Application in classroom settings	4 weeks	Faculty, Students	Educational platforms, apps, discussion forums
Formative Evaluation	Monitoring of skills development	4 weeks	Faculty, Researcher	Rubrics, checklists
Presentation of Results	Sharing outcomes and student reflections	1 week	Students, Faculty	Multimedia tools, collaborative platforms

Note: Adapted from Ruiz (2025).
The program is structured in six essential stages to ensure a progressive and coherent implementation. The diagnostic stage, lasting one week, establishes students' initial cognitive levels using digital forms to support tailored planning. During the one-day socialization phase, the program is presented to faculty and students to ensure shared understanding and alignment with objectives.
The one-week design phase focuses on selecting high-quality digital resources supported by robust rubrics. The core implementation spans four weeks, involving activities conducted through educational platforms, applications, and forums. Concurrently, a formative evaluation phase tracks student progress via rubrics and checklists. Finally, in the concluding week, results are presented by students, who showcase their work and reflect on the program's impact using multimedia and collaborative tools. This structured design ensures that each phase meaningfully contributes to achieving the program's objectives.

5. CONCLUSIONS

The systematic implementation of digital educational resources (DER) demonstrated a statistically significant impact on the development of cognitive competencies. The experimental group showed substantial improvements across all assessed dimensions—basic, higher-order, and perceptual—confirming that technology-mediated instruction, when pedagogically integrated, enhances processes such as attention, memory, logical analysis, and critical reasoning.
Inferential analysis using the Mann-Whitney U test revealed significant differences between the control and

experimental groups in the post-test (p = 0.000), providing empirical evidence for the effectiveness of the digital program. Notably, higher-order and perceptual cognitive dimensions exhibited the greatest gains, underscoring the role of digital environments in stimulating higher-order thinking and complex sensory processing.

These findings support the conclusion that pedagogically guided technological innovation is an effective strategy for improving the quality of learning in higher education. Teacher training, student-centered instructional design, and the coherent integration of digital platforms are critical factors in fostering inclusive, dynamic, and cognitively stimulating educational environments.

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