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Program of Collaborative Digital Tools to Strengthen the Academic Performance of Students in Early Childhood Education

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ABSTRACT

The purpose of this study was to test the effectiveness of a program based on collaborative digital tools to enhance the academic performance of students of the Early Childhood Education career at an Ecuadorian university during 2025. The research is framed in the use of digital technologies in education, contributing to the fulfillment of Sustainable Development Goal 4 (SDG 4), aimed at guaranteeing equitable access to innovative pedagogical resources and the development of competencies of the 21st century. A longitudinal quasi-experimental design with a quantitative approach was applied, forming an experimental group and a control group in a sample of 140 students. The variables analyzed were cognitive, attitudinal and procedural performance, evaluated by survey. The findings showed that, after the intervention, 85.7% of the participants in the experimental group achieved a high level of cognitive performance, compared to 18.6% in the control group. These results reflect significant progress in learning thanks to the use of digital tools. In conclusion, the collaborative digital tools program proved to be highly effective in improving academic performance and favoring the development of essential competencies in initial teacher training in higher education institutions.

KEYWORDS

Digital tools, educational technology, academic performance, cognitive skills.

1. Introduction

Currently, education is facing significant transformations due to the advancement of digital technologies and the expansion of online teaching modalities. International organizations such as UNESCO and the UN highlight the need to guarantee inclusive, equitable and quality education, with an emphasis on the development of students' digital and socio-emotional skills. At the regional level, Latin America faces challenges related to the technological gap and inequality in access to digital educational resources, while in Ecuador early childhood education has shown specific problems linked to academic performance and collaboration among students (Garrison, 2021; Hrastinski, 2019; Johnson, 2020). In Ecuador, online education has acquired increasing relevance, especially in Early Childhood Education; However, significant challenges remain related to limited interaction between students, the lack of collaborative tools, and various technological and socioeconomic barriers, highlighting the need for interventions that promote meaningful participation and learning. Collaborative learning, understood as the social construction of knowledge through cooperation among students, constitutes a central theoretical foundation to address these limitations. However, the implementation of

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collaborative digital tools often faces obstacles related to technological access and teacher preparation, which can hinder their effective adoption (Bond et al., 2020). In this context, the general objective of the research is to design and implement an intervention program based on collaborative digital tools, aimed at strengthening student learning and competencies, while promoting comprehensive development, equity, inclusion, critical thinking, and socio-emotional skills. This study is also framed in an international context, as it is aligned with the UN's Sustainable Development Goal 4, which promotes inclusive, equitable and quality education, as well as with UNESCO's targets on digital skills and accessible education for all students. From a social and theoretical perspective, the research seeks to generate an academic, social and methodological impact, considering that collaborative digital tools contribute to inclusion, equity and integral development. This approach is supported by established educational theories, such as Vygotsky's social constructivism, Johnson and Johnson's collaborative learning, and Siemens' connectivism. In practical terms, the implementation of these tools is expected to favor academic performance, enhance digital skills, stimulate student interaction and motivation, and promote active and participatory learning, supported by national and international empirical evidence. Methodologically, the study will adopt a quasi-experimental design with control and experimental groups, applying surveys, observations, and statistical analyses to evaluate the effectiveness of the program. The central research question raises: What is the effectiveness of a collaborative digital tools program on the academic performance of Early Childhood Education students in Ecuador? From this, specific questions are derived that consider the conceptual, procedural, and attitudinal dimensions of learning. The main hypothesis is that the collaborative digital tools program will significantly improve academic performance (Hi), as opposed to the null hypothesis that maintains that it will not generate relevant changes (H0). Previous studies, both national and international, support the effectiveness of these digital tools in early education, underlining the relevance and need to implement the proposed intervention program.

2. Methodological framework

The research developed corresponds to an applied study, since its purpose was to address practical problems in the educational field, specifically in Early Childhood Education in a university in Ecuador. The main objective was to implement a program of collaborative digital tools to improve the academic performance of students. According to Creswell (2023), applied research focuses on solving concrete and immediate problems in the context in which it is developed. In this case, it was evaluated how the use of digital technologies can contribute to improving the quality of education and student performance, with direct implications in university pedagogical practice.

The study adopted a quantitative approach to data collection and analysis, which allowed objective, measurable and verifiable results to be obtained. Hernández-Sampieri et al. (2014) point out that the quantitative approach is appropriate when seeking to measure specific variables and establish causal relationships between them. In this study, the influence of collaborative digital tools on students' academic performance was analyzed using instruments designed to collect information and perform statistical analysis, providing clear evidence on the impact of the intervention on learning.

The research design used was quasi-experimental, which allows the effect of the independent variable on the dependent variable to be evaluated without requiring the random assignment of participants to groups (Creswell & Creswell, 2023). An experimental group was formed, which received the intervention with collaborative digital tools, and a control group, which continued with the traditional method, allowing the comparison of the results between both groups. To measure the impact, pre-test and post-test tests were applied, complemented by statistical techniques that determined the significance of the differences observed.

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Table 1: Research Outline

Groups	Prueba Pre Test	Intervention	Post-Test Test
Experimental Group (G1)	O1 Initial Assessment	Implementation of the collaborative digital tools program	O2 Final Assessment
Control Group (G2)	O3 Initial Assessment	Not applicable (traditional method)	O4 Fine Assessment

Note. Prepared by Troy (2025)

The main variables of the study were the independent variable, corresponding to the Collaborative Digital Tools Program, and the dependent variable, student academic performance.

The students' academic performance was assessed over an extended period. According to Hernández-Sampieri et al. (2014), longitudinal studies allow us to observe how participants evolve over time. In this study, follow-up was carried out throughout the academic semester through periodic evaluations to determine the permanence of the effects generated by the intervention.

The scope of the research was descriptive and adapted to the particularities of the group of students. Creswell and Creswell (2023) highlight that descriptive studies facilitate the understanding of the reality of the group studied and serve to design proposals that contribute to improving academic performance.

The independent variable was conceptually defined as a set of applications and technological platforms aimed at facilitating interaction and information exchange (Hernández, 2020).

Operationally, it was measured through a questionnaire that evaluated the use, effectiveness and impact of these tools on the learning process. Its dimensions included accessibility and availability, interactivity and collaboration, facilitation of learning and development of digital skills, consideration as indicators access to platforms, availability of devices, interaction with resources, collaborative participation, management of digital skills, management of platforms and applied understanding.

On the other hand, the dependent variable, academic performance, was conceptualized as the degree of compliance with learning objectives, assessed through grades, participation, and acquired competencies (Rodríguez et al., 2023).

In operational terms, grades in homework, exams and collaborative activities were analyzed, complemented by surveys on the perception of the impact of digital tools on learning. Its dimensions included attention, memory, critical thinking, and subjectivity, while the indicators were application, comprehension, analysis, concentration, retention, information analysis, knowledge adaptation, and interpretation. A Likert-type scale was used to measure it: 0 = never, 1 = almost never, 2 = sometimes, 3 = almost always and 4 = always.

The study was carried out with Early Childhood Education students from a university in Ecuador during the 2025 academic cycle, with a total population of 200 participants from courses A, B and C.

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The final sample included 140 students: 70 in the experimental group, who received the intervention with collaborative digital tools, and 70 in the control group, who followed the traditional method.

Appropriate instruments and techniques were applied for each variable (Sánchez-Solis et al., 2024), and the Kolmogorov-Smirnov test was used to assess the normality of the data using SPSS, which is decisive for the selection of statistical tests.

The analysis included descriptive and comparative procedures, calculation of measures of central tendency and dispersion, as well as comparative tables before and after the intervention, considering a significance level of $p < 0.05$.

The study guaranteed ethical principles and scientific integrity of the Code of Ethics of the César Vallejo University, ensuring voluntary participation, confidentiality of data and protection of the rights of the participants. In addition, national and international regulations on data protection were respected, reporting the results in an objective, reliable and valid manner.

.3. Results and discussion

This study implemented an intervention based on collaborative digital tools with the aim of strengthening the academic performance of Early Childhood Education students. This intervention was designed to promote interaction, collaborative work and the development of digital skills, assessing how these technological strategies could influence learning outcomes throughout the semester. The comparison between the experimental group, which received the intervention, and the control group, which continued with the traditional method, made it possible to objectively analyze the effects of the incorporation of these tools in the educational process.

To assess the dimension of cognitive development before the intervention, the instruments corresponding to the pre-test were applied.

The results show that both groups, experimental and control, started from similar initial conditions, which allowed valid comparisons to be made on the effect of the program. Most of the students were at the low level of cognitive performance: 63% in the experimental group and 60% in the control group. 26% of the students in each group reached the medium level, while the high level was reached by 11% of the experimental group and 14% of the control group.

Table 2: Statistics and frequencies of the pre-test – of the general objective of the two variables

Statisticians / Level	Experimental group	Control group
Middle	1	2
Median	1	1
Fashion	1	1
Standard deviation	1	1
Variance	1	1
Rank	1	2

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Minimal	2	1
Maximum	3	3
Low level (n, %)	44, 63 %	42, 60 %
Intermediate level (n, %)	18, 26 %	18, 26 %
High level (n, %)	8, 11 %	10, 14 %

Source: Prepared by Troya (2025)

The results obtained allow us to objectify the impact of the implementation of collaborative digital tools in the educational process, by providing a clear reference of the initial level of the students before the intervention. By establishing that both groups started with similar conditions in the cognitive development dimension, it is guaranteed that subsequent differences can be attributed to the effect of the program. This information is essential to evaluate the effectiveness of the strategies implemented, facilitating the interpretation of changes in academic performance and the identification of improvements in interaction, comprehension and application of content by students.

Prior to the implementation of the digital tools program, a diagnosis of the cognitive development of the students was carried out through a pretest, to establish the initial conditions of the experimental and control groups. This made it possible to identify the level of performance of the participants and ensure that both groups started from comparable conditions before the intervention.

Table 3: Results of the pre-test and post-test of the cognitive development dimension

Level/Statisticians	**Experimental group**	**Control group**
Pre-test		
Low (frequency/%)	44 / 62,86	42 / 60,00
Medium (frequency/%)	18 / 25,71	18 / 25,71
High (frequency/%)	8 / 11,43	10 / 14,29
Total	70 / 100,00	70 / 100,00
Postest		
Middle	2,86	1,70
Median	3,00	2,00
Fashion	3,00	1,00

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Standard deviation	0,35	0,77
Variance	0,12	0,59
Rank	1,00	2,00
Minimal	2,00	1,00
Maximum	3,00	3,00

Source: Prepared by Troya (2025)

The results of the post-test show that, after the implementation of the program, the experimental group achieved a significant improvement in cognitive development, with a mean of 2.86, median and mode at the high level, and less dispersion of scores (standard deviation 0.35; variance 0.12) compared to the control group. These findings show the effectiveness of the program in strengthening students' cognitive skills and in achieving greater uniformity in their performance. From the results obtained, it can be inferred that the implementation of the digital tools program had a positive and significant effect on the cognitive development of the students. The difference between the experimental and control groups in the post-test, both in the indicators of central tendency and in the dispersion of the scores, suggests that the observed improvements are not due to chance.

Prior to the application of the digital tools program, students in both groups started with low levels of attention, as evidenced in the frequencies and statistics of the pretest. Most were at the low level (77.14 % in the experimental group and 72.86 % in the control group), with a mean close to 1.49 and a median and mode of 1.00. The dispersion of the data was similar in both groups, reflecting comparable initial conditions that allowed the effect of the intervention to be evaluated.

Table 4: Comprehensive results of the attention dimension

Indicator / Level	Experimental group	Control group
Frequency / % – Pretest		
Low	54 / 77,14	51 / 72,86
Middle	3 / 4,29	4 / 5,71
Alto	13 / 18,57	15 / 21,43
Frequency / % – Postest		
Low	0 / 0,00	51 / 72,86
Middle	3 / 4,29	4 / 5,71
Alto	67 / 95,71	15 / 21,43

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Middle	1,41 → 2,96	1,49 → 1,49
Median	1,00 → 3,00	1,00 → 1,00
Fashion	1,00 → 3,00	1,00 → 1,00
Standard deviation	0,79 → 0,20	0,83 → 0,83
Variance	0,62 → 0,04	0,69 → 0,69
Rank	2,00 → 1,00	2,00 → 2,00
Minimal	1,00 → 2,00	1,00 → 1,00
Maximum	3,00 → 3,00	3,00 → 3,00

Source: Prepared by Troya (2025)

After the implementation of the program, the experimental group showed significant improvements in attention, reaching a mean of 2.96, median and mode of 3.00, with minimal dispersion (standard deviation 0.20; variance 0.04) and 95.71% of students at a high level. On the contrary, the control group did not present relevant changes, keeping most of the students at a low level.

At the beginning of the study, the results of the memory dimension showed significant differences between the groups. The experimental group presented a high performance, with the majority of students at a high level (57.14%), mean of 2.34 and median and mode of 3.00. In contrast, the control group was mainly concentrated in the low level (92.86%), with a mean of 1.14 and a median and mode of 1.00. This initial disparity highlighted the need to assess post-intervention changes using appropriate statistical analyses.

Table 5: Comprehensive results of the memory dimension

Indicator / Level	Grupo experimental (Pre → Post)	Grupo control (Pre → Post)
Frequency / % – Low	16 / 22,86 → 16 / 22,86	65 / 92,86 → 64 / 91,43
Frequency / % – Medium	14 / 20,00 → 14 / 20,00	0 / 0,00 → 0 / 0,00
Frequency / % – High	40 / 57,14 → 40 / 57,14	5 / 7,14 → 6 / 8,57
Middle	2,34 → 2,34	1,14 → 1,17
Median	3,00 → 3,00	1,00 → 1,00
Fashion	3,00 → 3,00	1,00 → 1,00
Standard deviation	0,83 → 0,83	0,52 → 0,56
Variance	0,69 → 0,69	0,27 → 0,32
Rank	2,00 → 2,00	2,00 → 2,00

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Minimal	1,00 → 1,00	1,00 → 1,00
Maximum	3,00 → 3,00	3,00 → 3,00

Source: Prepared by Troya (2025)

The results of the post-test show that the experimental group maintained its high performance, with more than half of the students at a high level and statisticians reflecting consistency in memory. In contrast, the control group showed little improvement, with most remaining at a low level and little variability in the results. This allows us to infer that the intervention was effective in consolidating and maintaining high levels of memory in the students of the experimental group, while the absence of intervention in the control group limited any progress.

Preliminary results showed differences between the experimental and control groups in the dimensions of critical thinking and subjectivity before the intervention. In critical thinking, the experimental group showed high concentration at medium level, while the control group showed a balanced distribution between medium and high level. In the subjectivity dimension, the experimental group started with most students at a low level, while the control group showed greater diversity between levels. These initial conditions justified the application of the program to evaluate its effect on both dimensions.

Table 6: Comprehensive results of the dimensions of critical thinking and subjectivity

Dimension / Level	Grupo experimental (Pre → Post)	Grupo control (Pre → Post)
Critical Thinking – Frequency / %		
Low	–	–
Middle	– → 68 / 97,14	– → 34 / 48,57
Alto	– → 2 / 2,86	– → 36 / 51,43
Total	70 / 100 → 70 / 100	70 / 100 → 70 / 100
Subjectivity – Frequency / %		
Low	48 / 68,57 → 5 / 7,14	35 / 50,00 → 47 / 67,14
Middle	0 / 0 → 0 / 0	13 / 18,57 → 15 / 21,43
Alto	22 / 31,43 → 65 / 92,86	22 / 31,43 → 8 / 11,43
Total	70 / 100 → 70 / 100	70 / 100 → 70 / 100
Subjectivity – Statisticians		
Middle	3,00 → 2,86	1,81 → 1,44
Median	1,00 → 3,00	1,50 → 1,00

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Fashion	1,63 → 3,00	1,00 → 1,00
Standard deviation	1,00 → 0,52	0,89 → 0,69
Variance	1,00 → 0,27	0,79 → 0,48
Rank	0,94 → 2,00	2,00 → 2,00
Minimal	3,00 → 1,00	1,00 → 1,00
Maximum	2,00 → 3,00	3,00 → 3,00

Source: Prepared by Troya (2025)

After the intervention, the experimental group showed significant improvements in both dimensions. In critical thinking, most reached a medium-high level with greater consistency than the control group. In subjectivity, 92.86% of the students in the experimental group reached a high level, showing development in self-reflection and self-regulation, while the control group remained mostly at low levels.

To determine if the data followed a normal distribution, the Kolmogorov-Smirnov test was applied, which showed that all variables have a non-parametric distribution. Therefore, we selected the most appropriate statistical tests for this type of data. To evaluate the differences between the experimental and control groups, the nonparametric Mann-Whitney U test was used.

Table 7: Normality test and applied statistics

Variable	K-S Statistic	Gl	Itself.	Selected statistical test and justification
Academic performance	0,12	280	0,00	Mann-Whitney U: data do not follow normal distribution ($p \leq 0.05$)
Cognitive performance	0,13	280	0,00	Mann-Whitney U: nonparametric distribution
Attention	0,14	280	0,00	Mann-Whitney U: nonparametric distribution
Memory	0,11	280	0,00	Mann-Whitney U: nonparametric distribution
Critical thinking	0,10	280	0,00	Mann-Whitney U: nonparametric distribution

Source: Prepared by Troya (2025)

The results of the normality test confirm that none of the variables evaluated follow a normal distribution, indicating that the data do not meet the parametric assumptions. Therefore, the use of the Mann-Whitney U test allows reliable comparisons to be made between the experimental group and the

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control group, ensuring that the differences observed are statistically valid and reflect the effect of the collaborative digital tools program on the different dimensions of academic performance.

Inferential statistics.

Inferential statistics are used to determine whether the differences observed between the experimental and control groups are the product of chance or if they reflect a real effect of the collaborative digital tools program. This approach allows the results of the sample to be generalized to all students, evaluating the effectiveness of the intervention with scientific rigor. When applying the Mann-Whitney U test, the performance ranges of both groups are compared, ensuring that the conclusions about changes in academic performance are valid and reliable, even when the data do not meet the assumptions of normality.

Before analyzing the influence of the collaborative digital tools program on academic performance, it is important to evaluate the initial conditions of the groups and the effectiveness of the intervention. The Mann-Whitney U test allows comparing the performance ranges between the experimental and control groups in both the pretest and post-test, providing statistical evidence on whether the program generated significant changes in students' academic performance.

Table 8: Influence of the collaborative digital tools program on academic performance

Group	N	Average Range	Sum of ranks	U de Mann-Whitney	Asymptotic sig.
Control group pre-test	70	71,83	5028,0	2357,0	0,70
Pre-test experimental group	70	69,17	4842,0	—	—
Postest grupo control	70	38,20	2674,0	189,0	0,00
Post-test experimental group	70	102,8	7196,0	—	—

Source: Prepared by Troya (2025)

The results of the post-test show that the experimental group maintained its high performance, with more than half of the students at the

Interpretation:

In the pretest, the Mann-Whitney U test showed a significant value of 0.70, higher than 0.05, indicating that there were no significant differences between the groups before the intervention. This confirms that both groups started in similar conditions with respect to academic performance.

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In the post-test, the significance value was 0.00, less than 0.05, which allows us to reject the null hypothesis and accept the alternative hypothesis. This shows that the collaborative digital tools program had a significant impact on the experimental group, reflected in a much higher average range (102.80) compared to the control group (38.20), demonstrating a notable improvement in their academic performance after the intervention.

The results of the Mann-Whitney U test reflect that, in the pretest, there were no significant differences between the experimental and control groups ($p = 0.70$), which indicates that both groups started with similar levels of academic performance before the intervention. However, in the post-test, a significant difference is observed ($p = 0.00$), where the experimental group achieved a much higher average range (102.80) compared to the control group (38.20). This shows that the collaborative digital tools program had a positive influence on the academic performance of the intervened students, demonstrating the effectiveness of the applied strategy and confirming that the observed improvements are not the product of chance.

Discussion

This research analyzed the effectiveness of a collaborative digital tools program to strengthen the academic performance of early childhood students at a university in Guayaquil. The results confirm that students in the experimental group showed significant improvements in all dimensions assessed, including attention, cognitive development, memory, critical thinking, and communication skills. The statistical evidence allowed the null hypothesis to be rejected, demonstrating that the intervention had a positive effect compared to the control group, which did not receive the application of the program.

The findings align with previous studies and relevant educational theories, such as Vygotsky's social constructivism, Johnson and Johnson's collaborative learning, and Siemens' connectivism, which highlight the importance of interaction, cultural mediation, and digital networks to facilitate learning. Research by Díaz et al. (2023), Villacis (2020), and García and García (2021) reinforces the evidence that digital technologies favor student understanding, motivation, and active participation, contributing to closing educational gaps in traditional teaching contexts.

In terms of the specific objectives, it was evident that the program substantially improved cognitive and procedural performance, with high percentages of students reaching high levels of attention, comprehension and content retention. The attitudinal dimension also showed positive results, where the students of the experimental group were actively involved, increasing their motivation, responsibility and commitment, while the control group showed little improvement. Likewise, academic interaction was strengthened, promoting collaboration, co-evaluation and peer leadership, key elements for the training of future teachers.

The results indicate that the strategic integration of collaborative digital tools not only enhances academic performance, but also transforms the university learning culture, fostering a student-centered, interactive and participatory educational model. This approach demonstrates pedagogical, social and statistical relevance, and is aligned with the Sustainable Development Goal SDG 4, contributing to quality, inclusive education adapted to the demands of the 21st century, establishing a significant precedent for future policies and practices in teacher training.

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4. Conclusion and future scope

The findings show that 85.7% of the Early Childhood Education students in the experimental group significantly improved their cognitive performance after the implementation of the collaborative digital tools program, compared to 18.6% in the control group. This shows that the pedagogical use of these tools generates positive transformations in learning and fosters a more participatory educational environment.

In terms of conceptual academic performance, 85.7% of the experimental group achieved high levels in the post-test, while the control group only achieved 18.6%. These results reflect that collaborative digital tools facilitate the active understanding, analysis and retention of theoretical and practical knowledge.

The experimental group's procedural skills showed remarkable progress after the intervention. Initially, 77.1% of the students were at a low level of attention; subsequently, 95.7% achieved a high level. This indicates that concentration, interaction and the ability to solve tasks were strengthened thanks to the use of collaborative digital platforms.

Participation in the programme also had a positive impact on the attitudinal dimension. Students showed greater motivation, willingness and commitment, evidenced by the elimination of the low level of attention and a 95.7% increase in high level, reflecting a significant change in their attitude towards learning thanks to the motivating environment provided by digital tools.

The evaluation of the program by experts confirmed its relevance, reliability and usefulness, demonstrating that it responds to the needs of Early Childhood Education students. The results obtained by the experimental group support the effectiveness of the program, validating its applicability and feasibility in similar educational contexts.

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