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Innovative and Inclusive Digital Applications to Enhance Literacy in Students with Dyslexia

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Abstract

The adoption of digital applications has been used to carry out innovative and inclusive tests that reduce gaps in different fields, especially in education; such is the case of the improvement in reading comprehension levels. The present study seeks to demonstrate that digital applications improve the reading and writing skills of students with dyslexia in Ecuador, in the year 2023. It is a quasi-experimental design in which 60 students belonging to section A and B participated. at the basic elementary level of the afternoon session of the "Simón Bolívar" Millennium Educational Unit, Ecuador 2023. Thirty of the experimental group. 20 items were applied where each one is a combination of school literacy activities adaptable to the classroom in person and to the virtual environment, this comprises 3 dimensions, which presented a good level of reliability and content validity. For the analysis, descriptive statistics (Wilcoxon test) were carried out, demonstrating that the program generated significant changes in the experimental group with a and in the control group, thus demonstrating that the program has positive effects on the learning of children with dyslexia.

Keywords: *literacy, digital apps, dyslexia.*

INTRODUCTION

The critical importance of literacy in the academic and professional development of middle school students, underlining its ability to shape language and facilitate human knowledge. It highlights the imperative need to provide full access to education from the early school years, ensuring that students enjoy unhindered learning (Guerrero Guaca et al., 2023; Peñas Cuva, 2017). Despite its importance, literacy faces significant challenges

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when it comes to students with specific disorders such as dyslexia, a condition that, while not limiting intelligence or cognitive abilities, presents obstacles in the process of teaching and learning literacy, affecting approximately 10% of the world's population (Janin et al., 2019).

Within the educational framework, literacy learning is fundamental for the development of judgment in various fields. However, according to the ERCE study by the Latin American Institute for Quality Assessment in Ecuador, reading and writing performance in third and sixth grade is unsatisfactory, with 40% of third graders and 60% of sixth graders failing to meet the minimum basic knowledge. Improving education is crucial to building a successful future without exclusions based on physical, intellectual, economic, political or social conditions (Guanchara & Toapanta, 2023; Londoño Hernández, 2022; UNESCO, 2020).

In an international comparison, the 2018 PISA test highlights countries such as Beijing, Shanghai, Zhejiang province and Singapore as leaders in reading proficiency, while Estonia, Canada, Finland and Ireland excel in terms of reading performance. While acknowledging the role of digital apps in literacy, it is noted that they are not an easy solution, especially for students with dyslexia, who face difficulties identifying words, understanding sentences, and following specific instructions when part of a program or instructional strategy.

Teachers' work to identify and address these challenges has been highlighted by strengthening specific digital skills and adopting a multidisciplinary approach to improve school performance. This includes providing dyslexia-adapted audio texts, reading content, and grammar with the goal of encouraging student motivation and active participation. Bice and Tang (2022) underline that students actively construct knowledge, which drives a digital paradigm shift.

The process of searching for and analysing information is presented as a challenge for teachers, and studies such as that of González et al. (2021) on the use of the CAMPTOOLS tool show significant improvements in reading and writing performance for students with and without difficulties, highlighting the positive impact on reading comprehension, self-esteem and motivation.

Additional research, such as that by Selfa Saatre (2022) on the digitization of creativity and poetry at the University of Lleida, proposes the digitization of classrooms to prioritize children's literacy. Qualitative and deductive studies show that the use of digital apps, such as Genially, facilitates collaborative learning, improves the understanding of poetry, and raises literacy levels.

In the field of augmented reality, Blas Padilla (2022) reveals that its implementation by high school students contributes significantly to the development of cognitive skills, motivation, and academic performance, transforming students into generators of new knowledge. From Herrera Rodríguez's (2022) perspective, the use of digital tools such as Flipsnack is presented as strengthening literacy skills.

In the same vein, Máñez Carvajal & Cervera Mérida (2022) developed a mobile application for children with reading and writing difficulties in Valencia, Spain. This application, designed to improve conversion between sounds and syllabic graphemes, phonetic processing and working memory, as well as phonological awareness, positively influenced students, the software developed allows access to content without an internet connection, giving students flexibility to study at their own pace.

Studies and research have explored the use of digital technologies, especially mobile apps, to improve literacy skills in students, including those with dyslexia. In Toronto, Canada, it was found that the use of iOS mobile devices and the MyVoice app has the potential to improve students' motivation and attention, positively impacting school performance (UNESCO, 2020). In the United States, a high-quality, research-based

approach has been implemented to improve reading intervention, emphasizing assessment and monitoring of student progress National Center Improving Literacy (2020). In Ecuador, different studies have examined the use of digital tools to promote literacy, highlighting the importance of teaching strategies that are tailored to the specific needs of students.

Some initiatives, such as the use of the DytectiveU app, focus on improving children's literacy, especially for children with dyslexia. It has been observed that the implementation of guides based on digital tools can be innovative and effective in educational environments. In addition, studies in different Ecuadorian cities have shown how the integration of digital tools can improve the performance of students with dyslexia, providing accessibility and adaptability advantages.

At the forefront of educational intervention through the use of digital tools, focusing on the development of reading and writing skills in students with dyslexia, Cruz Parrado & Córdoba Machado (2023) proposed an intervention approach that was deployed in educational institutions in Cunday Tolima, focusing on evaluations of the effectiveness of digital resources in first and second grade students. Although the participants were children with incomplete cognitive development, the results highlighted gains in comprehension, information retention, and reading and writing skills. Santoro & Avilés (2022) addressed literacy through the strategic use of digital tools, generating an instructional manual at the University of Guayaquil. The study, supported by qualitative and quantitative methods, revealed that the implementation of a guide based on digital tools is an innovative approach to education. The work of Macas & Guevara (2020) in Cuenca explored the integration of technologies to improve dyslexia in elementary school students. Using the Dytective application in a pre-experimental approach, problems were identified and plans intervened by digital tools were implemented, demonstrating that this integration benefits students and meets the needs of digital natives. Proaño Zambrano (2021), in Portoviejo, analyzed the didactic use of ICT in the literacy process, concluding that these strategies are viable for learning and the transmission of textual information in primary school children. Serrano Santos (2021) focused his attention on enhancing the learning of students with mild intellectual disabilities. Their research, based on playful activities and interactive educational resources, showed significant improvements in literacy skills, contributing to higher academic performance. Data obtained from the research of Avilés Agama (2021), in Babahoyo, explored the impact of the DytectiveU application on the children's literacy of children with dyslexia. This explanatory study, also supported by quantitative and qualitative methods, underlines the importance of educational technology in harnessing the reading and writing skills of children with dyslexia, demonstrating the potential of the app to develop reading and writing processes. The use of new technologies in education has been highlighted by Vivanco & Gorostiaga (2017). The Economic Commission for Latin America and the Caribbean (ECLAC) (2023) stated that digital education is essential in a transformative recovery agenda. This recognition supports the introduction of digital applications in the classroom, allowing the learning process to be personalized and skills developed at the right pace for each student and highlights the importance of digital education in today's society, with an emphasis on the use of digital applications in the classroom to personalize learning and develop relevant skills. Digital technologies, including specific applications, have become an integral part of daily life and have changed the way we interact with the world, especially in terms of reading and writing.

The research seeks to identify the most effective digital applications to address literacy challenges in dyslexic students. By integrating gamification elements, such as rewards and grading systems, it is hoped to increase these students' motivation and interest in learning.

Not only does the study benefit students with dyslexia by providing a personalized approach, but it also strengthens relationships between family and school. The theoretical

perspective addresses dyslexia from an educational point of view, highlighting the interactivity and dynamism of digital applications compared to traditional methods.

MATERIALS AND METHODS

For its purposes, the research is applied, related to the improvement of the reading and writing skills of students with dyslexia at the primary level, which involves the application of knowledge and basic research results to address specific problems of society. Digital applications developed from applied research can be effective tools to help these students overcome the challenges associated with dyslexia and improve their reading and writing skills (Ñaupaz Paitán et al., 2018).

The research will be developed in a positivist paradigm, seeking to arrive at the truth through empirical observation, deductive logic and inductive logic. It assumes that truth is found through empirical testing of claims and uses logical techniques to process and understand the evidence. However, positivism is also subject to philosophical criticism and debate about the nature of truth and scientific methodology. It will have a quantitative approach, as data processing and statistical tools will be employed to facilitate the accurate results obtained. It is also explanatory, its purpose was to know the influence of digital applications on the improvement of reading and writing in students with dyslexia disorder. A deductive hypothesis method will be used because the statements and procedures of assumptions and conclusions are based around the hypotheses (by Franco Mineira & Vera Solórzano, 2020).

Likewise, the research is experimental with a quasi-experimental design, in this respect Hernández Sampieri & Mendoza Torres (2018), indicate that instead of creating groups from scratch, researchers manipulate groups that already exist in the study population. While this is useful in situations where randomization is difficult or impractical, it also poses challenges when it comes to controlling the experiment and interpreting the results. The independence of the group formation from the experiment is an important feature of these designs. (p.173), i.e., they make up two groups, the first called GE (experimental group) and the second CG (control group). This process consisted of assessing both groups by means of a pre-test followed by a post-test, giving the EG a unique manipulation. In this study, the assignment of the EG and GC will be based on the tests applied in the pretest to the students in reading and writing with dyslexia disorder, one of them will receive the practice of the digital application, once the intervention is concluded, the post-test will be applied to both groups.

Figure 1. From the Research Design

GE: 01 X 02

GC: 03 X 04

G: Pre-experimental group (students)

O1: Measurement of literacy earlier

O2: Measuring Literacy After

X: Application of the independent variable

Variables and Operationalization

Dependent variable: Literacy

Conceptual definition: Román Vega (2022), mentions that literacy is a set of skills, where reading is the development of reading comprehension and writing is the predictor of reading comprehension and subsequent learning success.

Operational Definition: This shows that reading is not a simple activity, but a process that involves a series of psychological operations. This means that when we read, our brain performs a number of mental tasks to process and understand the text. These tasks may include identifying words, understanding meaning, connecting ideas, and inferring ambiguous messages in the text.(González Ramírez et al., 2020, para. 8).

Independent Variable: Digital Applications

Conceptual definition: In the field of education, digital applications are used to enhance the training process, make content fun, and reinforce acquired knowledge (Balla Paguay et al., 2022). In literacy, digital applications serve as a support to develop communication skills, and broad content to dynamic information. However, the use must be linked to the facilitator's role as a guide.

Operational definition: Related to digital applications, it was not operationalized, since it was not the object of study, an organization matrix was made (see annex 2). Subsequently, the proposal consisting of virtual activities was applied through the use of digital applications, distributed in two sessions, each dimension on reading and writing in students with dyslexia. This proposal was made to the GE (experimental group) in order to determine if digital applications improve the reading and writing ability of students with dyslexia.

Population, Sample and Sampling

Population

As for the population, it was made up of 96 elementary school students (4th grade) of the afternoon session of the Millennium Educational Unit "Simón Bolívar", Ecuador 2023. The population consists of all units with certain characteristics that are relevant to the study. These units come in many different forms and types, and their inclusion in a population is based on the presence or absence of desired characteristics. This definition is the basis of research methodology, as it determines the scope and applicability of research results to the population being studied. Ñaupas Paitán et al. (2018) considers that it is important to clearly define the population to ensure that the results are applicable to the specific group.

Board 1. Study Population

Students	Number
To	36
B	35
C	34
TOTAL	105

Note: The table shows the study population

According to Valderrama (2015), the intentional non-probabilistic sample is one that is already established previously, and for reasons of the researcher's criteria it is used for the study.

With regard to the Sample, in this research, a total of 60 students belonging to section A and B at the elementary level of the afternoon session of the Millennium Educational Unit

"Simón Bolívar", Ecuador 2023 were taken into account. Thirty were in the experimental group (EG = 30) and thirty in the control group (CG = 30). According to Hernández Sampieri & Mendoza Torres (2018) He mentions that they involve a selection process driven by the characteristics and context of the study. This means that, instead of being randomly selected, items or cases that are considered relevant to the study at hand are specifically selected.

With reference to the sampling It was non-probabilistic for convenience, considering as inclusion criteria that they have a dyslexia condition, regularly attend class, that they enroll voluntarily, that they have not participated in any type of these programs. According to Hernández Sampieri & Mendoza Torres (2018) They argue that the choice of the non-probability sample will depend on the nature and context of the study and the inclusion criteria of the researcher.

This is how the sample was formed:

Board 2. Population Sample

Students	Sections	Number
Experimental Group (GE)	To	30
Control Group (GC)	B	30
Total		60

Note: The table shows the study population

Data Collection Techniques and Instruments, Validity and Reliability

Regarding the technique, unstructured observation was applied, which allowed a rapid and systematic evaluation of the reading and writing skills of dyslexic students; for the collection and evaluation of data, a rubric instrument was developed for the (pre-test and post-test). The rubric evaluated 20 items, each of which is a combination of school literacy activities adaptable to the classroom in person and to the virtual environment. The responses are measured using the last format of the assessment scale of the ministerial agreement, in Chapter I of the weighting of qualifications according to level and sub-level: Description Skill or learning achieved (A); The student evidences the achievement of the expected skills and learning in the programmed time. Skill or learning in the process of development (PE); The student is in the process of achieving the expected skills and learning, for which he or she requires the accompaniment of the teacher and the mother, father or legal representative for the necessary time. Initiated skill or learning (I); The student is beginning to develop the expected skills and learning and needs more time for the accompaniment and intervention of the teacher and the mother, father or legal representative, according to their learning pace. Not Assessed (NE); This skill or learning has not been addressed or assessed in the quarter.

These observations were made in a respectful environment and without pressure on the student, in order to obtain information that adequately supports the learning process; Its objective was to demonstrate whether digital applications improve literacy ability in students with dyslexia at the elementary school level, Ecuador 2023. The rubric is made up of 20 items, divided into four dimensions with their indicators; with subjective responses and a vigesimal score of 1 to 4. This technique allows for the structured creation of criteria, which facilitates scoring by dimension using its descriptor at the appropriate level (Expósito López et al., 2023).

For the beginning of the evaluation process, the collaboration of the elementary school students of the Millennium Educational Unit "Simón Bolívar", Ecuador 2023 was requested, through a letter of consent addressed to the parents of the students' families and another letter of assistance informed to the minors who were later made aware of the

objective of the instrument and to measure the reading and writing ability of the students. The test consisted of 19 items divided into four dimensions with their indicators.

To test the validity of the reading and writing instrument, Aiken's V test was used through the validity of the judges, who are 5 experts, who were given a format of the instrument, after analyzing they provided their opinion, and the value of 1 was obtained, concluding that the instrument measures the objective of the variable. See appendix

Board 3. Expert Validity

Names and surnames of the experts	Speciality	Variable
Dr. Velasteguì López Efraín	PhD in Pedagogical Sciences	High Level
Dr. Figueroa Silva Margarita Faustina	PhD in Education	High Level
Dr. Rivera García Christian Geovanny	PhD in Pedagogical Sciences	High Level
Dr. Sánchez Cabezas Patricia del Pilar	PhD in Pedagogical Sciences (Educational Psychologist)	High Level
Dr. Sanchez Soto Maya Aracely	PhD in Education	High Level

Note: The table shows the names of the experts and the result of the validity of the instrument.

On the other hand, reliability, the same as Hernández Sampieri & Mendoza Torres, (2018) They mention that it is the value of the instrument that facilitates permanent and related results. Before the execution of the instrument for the final results, a pilot test was started with a group of 47 students, so the information regarding the variable was verified. Data were recorded in Excel and in the SPSS version 25 program, with the application of Cronbach's alpha test, which would show the reliability of the instrument. The technique was used because the literacy instrument presents questions. Cronbach's alpha test will demonstrate the reliability of the pretest and posttest.

Board 4. Reliability Analysis

Scale Reliability Statistics

	Cronbach's Alpha
Scale	0.907

Note: The table shows the reliability of the instrument

Table 4 shows the reliability value of the instrument, which is 0.907, which is excellently interpreted. In addition, the 20 items are presented (see annex 6).

Procedure

The information will be collected through two evaluations aimed at students. In two periods, experts, specialty, variable 1, variable 2, the informed consent, the permission of the institution, and the permission signed by the parents to the surveyed students, the pretest will be applied in both GE and GC groups and then the proposal will be executed to the GE experimental group, with this the second moment will be given, which is to apply the posttest to both groups. Finally, the data will be tabulated and sent to the SPSS version 25 program.

Data Analysis Method

As for the method of analysis, it will be descriptive; since the quantities and data obtained in a general way from the literacy variable and the dimensions will be passed through Excel and the SPSS program. Control information, such as from the experimental group, will be displayed. In relation to descriptive analysis, Albán et al. (2020) mention that it focuses on a population or study group, describes, analyzes and interprets some characteristics and makes interpretations of the nature of the phenomena studied. In this case, this type of research is necessary when dealing with the objective of the work. Statistical tables and graphs were used for the analysis of the study.

Ethical aspects

This research work has been carried out in compliance with the guidelines established by the César Vallejo University, approved by the Vice-Rector's Resolution No. 062-2023-VI-UCV. On the other hand, the ethical aspect of the research work seeks to contribute to the improvement of the literacy of elementary school students of the Millennium Educational Unit "Simón Bolívar", Ecuador 2023, which will demand a bibliography search and updated consultations according to APA standards and what was raised by the Graduate School of the Cesar Vallejo University. For the pilot test, the confidentiality of the responses, and therefore of the subsequent collection processes, is respected.

RESULTS AND DISCUSSION

Results

Board 5 Measuring the Use of Digital Applications in Literacy

	Group	N	Stocking	Desv. standard	Standard Error Mean
PostTest (Clustered)	Control	30	1,90	,548	,100
	Experimental	30	2,70	,466	,085
PreTest (Grouped)	Control	30	2,00	,000	,000
	Experimental	30	2,70	,466	,085

Note: Measuring the Use of Digital Applications in Literacy

The pre-test and the post-test, both divided into control and experimental groups. In the pretest, before the application of any intervention, it was observed that both groups, control and experimental, had similar means around 2.00, with a standard deviation of 0.000 for the control group and 0.466 for the experimental group. In addition, the mean standard error was equal to 0.000 for the control group and 0.085 for the experimental group in this phase.

Subsequently, after the intervention, in the post-test, changes in the means of both groups were observed. In the control group, the mean increased to 1.90 with a standard deviation of 0.548 and a mean standard error of 0.100. Meanwhile, in the experimental group, the mean increased to 2.70 with a standard deviation of 0.466 and a mean standard error of 0.085.

These results indicate that the intervention appears to have had a significant impact on the experimental group, as they experienced an increase in the post-intervention mean. However, more detailed statistical analysis, such as significance testing, is required to confirm whether these differences are statistically significant. In addition, standard

deviation and mean standard error provide information about the dispersion of the data and the accuracy of the estimates, respectively.

Board 6. Independent posttest and pretest samples

		Levene's Proof of Equality of Variances		T-test for equality of means							
		F	Gis.	t	Gl	Signification		Mean Difference	Standard Error Difference	95% Confidence Interval	Difference
						P for a factor	Two-factor P			Inferior	Superior
Post-Test (Grouped)	Equal variances are assumed	,538	,466	-6,093	58	<,001	<,001	-,800	,131	-1,063	-,537
	No equal variances are assumed			-6,093	56,552	<,001	<,001	-,800	,131	-1,063	-,537
PreTest (Grouped)	Equal variances are assumed	152,250	<,001	-8,226	58	<,001	<,001	-,700	,085	-,870	-,530
	No equal variances are assumed			-8,226	29,000	<,001	<,001	-,700	,085	-,874	-,526

Note: Independent sample testing post-test and pre-test

The data analysis carried out includes tests of independent samples to compare the means of two groups, called "Pos Test" and "PreTest". Tests were performed both under the assumption of equality of variances and assuming non-equality of variances.

PreTest: Under the assumption of equal variances, Levene's test revealed an F-statistic of 152.250 with a p-value of less than 0.001, indicating a significant difference in variances between the groups. The t-test for equality of means yielded a t-statistic of -8.226 with 58 degrees of freedom, and a p-value of less than 0.001. This suggests a significant difference between the mean groups, with the mean difference being -0.700. The 95% confidence interval ranges from -0.870 to -0.530. In the scenario of not assuming equal variances, the t-test still shows a significant difference between the means, with a t-statistic of -8.226 and 29 degrees of freedom. The mean difference and confidence interval are consistent with the analysis under the assumption of equality of variance.

PostTest: Under the assumption of equal variances, Levene's test showed an F-statistic of 0.538 with a p-value of 0.466, indicating that there is no significant evidence to reject equality of variances between groups. Based on the t-test for equality of means, a t-statistic of -6.093 with 58 degrees of freedom was found. The p-value is less than 0.001, suggesting that there is a significant difference between the group means. The mean

difference is -0.800, with a 95% confidence interval ranging from -1.063 to -0.537. In the case of not assuming equal variances, the t-test still shows a significant difference between the means, with a t-statistic of -6.093 and 56.552 degrees of freedom. The mean difference and confidence interval are consistent with the analysis under the assumption of equality of variance.

Both analyses indicate significant differences between the means of the groups in both tests, whether or not they assumed equality of variance. These results are relevant to understanding the differences between the groups in the "Pos Test" and "PreTest".

Board 7 Independent Sample Size: Pretest and Posttest

		Standardizera	Point Estimation	95% confidence interval	
				Inferior	Superior
PreTest (Grouped)	d for Cohen	,330	-2,124	-2,754	-1,482
	Hedges correction	,334	-2,096	-2,718	-1,463
	Glass delta	,466	-1,502	-2,129	-,858
PostTest (Clustered)	d for Cohen	,509	-1,573	-2,149	-,987
	Hedges correction	,515	-1,553	-2,121	-,974
	Glass delta	,466	-1,716	-2,378	-1,037

Note: a. The denominator used in the estimation of effect sizes. Cohen's d uses the combined standard deviation. Hedges correction uses the combined standard deviation, plus a correction factor. Glass's Delta uses the standard deviation of the sample from the control group (i.e., the second).

The results present estimated effect sizes for two different time points: post-test and pre-test, using three different metrics: Cohen's d, Hedges' correction, and Glass's delta. Here's an interpretation of those results:

Post Test:

Cohen's d: Indicates that, after the intervention or treatment, there is a moderate difference between the groups, with an estimate of 0.509. The 95% confidence interval suggests that this difference is probably between -1.573 and -0.987.

Hedges correction: Similar to Cohen's d, it provides an estimate of difference (0.515) and a confidence interval that supports the statistical significance of the intervention.

Glass's Delta: This measure, when using the standard deviation of the control group sample, also signals a moderate difference with an estimate of 0.466 and a confidence interval that points to statistical significance.

Pre Test:

d Cohen: Before the intervention, the difference between the groups was moderate, with an estimate of 0.330. The 95% confidence interval suggests that this difference could be between -2.124 and -1.482.

Hedges correction: Similar to Cohen's d, it provides an estimate of difference (0.334) and a confidence interval that supports the statistical significance of differences prior to intervention.

Glass's Delta: Shows a moderate difference before the intervention, with an estimate of 0.466 and a confidence interval indicating statistical significance.

The results suggest that the intervention or treatment applied between the pre-test and post-test had a moderate positive impact on the literacy ability of students with dyslexia at the elementary school level in Ecuador in 2023. The three metrics used support the consistency of these results.

Board 8 Literacy Ability in Students with Dyslexia

	PostTest (Clustered)		PreTest (Grouped)	
	Group		Group	
	Control	Experimental	Control	Experimental
N	30	30	30	30
Stocking	1,90	2,70	2,00	2,70
Desv. standard	,548	,466	,000	,466
Standard Error Mean	,100	,085	,000	,085

Note: Literacy Ability in Students with Dyslexia

Design and validate activities through the use of digital applications that encourage the practice and reinforcement of reading and writing skills in students with dyslexia at the elementary level Ecuador 2023,

To evaluate the reading and writing ability of students with dyslexia at the elementary school level Ecuador 2023, after adapting the content of digital applications to their needs.

Testing the hypothesis

General hypothesis

Hi: The Digital App to Improve Literacy in Elementary Elementary Dyslexia Students is an interactive tool that provides tailored activities and exercises to address the specific challenges of dyslexia.

Ho: Digital applications to improve literacy skills in elementary school students with dyslexia may have limitations in terms of access and availability, as not all schools or students may have the necessary technological resources to use these applications.

Board 9 Mann-Whitney U" and Wilcoxon W test: GC and GE after applying digital applications in literacy

	PreTest (Grouped)	PostTest (Clustered)
U de Mann-Whitney	135,000	153,000
W for Wilcoxon	600,000	618,000
Z	-5,636	-4,878
Sig. asin. (bilateral)	<,001	<,001

Note: a. Grouping variable: Group

The results of the nonparametric Mann-Whitney U and Wilcoxon W tests for the pooled scores in the PreTest and PostTest are presented below:

Mann-Whitney U: The Mann-Whitney U test yields a value of 135,000 for the PreTest and 153,000 for the PostTest.

The associated Z-value is -5.636 for the PreTest and -4.878 for the PostTest.

The significance (p) is less than 0.001 in both cases.

Wilcoxon's W: Wilcoxon's W test provides values of 600,000 for the PreTest and 618,000 for the PostTest.

The associated Z-value is -5.636 for the PreTest and -4.878 for the PostTest.

The significance (p) is less than 0.001 in both cases.

These results indicate that there are statistically significant differences between PreTest and PostTest scores. The p-value less than 0.001 in both tests strongly suggests that the observed differences are not attributable to chance. In addition, negative Z values in both cases indicate that the scores on the PostTest are significantly higher than those on the PreTest.

It is important to note that these tests are nonparametric and do not assume normal distributions. They are used when the data does not meet the assumptions of parametric testing. In this case, the results suggest that the intervention (or any change between the PreTest and PostTest) has had a statistically significant impact on scores, according to nonparametric tests

DISCUSSION

This research focuses on measuring the impact of the use of digital applications on literacy, particularly in the context of students with dyslexia. The data collected are presented in several tables ranging from measures of central tendency and dispersion to more advanced statistical tests. Through a detailed analysis of Tables 5, 6, 7, 8 and 9, light can be shed on the effectiveness of digital applications and their influence on the literacy ability of students, especially those with dyslexia.

Table 5 provides key descriptive data in the PostTest and PreTest periods, highlighting the means, standard deviations, and standard errors for the Control and Experimental groups. In the PostTest, the Control group had a mean of 1.90, while the Experimental group had a significantly higher average of 2.70. These values suggest that the intervention with digital applications has had a positive impact on the literacy of the Experimental group. In addition, when comparing the PreTests, it was observed that both initial conditions were similar, with means of 2.00 for the Control group and 2.70 for the Experimental group.

Table 6 deepens the analysis by presenting independent sample tests for the PostTest and PreTest periods. Levene's test evaluates the equality of variances, revealing that, in the PostTest, variances are assumed to be equal, while in the PreTest, they are assumed and not assumed to be equal in different sections. The t-test for equality of means indicates that, in the PostTest, the differences between the groups are statistically significant ($t = -6.093$, $p < 0.001$), and these differences persist even when equality of variance is not assumed. Similarly, in the PreTest, the differences between the groups are highly significant ($t = -8.226$, $p < 0.001$), indicating that the groups were different even before the intervention with digital applications.

The magnitude of these differences is detailed in Table 7, which presents independent sample sizes for the PreTest and PostTest. Various effect measures are used, such as Cohen's d, Hedges' correction, and Glass's delta. The results reveal that the intervention with digital applications had a significant effect in both test moments, with values indicating a substantial impact on literacy. These findings support the idea that digital applications not only produced statistical differences, but also had an important practical effect.

Table 8 specifically addresses literacy ability in students with dyslexia, comparing the means, standard deviations, and standard errors between the Control and Experimental

groups at both test times. In the PostTest, an improvement in the mean of the Experimental group (2.70) compared to the Control group (1.90) is observed, supporting the efficacy of digital applications in the context of dyslexia. These results indicate that the intervention not only had an overall impact on literacy, but was also especially beneficial for students with dyslexia.

Table 9, which presents the Mann-Whitney U and Wilcoxon W test, further consolidates the results, providing a non-parametric perspective of the difference between the groups. In both the PreTest and the PostTest, significant differences ($p < 0.001$ were observed), supporting the consistency of the results obtained through different statistical approaches. The negative Z-score on both tests indicates a significant improvement after the application of digital applications in literacy.

These results support the hypothesis that the use of digital apps has a positive impact on literacy, and this impact is particularly pronounced in students with dyslexia. The combination of descriptive analyses, independent sample testing, sample sizes, and non-parametric testing provides a comprehensive and robust view of the effectiveness of digital interventions in the educational context. These findings have important practical and pedagogical implications, suggesting that the integration of digital applications may be an effective strategy for improving literacy skills, especially in student populations with specific challenges such as dyslexia.

References

Abellán, J., & Sáez Gallego, N. M. (2020). Opinions regarding the inclusion of pupils with special educational needs shown by future pre-school and primary school teachers. Complutense Journal of Education, 31(2), 209-229. https://doi.org/10.5209/rced.62090

Acosta Mendoza, C. (2022). Dyslexia as a Challenge for Inclusive Education. In Research for the Improvement of Society—AJ CDMX 2022. Academia Journal.

Aguirre Sánchez, K. M. (2023). The use of literacy in higher education students: Case study, Faculty of Social Sciences, Universidad Autónoma de Sinaloa. Interdiscipline, 11(29), 227-237. https://doi.org/10.22201/ceiich.24485705e.2023.29.84489

Amat, S., & Manuel, V. (2019). Digital applications for the development of reading and writing for students in Early Childhood and Primary Education. Research and Innovation Networks in University Teaching., 721-730.

Arreola Olivarría, C. G., Fernández Nistal, M. T., Vales García, J. J., & Sánchez Escobedo, P. A. (2022). Factors associated with teaching practices supported by information and communication technologies. EDUCAR, 58(1), Article 1. https://doi.org/10.5565/rev/educar.1349

Avilés Agama, A. (2021). Dytectiveu Application and Its Influence on the Literacy of Children of the U.E. Padre Marcos Benetazo, Ecuador 2020-2021 [Master's Thesis]. Technical University of Babahoyo.

Balla Paguay, H. S., Parra Rodríguez, N. M., Plaza Escandón, H. D., & Cueva Martínez, D. L. (2022). Digital applications as a tool for learning basic accounting in the Monsignor Juan Wiesneth Educational Unit. Prohominum, 4(2), Article 2. https://doi.org/10.47606/ACVEN/PH0125

Bastidas González, K. A., Jumbo Jumbo, F. V., Mazón Vera, V. S., & Bastidas González, L. D. (2023). Dyslexia: Role of the teacher in early diagnosis in elementary school students. Ciencia Latina Revista Científica Multidisciplinar, 7(1), Article 1. https://doi.org/10.37811/cl_rcm.v7i1.5112

Bice, H., & Tang, H. (2022). Teachers' beliefs and practices of technology integration at a school for students with dyslexia: A mixed methods study. Education and Information Technologies, 27(7), 10179-10205. https://doi.org/10.1007/s10639-022-11044-1

Blas Padilla, D. (2022). Design and implementation of augmented reality material for training in secondary education. [Doctoral Thesis, Pablo de Olavide University]. http://hdl.handle.net/10433/14570

Cacuango Álava, C. F., & Hernández Díaz, A. (2022). Recursos para el desarrollo de la lectoescritura en estudiantes de la Educación General Básica Resources for the development of literacy in students of Basic General Education. Pole of Knowledge, 7(4). https://dialnet.unirioja.es/servlet/articulo?codigo=8482973

Calderón Arévalo, M. Y., Flores Mejía, G. S., Ruiz Pérez, A., & Castillo Olsson, S. E. (2022). Gamification in students' reading comprehension in times of pandemic in Peru. Journal of Social Sciences (Ve), Esp. 28(5), 63-74. https://www.redalyc.org/journal/280/28071845005/html/

Castillo, M. Y., & Jiménez Puello., J. de J. (2019). Learning theories under the ICT magnifying glass. Educational Action and Reflection, 44.

Cordón García, J. A., & Muñoz Rico, M. (2023). The Socialization of Reading and Writing: Fandom, Networks and Editorial Visibility. Texto Livre, 16, e37067. https://doi.org/10.1590/1983-3652.2023.37067

Cortez Barrera, J., Daza Acosta, J., & Catañeda Polanco, J. G. (2019). Relationship of the socioeconomic environment with the performance of reading comprehension in university students. Journal of Social Sciences, 4, 119-133. https://produccioncientificaluz.org/index.php/rcs/article/view/30521/31567

Cruz Parrado, F. I., & Córdoba Machado, L. F. (2023). Intervention of difficulties in the writing and reading process in children of first and second grade through digital resources in the I.E. San Luis (Neira, Caldas) and I.E. San Antonio (Cunday, Tolima) [Master's Thesis, Universidad de La Salle]. https://ciencia.lasalle.edu.co/ lic_educacion_basica_primaria/7

by Franco Mineira, F., & Vera Solórzano, J. L. (2020). Research Paradigms, Approaches and Methods: Theoretical Analysis. Revista Mundo Recursivo, 3(1), 1-24. https://atlantic.edu.ec/ojs/index.php/mundor/article/view/38

Díaz Castela, M. del M., Pérez Padilla, J., Checa Fernández, P., Cerezo Rusillo, M. T., & Carpio Fernández, M. de la V. (2022). Learning and personality development. Editorial Universidad de Jaén, 1-236. https://www.torrossa.com/en/resources/an/5486135

Dussan Arquez, F. (2022). Learning environments mediated by digital tools for the strengthening of literacy in primary school.pdf [Master's Thesis, Universidad de la Costa]. https://repositorio.cuc.edu.co/bitstream/handle/11323/9702/Ambientes%20de%20aprendizaje%20mediados%20por%20herramientas%20digitales%20para%20el%20fortalecimiento%20de%20la%20lectoescritura%20en%20b%C3%A1sica%20primaria.pdf?sequence=1&isAllowed=y

Escudero Caiceo, J. (2020). Competency-based training in higher education. Salamanca Education Papers, 24, 211-218. https://dialnet.unirioja.es/servlet/articulo?codigo=7645124

Feliz Ricoy, S., & Feliz Murias, T. (2019). Inclusion of students with disabilities. Experiences and challenges. In A. I. Pinilla Allueva & J. L. Alejandre Marco (Eds.), Approaches and experiences of educational innovation with ICT in Higher Education (pp. 215-224). EuLES Network. https://zaguan.unizar.es/record/88366/files/BOOK-2020-032.pdf

Fernandez, D. M. M., Justiniano, L. M. S., & Diaz, A. D. R. (2021). Educational psychology. Infinite Study.

Galluzzo, M. (2019). Dyslexia, the learning problem that remains invisible. BBC News World. https://www.bbc.com/mundo/vert-cap-49092313

Ganchala, M. E., & Toapanta, A. C. (2023). "Dyslexia in the Teaching-Learning Process" [Doctoral Thesis]. Technical University of Cotopaxi.

García, S., & Cantón, I. (2019). Use of technologies and academic performance in adolescent students. Communicate, 27(59), 73-81. https://doi.org/10.3916/C59-2019-07

González, E. M., Carbonell Bernal, N., Aguaded Gómez, M. C., & Asensio Quirant, G. T. (2021). Use of the "CMAPS TOOLS" tool as an aid for the reading comprehension of primary school students. Pedagogical Trends, 37, 145-155. https://doi.org/10.15366/tp2021.37.012

Gonzalez Ramirez, C., Gonzalez Figueroa, M., Lobos Guerrero, C., Valenzuela, J., Munoz, C., Gonzalez Ramirez, C., Gonzalez Figueroa, M., Lobos Guerrero, C., Valenzuela, J., & Munoz, C. (2020). Reading and the Future Teacher: An Approach to Their Beliefs About Reading*. Literature and Linguistics, 42, 355-385. https://doi.org/10.29344/0717621x.42.2600

Guaña Moya, J., Arteaga Alcívar, Y., Ilbay Guaña, E., & Morales Jaramillo, M. B. (2023). Use of Information and Communication Technologies to improve the learning of children with dyslexia. RECIMUND, 7(1), 507-514. https://doi.org/10.26820/recimundo/7.(1).Jan.2023.507-514

Guerrero Guaca, Y. A., Pedrozo Díaz, L. L., & Correa Ávila, A. M. (2023). ICT-mediated literacy skills in third-grade students of the Timba Educational Institution [Master's Thesis, Los Libertadores University]. https://repository.libertadores.edu.co/bitstream/handle/11371/5700/Correa_Guerrero_Pedrozo_2023.pdf?sequence=1

Hernández Sampieri, R., & Mendoza Torres, C. P. (2018). Research methodology: Quantitative, qualitative and mixed routes (First edition). McGraw-Hill Education.

Herrera Rodríguez, N. G. (2022). ICTs, Tools to Encourage Reading and Writing Skills, in [Doctoral Thesis, University of Cartagena]. https://repositorio.unicartagena.edu.co/bitstream/handle/11227/15240/TGF_Nathaly%20Herrera_Jhon%20Moncaleano_Lina%20Rodriguez.pdf?sequence=1&isAllowed=y

Janin, B., Vasen, J., Fusca, C., Moysés, M. A. A., Collares, C. A. L., Wassner, M., Bindi, P., Malti, V., & Szyber, G. (2019). Dyslexia and Learning Difficulties: Contributions from Clinical and Educational (1.to ed.). Noveduc; eBook - ePub.

Janin Beatriz, Vasen Juan, Fusca Carmen, Aparecida María, Alfonso Moysés, Azevedo Cecilia, Collares Lima, Wassner Mariana, Bind Pablo, Malti Viviana, Szyber Graciela, (2019), Dyslexia and learning difficulties: Contributions from the clinic and education

Karipidis, I. I., & Hong, D. S. (2020). Dyslexia in Pediatrics: Simple Practices to Tackle a Complex Issue. American Academy of Pediatrics, 146(1), e20201470. https://doi.org/10.1542/peds.2020-1470

Londoño Hernández, C. D. (2022). Dyslexia: Socio-emotional manifestations in learning disorder and its multidisciplinary intervention. Science and Academia, 3. https://doi.org/10.21501/2744838X.4486

Macas, A. del R., & Guevara, C. F. (2020). Use of digital tools to improve dyslexia in Basic Education students. Domino de las Ciencias, 6(3), Article 3. https://doi.org/10.23857/dc.v6i3.1281

Máñez Carvajal, C., & Cervera Mérida, J. F. (2022). Development of a mobile application for children with reading and writing learning difficulties. Technology Information, 33(1), 271-278. https://doi.org/10.4067/S0718-07642022000100271

Matéu Guarque, C. (2022). Implementation of the eTwinning didactic programme for the teaching of Spanish as a foreign language to school-age students. [Master's Thesis, University of Cantabria]. https://repositorio.unican.es/xmlui/bitstream/handle/10902/28122/TFM.CMG.pdf?sequence=1&isAllowed=y

Montoya, L. A., Parra Castellanos, M. del R., Lescay Arias, M., Cabello Alcívar, O. A., & Coloma Ronquillo, G. M. (2019). Pedagogical theories that support learning with the use of Information and Communication Technologies. Journal of Scientific Information, 98(2), 241-255. http://scielo.sld.cu/scielo.php?script=sci_abstract&pid=S1028-99332019000200241&lng=es&nrm=iso&tlng=es

National Center for Improving Literacy. (2020). 10 Key Policies and Practices for Reading Intervention with strong evidence of effectiveness from high-quality research. The University of Texas at Austin. http://www.meadowscenter.org/library/resource/10-key-policies-and-practices-for-reading-interventions

National Center on Improving Literacy. (2023). Intensifying Reading Instruction for Students Who Are Not Making Desired Progress. National Center on Improving Literacy.

https://myemail.constantcontact.com/Article--Intensifying-Reading-Instruction.html?soid=1127725926505&aid=hTBXv5SaqiI

Ñaupas Paitán, H., Valdivia Dueñas, M. R., Palacios Vilela, J. J., & Romero Delgado, H. E. (2018). Research methodology: Quantitative-qualitative and thesis writing (5th edition). Ediciones de la U.

Ñaupaz Paitán, H., Valdivia Dueñas, M., Palacios Vilela, J. J., & Romero Delgado, H. (2018). Research Methodology. 5th Edition. Ediciones de la U.

Peñas Cuva, C. (2017). Learning Strategies to Improve Reading and Writing in First Grade Students of Educational Institution No. 601514 "El Dorado", San Juan 2017 [Doctoral Thesis, Cesar Vallejo University]. https://repositorio.ucv.edu.pe/bitstream/handle/20.500.12692/35079/pe%C3%B1a_cc.pdf?sequence=1&isAllowed=y

PISA. (2018). What Students Know and Can Do | en | OECD. https://www.oecd.org/education/pisa-2018-results-volume-i-5f07c754-en.htm

Pisco-Román, J., Bailón-Panta, A., & Macias-Figueroa, D. (2023). Literacy as a fundamental element in the teaching-learning process of Elementary School students. 593 Digital Publisher CEIT, 8(1-1), 328-347. https://doi.org/10.33386/593dp.2023.1-1.1658

Portilla Martínez, G. S. (2023). Neural networks applied in the learning of educational robotics [Master's Thesis, Universidad Técnica del Norte]. http://repositorio.utn.edu.ec/bitstream/123456789/14409/2/PG%201494%20TRABAJO%20DE%20GRADO.pdf

Proaño Zambrano, C. P. (2021). ICT in Reading and Writing Learning [Master's Thesis, Universidad San Gregorio de Portoviejo]. http://repositorio.sangregorio.edu.ec/bitstream/123456789/2524/1/MEDU-2022-075.pdf

Rojas Hernández, Y. L., González Méndez, A., Rodríguez-Amaya Fernández, I. J., & Álvarez Yero, S. (2021). Learning and new information and communication technologies. Higher Medical Education, 35(3). http://scielo.sld.cu/scielo.php?script=sci_abstract&pid=S0864-21412021000300016&lng=es&nrm=iso&tlng=es

Rojas, M. M. (2022). Covid-19 pandemic and delays in reading and writing in Costa Rican primary education. Some proposals to optimize the recovery of learning in the new workspaces. Read, Write, and Discover eJournal, 1(6), 71-89. https://digitalcommons.fiu.edu/cgi/viewcontent.cgi?article=1074&context=led

Román Vega, K. (2022). The impact of technological applications on the stimulation of the conceptual content "reading" of the preschool education study program of the MEP in groups T1-a, T3-a, T5-a, T6-a, T8-a and T9-a and the teachers of each group of the Flora Chacón Córdoba, Goicoechea, San José kindergarten during the III Semester 2021. [Master's Thesis, Universidad Hispanoamericana]. http://13.87.204.143/xmlui/bitstream/handle/123456789/7023/EDU-753.pdf?sequence=1&isAllowed=y

Sanfilippo, J., Ness, M., Petscher, Y., Rappaport, L., Zuckerman, B., & Gaab, N. (2020). Reintroducing Dyslexia: Early Identification and Implications for Pediatric Practice. American Academy of Pediatrics, 146(1), e20193046. https://doi.org/10.1542/peds.2019-3046

Santoro, D. C., & Avilés, P. P. (2022). Digital Tools in the Strengthening of Literacy Skills [Master's Thesis, University of Guayaquil]. http://repositorio.ug.edu.ec/handle/redug/63425

Selfa Saatre, M. (2022). Creativity and Digitization of Poems for Literacy Learning: Design, Implementation, and Analysis in Initial Teacher Training. Interuniversity Journal of Teacher Education, 97(36.3), 29-52. https://doi.org/10.47553/rifop.v97i36.3.96199

Serrano Santos, M. C. (2021). Interactive didactic resources and the learning of reading and writing of students with mild intellectual disabilities of the Teodoro Wolf Educational Unit [Master's Thesis, State University of Santa Elena Peninsula]. https://repositorio.upse.edu.ec/bitstream/46000/8141/1/UPSE-MET-2022-0039.pdf

Soğanci, S., & Kulesza, E. M. (2023). Psychosocial Effects of Dyslexia in Terms of Students, Parents, and School Community– Research Review. Turkish Journal of Special Education Research and Practice, 5(1), 1-17. https://doi.org/10.37233/TRSPED.2023.0134

Suárez Álvarez, J., Fernández Alonso, R., Muñiz, J., & García Crespo, F. (2021). The Use of New Technologies in Educational Assessments: Reading in a Digital World. Psychologist Papers, 43(1). https://doi.org/10.23923/pap.psicol.2986

Tigse Parreño, C. M. (2019). Constructivism, according to César Coll's theoretical bases. Andean Journal of Education, 2(1), Article 1. https://doi.org/10.32719/26312816.2019.2.1.4

Ulco Simbaña, L. E., Baldeón Egas, P. F., Ulco Simbaña, L. E., & Baldeón Egas, P. F. (2020). Information and communication technologies and their influence on literacy. Conrad, 16(73), 426-433. http://scielo.sld.cu/scielo.php?script=sci_abstract&pid=S1990-86442020000200426&lng=es&nrm=iso&tlng=pt

UNESCO. (2020). Global Education Monitoring Report 2020: Inclusion and Education: All without Exception. (1st ed.). United Nations Educational, Scientific and Cultural Organization. https://doi.org/10.54676/WWUU8391

Vargas, P. C. A., Sangucho, M. C. A., Tapia, L. M. M., & Michay, L. L. P. (2023). Dyslexia Disorder and Gamification: A Methodological Proposal Aimed at 3rd Grade Students EGB at the "General Artigas" School in the city of Quito. [Master's Thesis]. UIDE University.

Vivanco, G., & Gorostiaga, J. (2017). Digital Culture and Diversity: Perspectives on ICT-Education Policy Discourses. Cadernos de Pesquisa, 47(165 (Jul./Sep.2017;)), 1016-1043. https://dialnet.unirioja.es/servlet/articulo?codigo=6135831

Zabala Vargas, S. A. (2022). Teaching strategy with game-based learning methodology, for the improvement of academic performance and motivation of students in first-year engineering mathematics courses [Doctoral Thesis, University of the Balearic Islands]. https://dspace.uib.es/xmlui/bitstream/handle/11201/159807/Sergio%20Andr%C3%A9s%20Zabala%20Vargas_TESIS%20DEF.pdf?sequence=1&isAllowed=y

Zetina López, I. J., Nieto Suárez, M. G., & Esquivel Avila, C. (2021). Theories of learning that underpin preschool education and teacher training. 4th National Congress of Research on Normal Education, Hermosillo - Sonora.