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English language learning through Mixed Reality: A study in Paraguayan public schools

Aprendizaje de Inglés a través de la Realidad Mixta: Un Estudio en Escuelas Públicas de Paraguay

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ABSTRACT
In the early years of life, children develop foundational skills that prepare them for formal reading and writing. Therefore, there is no specific age at which children are ready to read; instead, they are ready when they have acquired the necessary skills. Learning another language from an early age further reinforces these foundational skills and facilitates intellectual development. In Paraguay, despite the enactment of Law 5031/13, which requires English language instruction in public education from preschool through high school, the teaching of English as a foreign language shows deficiencies in the sustained formative trajectory that should begin at the early education level. The integration of mixed reality (MR) technologies has proven effective in various educational contexts, including language learning, by offering an interactive and immersive learning experience. This cross-sectional study analyzes the correlation between educational environments, teaching methodologies, and their impact on learning. It involved 174 students from four public schools in Paraguay with no prior exposure to English. The methodology was implemented twice a week for 40 minutes over three months, without textbooks with the Challenge program with Mixed Reality (MR) technology. The study included both schools with English teachers and those where the methodology was implemented by elementary school teachers. Teachers received training and pedagogical guides throughout the project. Students were assessed at the beginning and end of the study to measure progress in Speaking, Listening, Phonics, and Writing. The data were analyzed using inferential statistical tests to compare initial and final results, determining the effectiveness of the Challenge program and MR technology in improving English language skills. Activities included greetings, songs, keywords, and interactive exercises. The results indicate that the applied methodology is effective in improving students' language skills. These findings suggest that the sustainable implementation of early English literacy will benefit from innovative strategies and the expansion of educational opportunities in the country. Additionally, the intervention was equally effective regardless of whether the teacher was an English teacher or an elementary school teacher, reflecting the flexibility of the methodology, given the shortage of English teachers at a national level. Moreover, despite high technological costs, most public schools in Paraguay already have the basic infrastructure necessary for such pedagogical innovations.

Keywords: early literacy; English as a foreign language; educational technologies; public education in Paraguay; mixed reality; phonemic awareness.

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RESUMEN
Durante los primeros años de vida, los niños desarrollan habilidades precursoras que los preparan para el aprendizaje formal de la lectura y la escritura. Por lo tanto, no existe una edad específica en la que los niños estén listos para leer; en cambio, están preparados cuando han adquirido las habilidades y conocimientos necesarios. El aprendizaje de otra lengua desde la infancia refuerza aún más estas habilidades precursoras y facilita el desarrollo intelectual. En Paraguay, a pesar de la promulgación de la Ley 5031/13, que exige la enseñanza del inglés en la educación pública desde el Preescolar hasta el Tercero de la Media, la enseñanza del inglés como lengua extranjera presenta deficiencias en cuanto a la trayectoria formativa sostenida que debe comenzar en el Nivel Inicial. La integración de tecnologías de realidad mixta (RM), ha demostrado ser efectiva en diversos contextos educativos, incluyendo el área de lenguas, ofreciendo una experiencia de aprendizaje interactiva e inmersiva. Este estudio transversal analiza la correlación entre los entornos pedagógicos, las metodologías didácticas y su impacto en el aprendizaje. Participaron 174 estudiantes de cuatro escuelas públicas en Paraguay sin exposición previa al inglés. Se utilizó el programa Challenge con tecnología de Realidad Mixta (RM). La metodología se implementó dos veces por semana durante 40 minutos por tres meses, sin libros de texto. El estudio abarcó tanto escuelas que contaban con profesores de inglés como aquellas donde la metodología fue implementada por maestras de grado. Los docentes recibieron capacitación y guías pedagógicas durante todo el proyecto. Se evaluó a los estudiantes al inicio y al final del estudio para medir el progreso en Expresión Oral, Comprensión Auditiva, Conciencia Fonémica y Escritura. Los datos se analizaron utilizando pruebas estadísticas inferenciales para comparar los resultados iniciales y finales, determinando la efectividad del programa Challenge y la tecnología de RM en la mejora de las habilidades lingüísticas en el inglés. Las actividades incluían saludos, canciones, palabras clave y ejercicios interactivos. Los resultados indican que la metodología aplicada es efectiva en mejorar las habilidades lingüísticas de los estudiantes. Estos resultados sugieren que la implementación sostenible de la alfabetización inicial en inglés se beneficiará de estrategias innovadoras y de la expansión de oportunidades educativas en el país. Además, la intervención fue igualmente efectiva sin importar si el docente era profesor de inglés o maestra de grado, reflejando la flexibilidad de la metodología ante la escasez de profesores de inglés a nivel nacional. Por otro lado, a pesar de los altos costos tecnológicos, la mayoría de las escuelas públicas en Paraguay ya tienen la infraestructura básica necesaria para este tipo de innovaciones pedagógicas.

Palabras clave: alfabetización inicial; inglés como lengua extranjera; tecnologías educativas; educación pública en Paraguay; realidad mixta; conciencia fonémica.

Introduction

The early years of life are crucial for the development of a person's cognitive ability. Scientific evidence has shown that early attention influences sensory, motor, comprehension, expression, curiosity, exploration, non-verbal communication, vocabulary, and affective relationships. During this stage, early literacy takes place, developing foundational skills that prepare children for formal reading and writing (Dueñas et al., 2024). Children are not ready to read at a specific age; rather, they are ready when they have acquired the necessary skills and knowledge over time (Coch & Molins, 2022). Additionally, learning another language enhances neural connections, especially when learned from childhood (Gracia-Tabuenca et al., 2024). The integration of English learning from an early age, focusing primarily on phonemic awareness, can enhance this development. In our country, there is a weakness in the educational proposal for English as a Foreign Language from early childhood through the end of high school. This was one of the driving factors behind the development of our current research.

MR technologies are used in various educational settings, from elementary schools to graduate courses. Studies indicate that mixed reality (MR) significantly enhances the teaching and learning experience (Tan et al., 2024; Tang et al., 2020). MR is particularly distinctive as it merges real and virtual objects, offering real-time interaction in a three-dimensional space. This blend enables seamless interaction between the physical and virtual worlds (Yusoff et al., 2011). However, a common misconception is that simply integrating the latest technologies will automatically improve student attitudes and academic performance (Penn & Ramnarain, 2023). Implementing MR in classrooms requires more than just a demonstration of technology;

it demands thoughtful pedagogical designs that align technological tools with learning objectives. While MR has been used in different educational fields, its application in English Foreign Language (EFL) classrooms is a recent development. If these tools meet both the learning goals and the educational needs, integrating MR in the EFL classrooms can significantly improve learning experiences, fostering better understanding and retention.

This study aims to explore the impact of integrating Mixed Reality (MR) technology, through the Challenge English reading program, on the learning outcomes of students with no prior exposure to English in EFL instruction within public schools in Paraguay.

Implementation of English language education in Paraguay's public schools

The Paraguayan government has recognized the importance of incorporating the English language into national education curricula. MEC has been implementing changes in educational policies since the second decade of the 21st century. Law No. 5031/13 requires the implementation of English in public education from Preschool to the last year of Secondary Education. This law stipulates that the Ministry of Education and Sciences (MEC) must coordinate the necessary mechanisms for its gradual implementation. According to the Syllabus for English as a Foreign Language (MEC, 2019), the importance of English in globalization and its predominance in scientific and technological fields has led to its inclusion in Paraguay's official school curriculum from preschool. This aims to enrich education and personal development by providing early exposure to English, fostering cultural curiosity, and facilitating global communication. Similarly, the Ministry of Education and Sciences (MEC) has developed Syllabi for English as a Foreign Language from 1st grade to the 3rd Year of Secondary Education (MEC, 2011a, 2011b, 2011c, 2014, 2015, 2018, 2019). These plans aim for students to understand and produce oral and written texts using commonly used vocabulary and simple expressions, addressing basic communicative functions in familiar, school, and community contexts.

Nevertheless, there is no sustained educational trajectory that begins in preschool and continues through high school, except for 300 schools included in the Extended School Day Pilot Plan since 2021, all other schools in the country offer English only in the last three years of secondary education. The acquisition of English in Paraguay requires a strong educational trajectory starting from early education. Since English is not a language commonly heard in Paraguay, it is necessary to implement a comprehensive educational approach from the early years of schooling. Early exposure to English, combined with effective pedagogical methodologies and adequate resources, allows for the gradual development of linguistic competencies. Without an early formative foundation, students face greater challenges in reaching intermediate levels such as B1, which demands more sophisticated comprehension and expression skills. Therefore, educational planning must consider the implementation of continuous and progressive programs in English learning from Early Childhood Education through Higher Education.

Transformative potential of MR technologies and gamification in education

In postmodern times, the boundaries between truth and fiction have blurred, and new technologies create constructed realities that don't fully reflect the physical world nor stand as pure fiction (Bruns & Gabriel, 2020). Augmented reality (AR) and virtual reality (VR) have been around for decades. The first VR headset, created by Daniel Vickers in the 1970s at the University of Utah, allowed users to experience virtual scenes by turning their heads. In 1982,

the DataGlove was developed to track hand and finger movements and communicate them to a computer. The term "Virtual Reality" was introduced in the 1980s by Jaron Lanier, while "augmented reality" was coined in 1990 by Thomas Caudell and David Mizell to describe head-mounted displays used by electricians (Elmqaddem, 2019).

The spectrum of virtual and augmented experiences is defined as “Extended Reality” (XR) and encompasses three types of realities: virtual reality (VR), which uses visual and auditory effects to create an immersive environment; augmented reality (AR), which allows physical interaction with virtual objects in the real world, facilitated by mobile devices; and mixed reality (MR), which combines virtual and real elements (Ortega-Rodriguez, 2022). Despite being invented decades ago, these technologies are now more extensively used in different settings, and they have recently acquired significant interest due to their potential applications in the educational field.

MR technologies have gained interest in education due to their many applications in the field. MR technologies often enhance and motivate educational experiences, complementing traditional methods. However, their effectiveness compared to other tools depends on factors such as content choice, medium optimization, XR application availability, pedagogical methods, existing infrastructure, and technological support (Gaol & Prasolova-Førland, 2022). If applied appropriately, these technologies can yield positive outcomes in Literacy, Mathematics, and Science (Neumann et al., 2022). Hence, MR technologies have transformative potential in education, emphasizing the need for thoughtful integration to fully appreciate their benefits.

An area in the educational field where MR technologies have shown significant benefits is special needs education (SNE). Tan et al. (2024) analyzed immersive interactive mixed reality (I2MR) technologies. They found that these technologies are useful in SNE, as students improved mental well-being and academic and social skills. Aruanno et al. (2024) introduced an MR application designed to assist young students with special needs in learning laboratory activities in a case study. All students showed enthusiasm and interest. These findings highlight the potential of MR technologies to substantially enhance the learning experiences and outcomes for students with special needs.

These technologies enrich and innovate teaching methods. They open up new potential for immersive learning experiences and could transform traditional lectures, allowing students to engage in realistic scenarios (Sala, 2021). The integration of digital technologies such as VR, AR, and MR is also transforming education for young learners by enhancing their motivation, engagement, and creativity. Because “children do not have analytical skills and tend to process languages generally through sensory experience, and language develops from exposure to simplified and concrete input” (Benati & Angeelovska, 2016, p. 135), children benefit significantly from these immersive tools.

A fundamental aspect of integrating technologies in children's language classrooms is incorporating a gamified environment. Combining immersive experiences with game-based elements can boost engagement and learning outcomes. Syal and Nietfeld (2024) investigated the impact of a game-based learning environment (GBLE) on fifth graders’ reading comprehension and motivation. They found that the use of GBLE enhances both reading comprehension and motivation, particularly for struggling and uninterested readers. In another study, Yu (2023) findings revealed that gamified English vocabulary learning significantly outperformed non-gamified methods in terms of learning outcomes, motivation, and satisfaction. There is a powerful synergy between MR technologies and gamification, their

combined potential can transform educational experiences and notably improve student engagement and academic performance.

In summary, while considerable research has explored the use of Mixed Reality (MR) technology in various educational contexts, there is a notable lack of studies focusing on its application in English as a Foreign Language (EFL) instruction, particularly Paraguay. This study aims to address this gap by investigating the impact of the Challenge English reading program, utilizing MR technology, on the learning outcomes of students with no prior exposure to English. By doing so, this research will provide valuable insights into the potential benefits and challenges of integrating MR in EFL classrooms, offering guidance for future educational practices and research.

Methods

The research design is cross-sectional. This study seeks to analyze the correlation between pedagogical environments and didactic methodologies (content format, methodology, didactics, technology, and pedagogical guidance) through the Challenge program and the level of learning. Associations between these factors are analyzed to assess their impact on outcomes. This approach allows for the identification of relationships between key variables without establishing direct causality, providing a deeper understanding of how these elements interact within the educational environment.

Participants

The study involved 174 students from public schools in Paraguay who had never been exposed to English instruction. Participants were divided as follows:

School A: 25 first-grade students

School B: 42 students (7 K4 students, 17 K5 students, 15 first-grade students, 3 second-grade students, 8 third-grade students)

School C: 47 K5 students

School D: 60 K5 students

All participants experienced the same experimental condition using the Challenge program with MR technology.

Challenge English Reading Program

The Challenge English reading program, developed by VISANG LEARNING INC., integrates Mixed Reality (MR) technology to enrich the learning experience. The program utilizes a phonemic awareness approach to teach letter recognition and its relationship to the symbol (letter), emphasizing immersive and interactive activities, where the classroom becomes the physical experience of learning. The MR technology allows students to interact with virtual objects in real time, blending physical and virtual environments to facilitate learning. Challenge is designed to engage students through interactive and playful learning experiences, making English learning more enjoyable and effective. Additionally, it includes textbooks in three Steps. Each Step covers 10 units, with each unit containing 8 lessons. The program is designed so that each Step can be completed within an academic year, with a

workload of 2 weekly classes of 40 minutes each. The textbooks complement the digital content and primarily strengthen writing skills.

For the implementation of the Challenge, teachers installed the software on a laptop with a Windows operating system. In addition to the laptop, a projector or television, a speaker, and a webcam were used.

Procedure

The educational institutions were visited one week before the program implementation to administer the pre-test. This pre-test was conducted to determine the participants' English proficiency levels. The methodology was implemented twice a week for 40 minutes over three months. The entire experience was conducted without the support of textbooks. Upon completion, the pre-test was administered as a post-test to assess learning outcomes.

The study included schools with English teachers and schools where the methodology was implemented with the elementary classroom teacher. An initial in-person training session of two hours was conducted for the teachers. Teachers were provided with complete lesson plans, pedagogical and didactic guides, and videos with model lessons of digital content. In addition to the initial training, continuous 40-minute weekly virtual sessions were conducted throughout the study period. This allowed teachers to review the sequence of each lesson and prepare classes in advance by accessing the Virtual Learning Environment.

Classroom implementation

Procedure	Activities
Warm-up	Greeting in English Songs in English to motivate students and create a positive atmosphere.
Development	*Keywords* Teacher projects the keywords that will be learned for the day, emphasizing the sound and symbol of the letter. Gestures are also used to refer to the learned word. Example dialogue: T: Look at the screen! What do you see? Ss: Alligator! T: Right! You can see an alligator! The word alligator starts with the letter A. What does the letter A say? /æ/, / /æ/. Ss: A says /æ/, /æ/. T: Let's say it together. A says /æ/, /æ/. Ss: /æ/, /æ/. T: Let's make the alligator's mouth with the body. T: /æ/, / æ/, alligator. Ss: /æ/, /æ/, alligator. T: Great!

	Reinforcement Activities Keywords are presented again in an interactive format where students must repeat the words learned previously. A song is used that incorporates the learned letters and words, emphasizing the sounds. Sentences are practiced where the learned words appear, adding other high-frequency words in the language. For example: *I see an alligator*. Song Students learn one song per unit. In each class, they practice two to three phrases until the unit song is completed.
Closure	*Mixed Reality Activities* Dynamic activities are presented with the learned words and sentences, where students interact with the virtual environment through MR. The activities are designed playfully.

Instrument

A test was designed and used as a pre-test and post-test at the beginning and the end of the study to measure progress in various aspects of English language acquisition:

a) Speaking and Listening: Assessed through student responses to questions.

b) Phonics: Measured by asking students to match letters with representative images of words.

c) Writing: Evaluated by asking students to write letters in alphabetical order.

Data Collection and Analysis

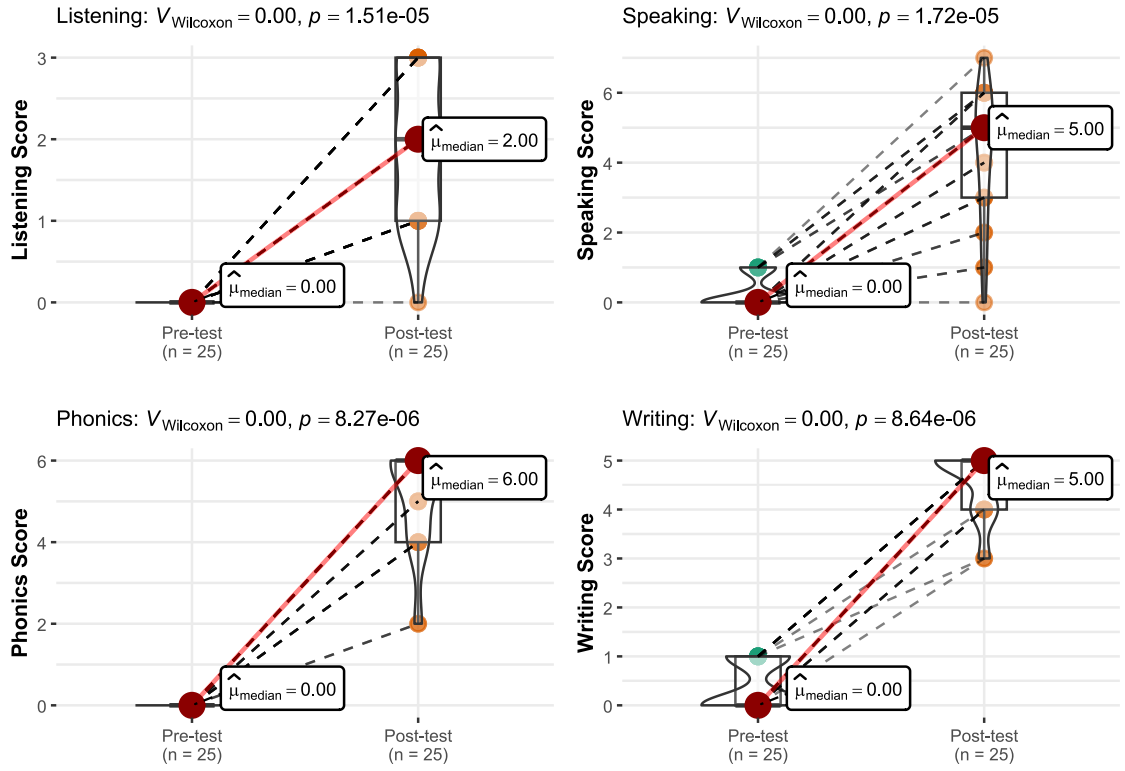
Quantitative data were collected using the pre-test and post-test described above to measure students' learning outcomes in various aspects of English language acquisition. The test results were analyzed using t-tests and non-parametric hypothesis tests for two paired samples, applying inferential statistics to compare the pre-test and post-test scores among the participants. The analysis focused on determining the effectiveness of MR technology and the Challenge program in improving learning outcomes for students with no prior exposure to English.

Results

School A

In this school, the experience was conducted with first-grade students. The results of the Wilcoxon test indicate significant improvements in the four skills evaluated. The extremely low p-values (<0.001) in each of the analyzed skills suggest that the observed improvements in student scores are not due to chance but reflect the positive impact of the applied teaching strategy. These conclusions are directly derived from the graphs in Figure 1, which represent box and violin plots useful for visualizing the data distribution.

Figure 1:

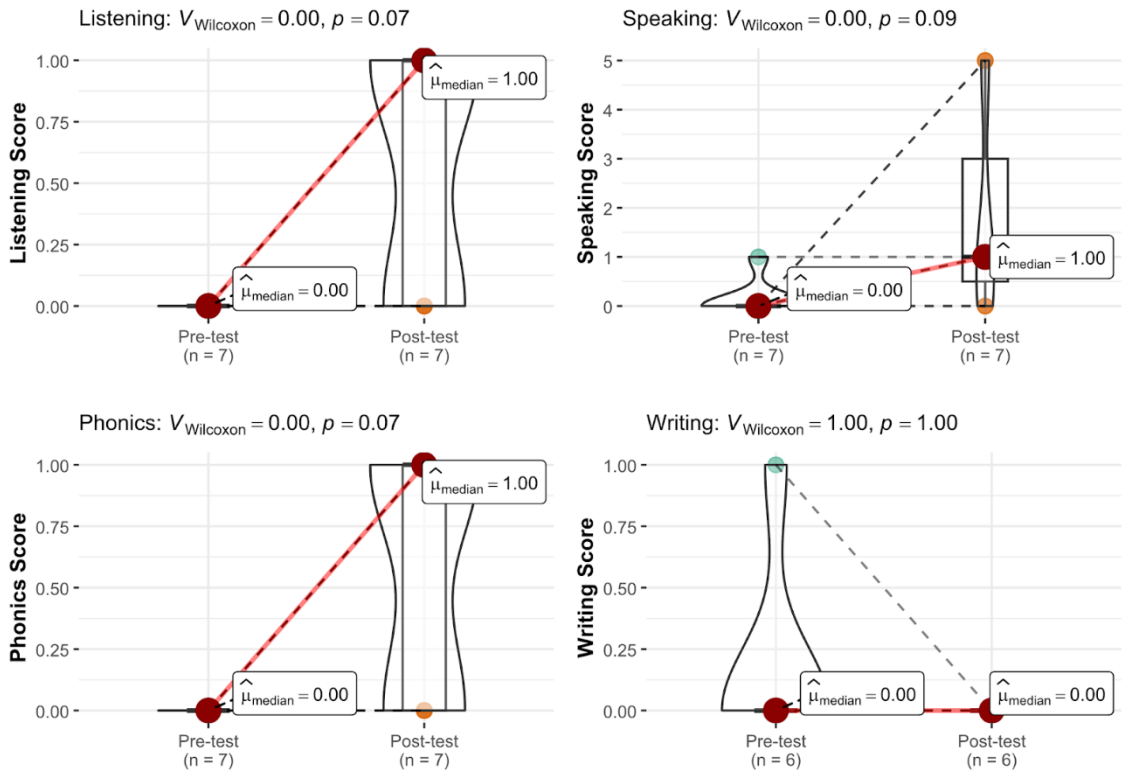


School B

Kinder 4

Considering the students in Kinder 4 from School B, the results of the Wilcoxon test indicate that, although improvements were observed in the four evaluated skills, these improvements did not reach statistical significance, as the obtained p-values are greater than 0.05. Specifically, the p-values were 0.07 for Listening and Phonics, 0.09 for Speaking, and 1.00 for Writing. These values suggest that the observed improvements in student scores do not necessarily reflect a positive impact of the applied teaching strategy. Although the graphs (Figure 2) show some increases in the median scores, the lack of statistical significance implies that we cannot confidently assert that the teaching strategy had a positive effect on this sample of students. This is likely due to the very small sample size.

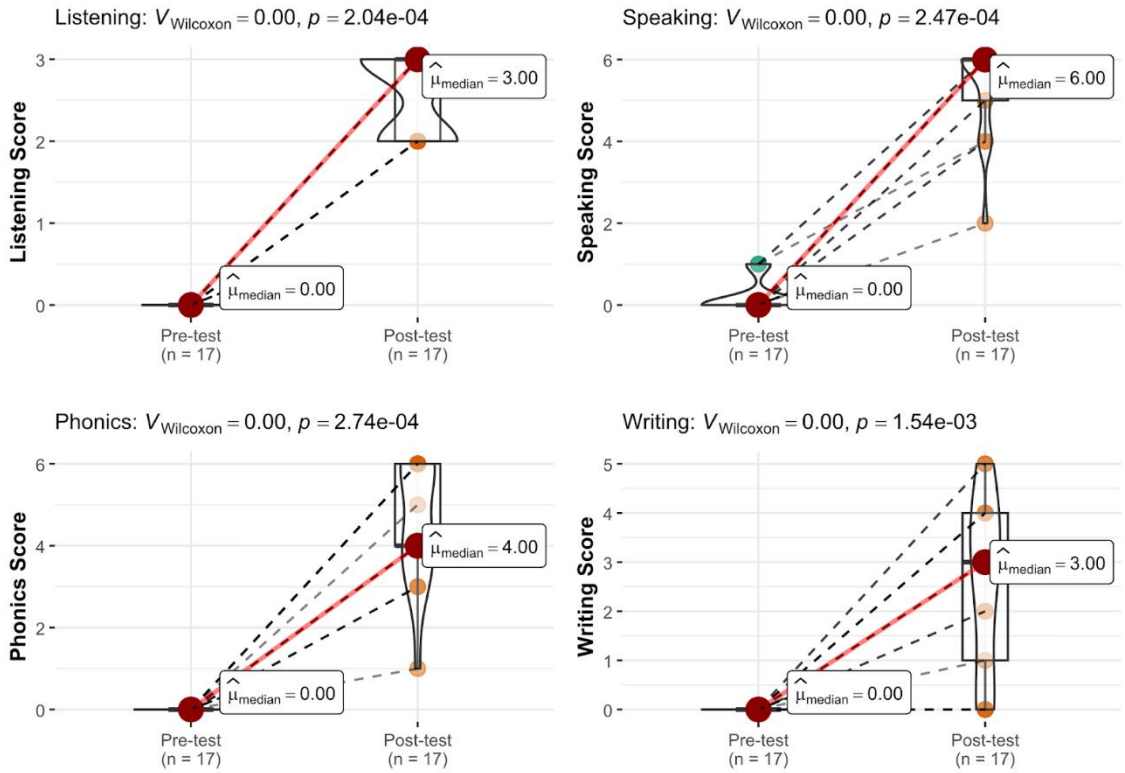
Figure 2:



Preschool

Regarding the preschool students, the analyses conducted using the Wilcoxon test for paired samples revealed significant improvements in all evaluated skills. The p-values, all below 0.001, reflect a significant positive impact of the applied teaching strategy. The positive slopes in all graphs illustrate this fact (Figure 3).

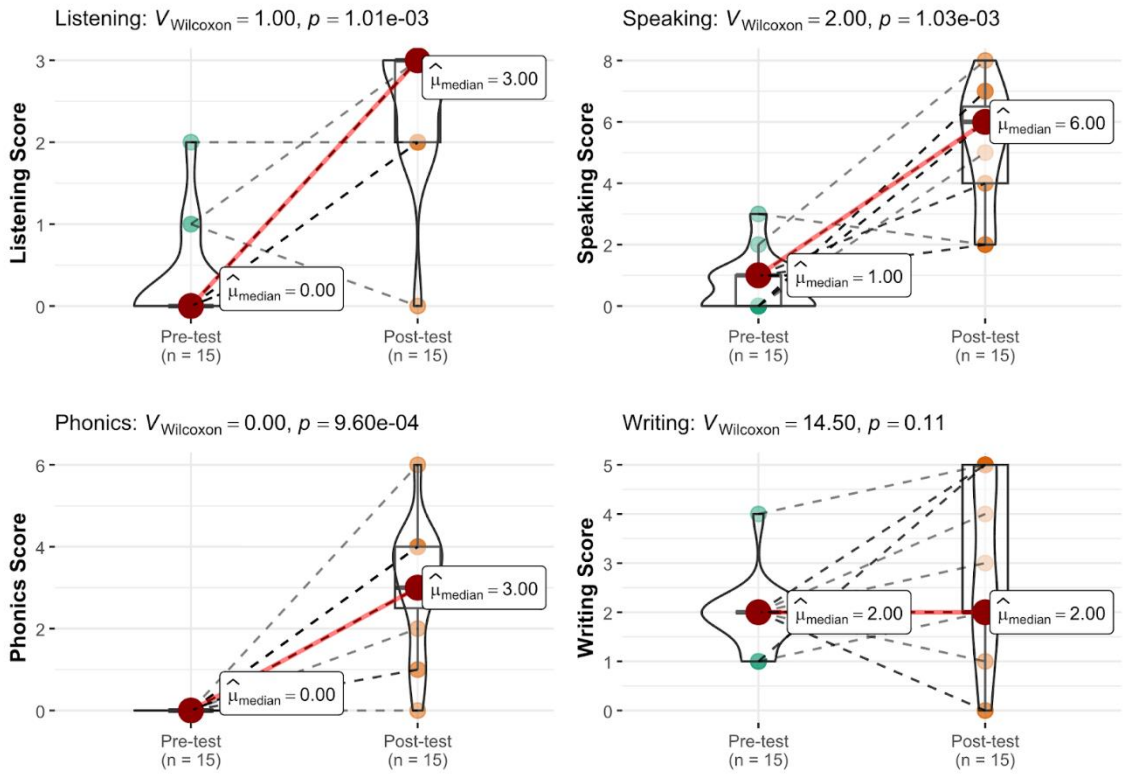
Figure 3:



First Grade

For first-grade students, the results show significant improvements in Listening, Speaking, and Phonics, with p-values less than 0.001, suggesting that these improvements are highly significant. However, in the case of Writing, although an increase in median scores was observed, this change was not statistically significant (p = 0.11). This suggests that the improvement in Writing skills may not be sufficiently consistent to attribute to the educational intervention with the same confidence as in the other areas.

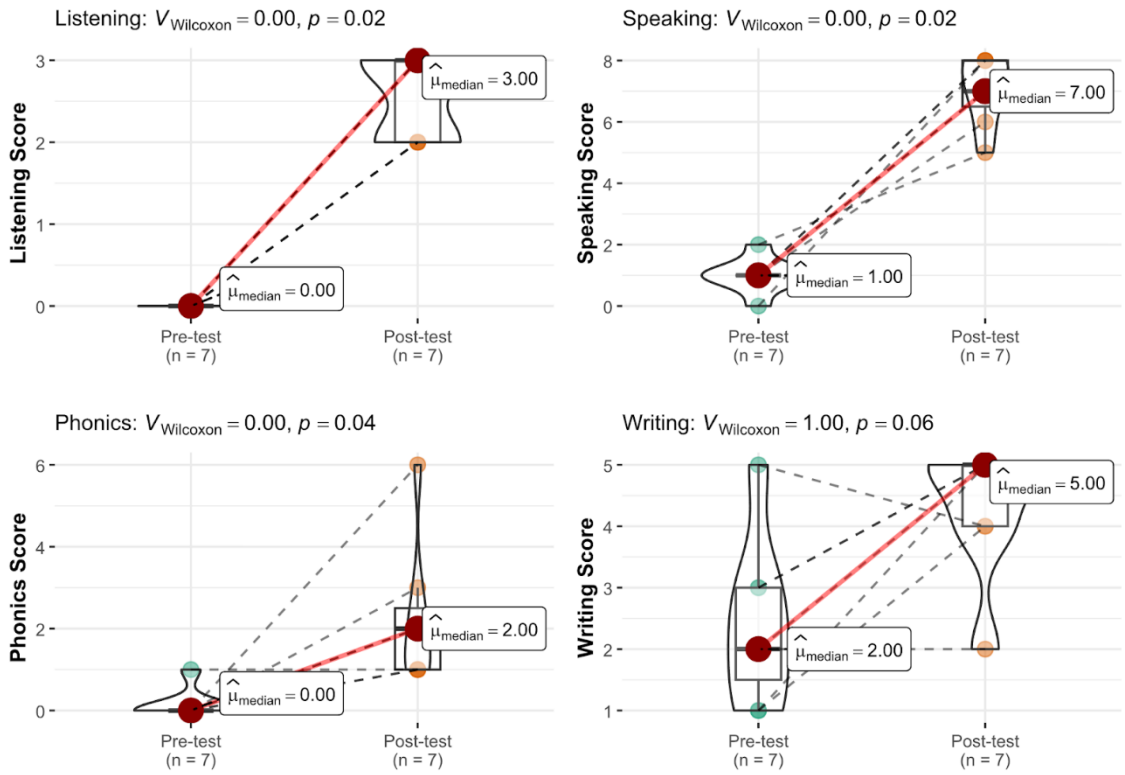
Figure 4:



Second Grade

In second grade, the Wilcoxon tests applied showed significant improvements in Listening, Speaking, and Phonics, with p-values of 0.02 and 0.04 (less than 0.05), indicating that the observed improvements in these skills are statistically significant. Regarding Writing, although an improvement in median scores was observed, it did not reach statistical significance (p = 0.06 > 0.05), suggesting that the improvement may not be sufficiently consistent to be considered significant from a statistical standpoint.

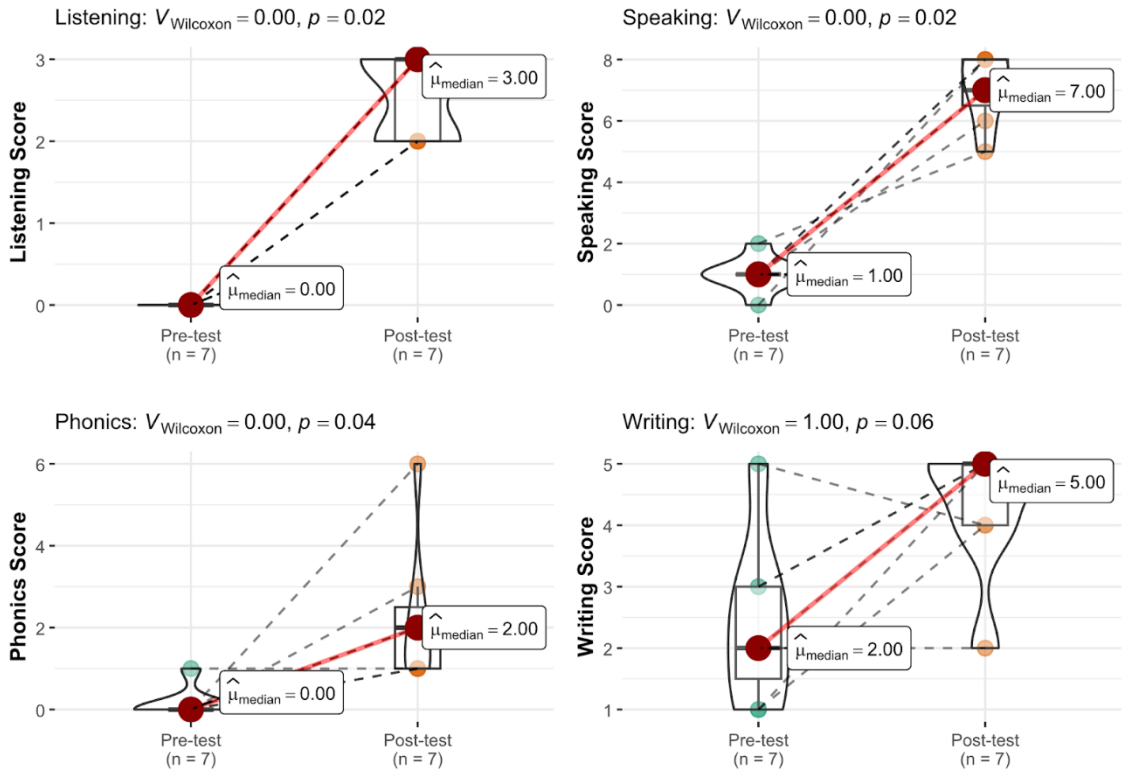
Figure 5:



Third Grade

In this grade, the results of the analysis with the Wilcoxon test also demonstrate significant improvements in Listening, Speaking, and Phonics, with p-values of 0.01, 0.02, and 0.02 respectively. In contrast, the observed improvement in Writing was not statistically significant (p = 0.11), suggesting that although there was an increase in median scores, it was statistically relevant.

Figure 6:

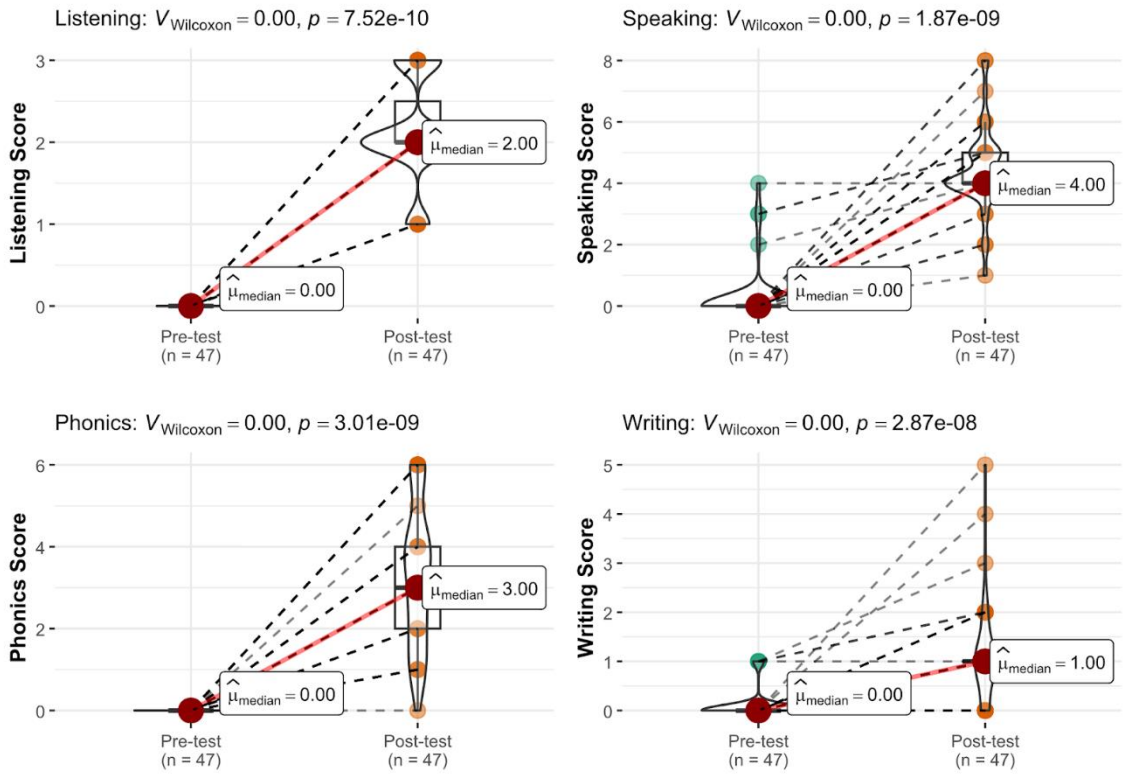


School C

Preschool

The results of the preschool students from School C demonstrate highly significant improvements in all four areas, with extremely low p-values (<0.001). These improvements reflect a considerable impact of the implemented teaching strategy, showing clear progress in the evaluated skills.

Figure 7:

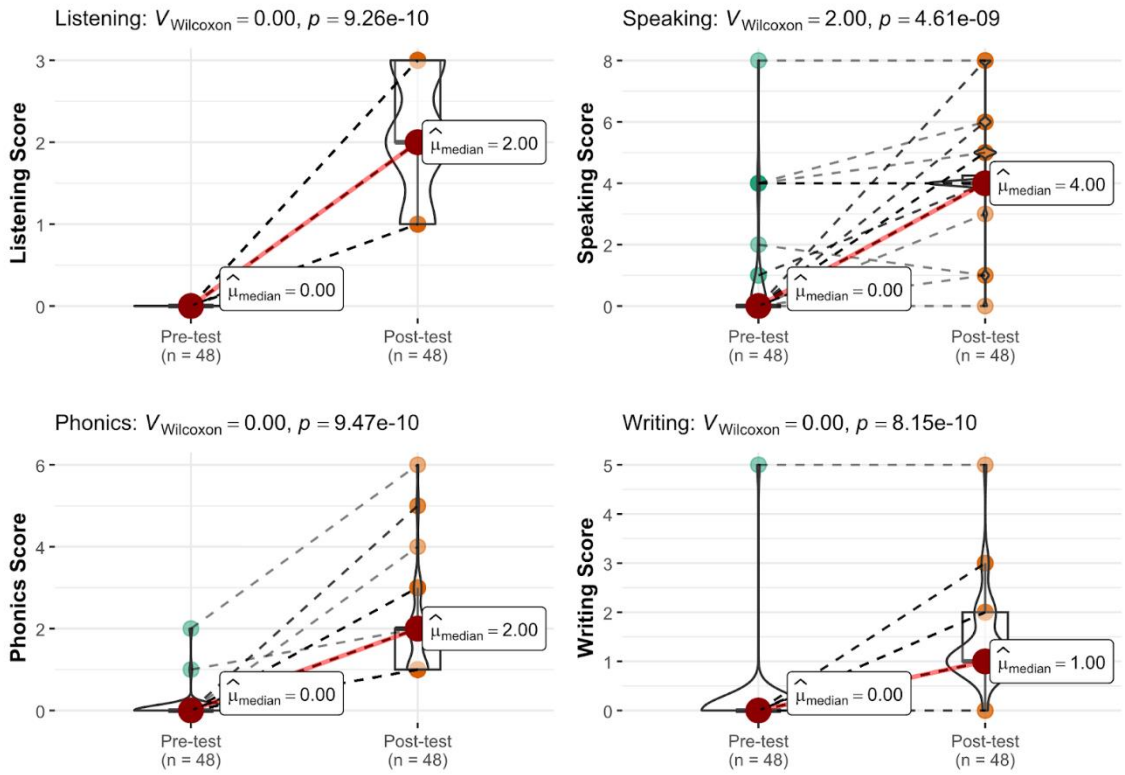


School D

Preschool

The Wilcoxon tests, supported by the respective graphs, indicate significant differences in all considered areas in favor of learning at School D, as the p-values are much lower than 0.05 (even much lower than 0.001). These results support the fact that the improvements in skills were substantial in the context of the experience, statistically speaking.

Figure 8:



Conclusions

Box and violin plots showed positive distributions and improvements in median scores, leading to the conclusion that the applied methodology is effective in enhancing students' linguistic skills. These consistent results reinforce the validity of the intervention and its potential benefit in various educational contexts. The results obtained through the Wilcoxon test provide a clear view of the improvements observed in Listening, Speaking, Phonics, and Writing, allowing the identification of areas of success and aspects that require additional adjustments.

The applied teaching strategy has a significant positive impact on Listening, Speaking, and Phonics skills in Preschool, First Grade, Second Grade, and Third Grade levels, as demonstrated by the extremely low p-values (<0.001) in most cases. This suggests that the observed improvements are not due to chance but to the implemented methodology. Although improvements in Writing skills were observed, they did not reach statistical significance in several grades (First, Second, and Third Grade). This result could be attributed to the lack of textbooks. Furthermore, the effectiveness of the intervention is different in one of the

educational levels. In Kinder 4 from School B, improvements in the evaluated skills did not reach statistical significance, which could be due to a small sample size resulting from absenteeism at this level. This variability underscores the importance of considering the particular characteristics of each group when implementing educational strategies.

Another relevant finding is that no significant differences were observed in skill outcomes between grades, regardless of whether the teacher was an English teacher or an elementary classroom teacher. This suggests that the implemented teaching strategy was equally effective, regardless of the teacher's specialization, reflecting the flexibility of the methodology used.

Finally, the sustainability and scalability of an initial literacy introduction policy in the English language will benefit from strategies like this, in addition to expanding quality opportunities nationwide. Introducing technology as a means for learning processes is tied to significant financial resources. However, in our country, most public schools have the basic infrastructure mentioned above for the implementation of this initial literacy methodology. With this experience, we also presume that it is feasible to train classroom teachers, given the shortage of English teachers.

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