MONTESSORI-BASED DIGITAL INSTRUCTION AND EARLY PRE-READING DEVELOPMENT: A QUASI-EXPERIMENTAL STUDY

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ABSTRACT
Research on the effectiveness of Montessori-based digital teaching in improving early pre-reading skills in preschoolers. Research on quasi-experimental comparative design was conducted in two early childhood education institutions in Indonesia. The experimental group of 13 children received learning using Montessori-based digital, while the control group of 13 children received conventional learning. Early pre-reading skills were assessed using a validated observational instrument consisting of ten indicators assessed on a four-point scale (maximum score = 40). Data were analyzed using descriptive statistics, Shapiro-Wilk normality test, Levene homogeneity test, paired sample t-test, and independent sample t-test. The results showed that all data were distributed normally and homogeneously ($p > 0.05$). The control group showed a significant improvement from pretest to posttest ($M = 20.54$ to 25; $p < 0.05$), while the experimental group showed a greater improvement ($M = 22.08$ to 36; $p < 0.001$). Post-test comparisons revealed statistically significant differences between the group ($p < 0.001$) and moderate effect sizes (Cohen's $d = 0.45$), suggesting meaningful practical significance. These findings suggest that Montessori-based digital teaching is an effective and educationally relevant approach to improving early pre-reading skills among preschoolers
Keywords: Montessori Learning, Digital Instruction, Early Pre-Reading Skills, Preschool Education, Quasi-Experimental Studies

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INTRODUCTION

Early pre-reading skills are an important foundation for literacy development and academic success in the future. Skills such as phonological awareness, letter recognition, and initial word comprehension allow children to transition more effectively to formal reading instruction at the elementary school level. So that when basic skills are not developed, children will experience persistent difficulties in reading comprehension and academic achievement. Research shows that mastery of pre-reading skills, such as phonological awareness and literacy knowledge, has a major influence on reading ability and reading comprehension in schools. Children who have a strong pre-reading foundation tend to adapt more easily to formal reading learning and show better academic results (Engel de Abreu et al., 2020; Fitriah et al., 2025; Hjetland et al., 2020)

The context of early childhood education, low reading ability in children with limited literacy stimulation at home, environment supports inadequate literacy and monotonous activities centered on teachers. The lack of varied and interesting media can reduce children's motivation and attention, thus limiting optimal literacy development. These challenges highlight the need for instructional approaches that are developmentally appropriate, engaging, and responsive to the child's learning characteristics (Bigozzi et al., 2023; Rahman & Nurani, 2024). Low pre-reading ability in early childhood is often caused by a lack of stimulation from parents, lack of literacy facilities at home, and unformed reading habits. Parental awareness and involvement are very important in preparing children's reading readiness before entering the next level of education (Asmawati, 2015; Magdalena, 2020) Monotonous learning, lack of variety, and lack of use of interesting media can cause children to be less interested and have difficulty recognizing letters, sounds, and word structure. The use of methods that are appropriate to the child's characteristics, such as playing while learning, is highly recommended to improve pre-reading skills (Amalafitra et al., 2022; Anisa & Faqihatuddiniyah, 2022; Nurhayati & Rosita, 2023; Syamsiah, 2022; Syima, 2017)

A variety of learning methods and strategies, including the use of technology, play activities, and culture-based approaches, have been shown to be effective in developing pre-reading skills. The use of appropriate methods, such as phonetics, the whole language, as well as the integration of digital media and interactive applications, can increase children's motivation and involvement in the reading learning process (Cazco et al., 2024; Purwandari & Nasution, 2025; Wahyuni, 2021) Recent studies emphasize the importance of early intervention and a learning environment with a lot of letter recognition, both at home and at school. Teachers and parents are expected to be able to choose and implement adaptive strategies according to the needs and characteristics of children, so that the transition process to formal reading learning runs optimally (Khosa, 2025; Nims-Fournier, 2024; Scarparolo & Hammond, 2018) Montessori education emphasizes child learning, independent activity, hands-on experience, and multisensory engagement. These principles are in harmony with the characteristics of young children's development, especially in fostering language readiness and literacy. In recent years, the integration of digital media into early childhood education has expanded learning opportunities by providing interactive, visual, and auditory stimulation that can support the development of early literacy when used appropriately.

Longitudinal studies show that Montessori education that emphasizes independent activity, hands-on experience, and multisensory environments can significantly improve children's academic, social, and cognitive outcomes, as well as aid in the equitable distribution of learning outcomes among different socioeconomic groups (Lillard et al., 2017) There are several studies that confirm that the Montessori method has a positive impact on the development of early childhood literacy skills, and its principles are very relevant to be applied in the context of modern education (Durdas, 2024; Prochazka, 2024) Montessori strategies such as Three-Period Lessons, the use of concrete materials, and interactive and multisensory activities have been

shown to be effective in improving vocabulary acquisition and children's involvement in language learning (Prochazka, 2024). The use of interactive digital media, such as educational games and application-based multimedia, has been proven to be effective in improving early literacy skills, learning motivation, and children's involvement in the learning process (Purnamasari, 2023; Rahmadi et al., 2025; Rahman & Nurani, 2024).

Previous research studies on Montessori-based digital teaching in early childhood education in Indonesia are still limited. Recent studies show that digital letter boards are able to stimulate syllable recognition in children with Montessori practice (Ihsan et al., 2021). However, empirical evidence examining the combined use of Montessori principles and digital teaching remains limited, especially in Indonesian preschool settings. There is a lack of comparative experimental research evaluating whether Montessori-based digital instruction offers added value over conventional teaching methods in improving early pre-reading skills. Therefore, this study addresses this gap by investigating the effectiveness of Montessori-based digital teaching compared to conventional teaching in improving early pre-reading skills among preschoolers in Indonesia. Thus, this study aims to contribute empirical evidence to inform early childhood literacy practices and instructional design.

RESEARCH METHODOLOGY

This study used a quasi-experimental comparative design using a pretest-post-test control group approach. This design was chosen to test the effectiveness of Montessori-based digital instruction in improving early pre-reading skills among preschoolers while controlling for basic differences between groups. Two comparable preschool institutions were deliberately selected based on the type of services, curriculum, characteristics of the institution and children from urban backgrounds. Although random assignments were not feasible, comparisons between groups were considered through similarities in age distribution, previous exposure to literacy teaching, and institutional learning resources. Data on parents' socioeconomic backgrounds and teachers' experiences are not fully available and are therefore limited to the research.

The participants consisted of 26 preschoolers aged 5-6 years who were registered in two early childhood education institutions in Indonesia. The children were divided equally into two groups. The experimental group consisted of 13 children from Pertiwi Kindergarten 45 Kalisegoro, while the control group consisted of 13 children from Nurul Wathon Kindergarten. The selection of participants is based on institutional availability, similarity in age range and level of education. All participants had a comparable developmental background and had not previously received a structured digital literacy intervention. Parental consent and institutional consent are obtained prior to data collection. The experimental group received Montessori-based digital instruction designed to integrate Montessori's core principles with digital learning media. The instructional approach emphasizes self-paced learning, hands-on exploration, repetition, and multisensory engagement. Digital materials are used to support phonological awareness, letter recognition, voice-letter correspondence, and decoding initial words through interactive and visually appealing activities. Children are encouraged to explore learning materials independently while getting minimal guidance from teachers.

In contrast, the control group received conventional instruction that is commonly practiced in early childhood classes. This approach is predominantly teacher-centric, relying on verbal explanations, worksheets, and whole-class teaching without the systematic integration of digital media or Montessori-based learning principles. Early pre-reading skills were assessed using observational assessment instruments developed specifically for this study. The instrument consists of ten indicators that reflect the key components of early literacy development: 1) early speech recognition, 2) late speech recognition, 3) letter recognition, 4) voice-letter correspondence, 5) identification of familiar words, 6) ability to repeat phonemes, 7) vocabulary recognition, 8) attention to print, 9) initial word decoding, and 10)

verbal response to literacy stimuli. Each indicator was graded using a four-point Likert scale ranging from 1 (Not Developed) to 4 (Very Well Developed), resulting in a maximum total score of 40. The instrument undergoes content validation through expert assessment by early childhood education and literacy specialists to ensure its relevance, clarity, and appropriateness for children aged 5-6 years. The observational assessment instrument underwent content validation through expert assessment. To improve measurement consistency, observers receive structured training on the use of instruments and assessment criteria. Observations are made using standard guidelines to minimize subjectivity. However, the reliability coefficient between formal raters is not calculated, which should be discussed in future studies.

Data analysis was carried out using SPSS software. Descriptive statistics were used to summarize the average and distribution of pretest and post test scores for both groups. Prior to the inferential analysis, assumption testing was performed using the Shapiro-Wilk test to check the normality of the data and the Levene test to assess the homogeneity of variance. To analyze the differences in groups between pretest and post test scores, paired sample t-tests were performed separately for the control and experimental groups. An independent sample t-test was then used to compare posttest scores between the two groups and determine the effectiveness of the instructional intervention. All statistical tests were performed at a significance level of 0.05.

RESEARCH RESULTS

Before performing inferential statistical analysis, an assumption test is performed to ensure the suitability of parametric testing. As presented in Table 1.

Tabel 1 Hasil Uji Normalitas Shapiro-Wilk

Groups	Your	Signs (p)	Interpretasi
Control	Prates	> .05	Normal
Control	Post-tests	> .05	Normal
Experimental	Prates	> .05	Normal
Eksperimental	Post-tests	> .05	Normal

The Shapiro-Wilk normality test showed that all pretest and post test scores for the control and experimental groups were distributed normally ($p > 0.05$). These findings confirm that the data meet the normality assumptions required for t-test analysis. Furthermore, the **Levene test for equivalence of variance** showed no significant difference in posttest score variance between the control and experimental groups ($p > 0.05$), as shown in Table 2.

Tabel 2 Tes Levene untuk Kesetaraan Varians

Variabel	Signs (p)	Interpretasi
Post-Score	> .05	Homogeneous

These results show that the assumption of variance homogeneity is met, allowing the use of **an independent sample ttest with the same assumed variance**. Descriptive statistics revealed an improvement in early pre-reading skills in both groups after the intervention period. As summarized in Table 3.

Table 3 Descriptive Statistics of Pretest and Post test Scores in the Control and Experimental Groups

Group	N	Pretest Mean	Posttest Mean	Mean Difference
Control	13	21	25	+4
Experimental	13	22	36	+14

The average score of the control group increased from **21 (pretest)** to **25 (post-test),** while the average score of the experimental group increased from **22 (pretest)** to **36 (post-test).** Although both groups showed progress, the magnitude of the improvements differed substantially. The experimental group showed a much larger average increase (+14 points) compared to the control group (+4 points), suggesting a stronger instructional effect related to Montessori-based digital learning.
Paired sample t-tests were performed to check for differences in groups between pre and post test scores, as reported in Table 4.

Table 4 Paired Samples t-Test Results for Pretest and Post test Scores

Group	Mean Pretest	Mean Posttest	Sig. (p)	Result
Control	21	25	< .05	Significant
Experimental	22	36	< .001	Highly significant

For the **control group**, the results showed a statistically significant improvement in early pre-reading skills ($p < 0.05$). However, the observed improvement is relatively modest, suggesting that conventional instructional practices contribute to developmental gains but with limited impact. In contrast, the **experimental group** showed **a very significant improvement** in pre-reading skills after the intervention ($p < 0.001$). The average score increased from **22 to 36**, demonstrating the strong effect of Montessori-based digital teaching on children's early literacy development. These findings highlight the superior effectiveness of interventions in facilitating meaningful learning gains beyond natural developmental development.
An independent sample of the test was conducted to compare posttest scores between the two groups. As presented in Table 5.

Table 5 Independent Samples t-Test Comparing Posttest Scores

Group	N	Mean	SD	Sig. (p)	Effect Size (Cohen's d)	Interpretation
Control	13	20.54	2.57			
Experimental	13	22.08	4.05	< .001	0.45	Moderate effect

Independent sample t-tests revealed a statistically significant difference in post-test scores between the experimental and control groups ($p < 0.001$). The experimental group achieved a higher average score ($M = 22.08$, $SD = 4.05$) than the control group ($M = 20.54$, $SD = 2.57$). The effect size was moderate (Cohen's $d = 0.45$), indicating a meaningful practical impact of Montessori-based digital instruction. These results confirm that Montessori-based digital instruction produces much better learning outcomes than conventional instruction in improving early pre-reading skills. The results of this study provide strong empirical evidence that Montessori-based digital teaching is highly effective in improving early pre-reading skills among preschoolers. The assumption test confirms that the data meets the requirements for parametric analysis, thereby strengthening the validity and reliability of statistical conclusions. The substantial improvement observed in the experimental group, as shown by the paired sample t-test ($p < 0.001$) and supported by descriptive statistics (Table 1), suggests that integrating Montessori principles with digital media creates an enriched learning environment. This environment promotes active engagement, repetition, and multisensory learning, which is essential for developing phonological awareness, letter recognition, and initial word comprehension. Although the control group also showed a statistically significant improvement ($p < 0.05$), relatively modest gains suggest that conventional instructional approaches can support basic developmental progress but are less effective in optimizing early literacy outcomes. Significant differences in posttest scores between groups, confirmed by an

independent sample of t-tests ($p < 0.001$), further reinforce the instructional advantages of Montessori-based digital learning.

This research shows that Montessori-based digital teaching offers a healthy and pedagogically impactful approach to encouraging early pre-reading development in early childhood education settings. The influence of digital media has a positive impact on the development of pre-reading in children aged 5-6 years, this is reinforced by several studies on the use of ICT (including videos, applications, and interactive multimedia) in pre-reading learning to significantly increase children's motivation, creativity, and learning outcomes. The Montessori method, when combined with digital media, reinforces multisensory and individual learning aspects (Cazco et al., 2024; Ihsan et al., 2021; Iswara et al., 2023) Canva as an interactive learning medium has proven to be very effective, practical, and engaging in improving the understanding of concepts and reading skills in elementary school students. Expert validation shows a high level of feasibility and effectiveness, as well as a positive response from teachers and students (Apriana et al., 2025; Pinandhita & Yasin, 2025; Safa'at et al., 2024)

DISCUSSION & CONCLUSION

The study concluded that Montessori-based digital teaching had a powerful and meaningful effect on improving early pre-reading skills in preschoolers. Compared to conventional teaching, the integrated approach results in much greater learning advantages, both statistically and practically. These findings support the use of developmentally appropriate digital media based on Montessori principles as an effective strategy for the development of early literacy. Future research is recommended to 1) examine the long-term retention of pre-reading skills after Montessori-based digital interventions, 2) examine early literacy abilities transitioning to formal reading at the elementary school level and 3) explore specific digital variables such as screen time duration, types of digital interactions, and parental involvement in digital literacy activities. Expanding sample sizes and using stricter reliability testing will further strengthen the evidence base in this area.

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