GOLDEN RATIO OF DATA IN SUMMARY
VOLUME 6, ISSUE. 2 (2026)
Website: https://goldenratio.id/index.php/grdis

GOLDEN RATIO
ISSN [Online]: 2776-6411

DATA IN SUMMARY | EDUCATION, LINGUISTICS

The Impact of Interactive Flat Panel Display–Based Digital Games with a Cognitive Scaffolding Approach on the Improvement of Early Childhood Literacy and Numeracy

Ahmad Widianto[1], Kabul Suprayitno[2]

[1,2] Institut Studi Islam Muhammadiyah Pacitan, Pacitan, Indonesia. Email: pejuangpendidikanmu@gmail.com[1], kabuls@inismupacitan.ac.id[2]

ARTICLE HISTORY

Received: March 04, 2026
Revised: April 09, 2026
Accepted: April 09, 2026

DOI
https://doi.org/10.52970/grdis.v6i2.2141

ABSTRACT
This study aims to explore the effect of using digital games based on an Interactive Flat Panel Display (IFPD) with the application of cognitive scaffolding on early literacy and numeracy at Mutiara Hati Kindergarten. The research employed a qualitative case study approach involving the principal, teachers, and parents as subjects. Data were collected through semi-structured interviews and classroom observations and were then analyzed thematically. The results showed that the use of IFPD increased children's interest, focus, and engagement in literacy and numeracy activities. The implementation of cognitive scaffolding by teachers was proven to help children understand letters, words, numbers, and simple operations more effectively. The children also demonstrated improved literacy and numeracy skills, both in the classroom and at home. Based on these findings, it can be concluded that the integration of interactive digital games and teacher scaffolding effectively enhances early literacy and numeracy. This study provides implications for teachers and schools to optimize the use of interactive digital media in early childhood learning.

Keywords: Early Literacy, Early Numeracy, Digital Games, Interactive Flat Panel Display, Cognitive Scaffolding.

I. Introduction

Early literacy and numeracy are essential foundations for the cognitive development of preschool children. Literacy includes the ability to read and write, language comprehension, vocabulary development, and storytelling skills, while numeracy involves number recognition, basic counting concepts, and simple problem-solving abilities. These foundational skills play a crucial role in preparing children for formal education and in developing logical and analytical thinking. Research indicates that children who acquire strong early literacy and numeracy skills are generally more prepared to face academic challenges in primary school and demonstrate better long-term academic achievement. Early mastery of these skills also supports broader cognitive development, including memory, reasoning, and communication abilities.

Despite their importance, many young children encounter difficulties in understanding basic literacy and numeracy concepts when traditional teaching methods are used. Conventional instruction often relies on worksheets, rote memorization, and teacher-centered explanations, which may not align with the developmental characteristics of children aged four to six years. At this stage, children tend to have relatively short attention spans and learn more effectively through visual stimulation, direct interaction, and hands-on

ISSN [Online]: 2776-6411

experiences. A lack of engaging learning media can therefore hinder children's motivation and participation in classroom activities. Studies have shown that limited use of interactive learning tools often contributes to low engagement and slower development of early numeracy skills among young learners (Yuniria et al., 2023).

To address these challenges, educational technology offers promising opportunities to enhance early childhood learning. Digital games, particularly those presented through Interactive Flat Panel Displays (IFPDs), provide interactive and multimedia-rich learning experiences that can capture children's attention and support active engagement. Interactive digital environments allow children to touch the screen, select letters or numbers, and complete simple quizzes, making learning more dynamic and meaningful. Research on digital game-based learning has demonstrated that interactive games can significantly improve early literacy skills by providing repeated exposure to letters and words in an engaging context (Neumann, 2018). Similarly, interactive multimedia tools have been shown to enhance numeracy development by helping children recognize numbers and understand basic counting concepts more effectively (Yuniria et al., 2023). Digital games, particularly those presented through Interactive Flat Panel Displays (IFPDs), provide interactive and multimedia-rich learning experiences that can capture children's attention and support active engagement. This is in line with findings from game-based learning research in Indonesian educational settings, which show that digital quiz platforms can increase student participation and learning motivation (Nurfadila & Hajar, 2024).

In addition to technological tools, effective instructional support is necessary to maximize children's learning outcomes. One important pedagogical approach is cognitive scaffolding, in which teachers provide structured guidance and gradually reduce assistance as children gain independence. This approach ensures that children do not merely memorize information but develop a deeper understanding of concepts. Cognitive scaffolding is closely associated with the theory of the Zone of Proximal Development proposed by Lev Vygotsky, which suggests that children can achieve higher levels of understanding when supported by adults or more capable peers. Through scaffolding, teachers can break down complex tasks into manageable steps, model correct responses, and provide feedback that supports learning progress. Recent studies have confirmed the effectiveness of scaffolding in early childhood education. Scaffolding techniques have been shown to significantly improve children's language development and early literacy skills by providing structured guidance and interactive feedback (Anisah, 2024). Furthermore, research on digital learning environments indicates that scaffolding can enhance engagement and support deeper learning by guiding children's interactions with educational technology (Li & Wilson, 2025). When combined with digital tools, scaffolding helps children focus on relevant information and develop problem-solving strategies more effectively. In playful learning environments that integrate digital tools and guided instruction, children benefit from both exploration and structured support, leading to more meaningful learning experiences (Tsakeni et al., 2025). The need for more engaging and accessible learning media is increasingly relevant in the Indonesian educational context, where digital solutions are considered important for addressing instructional limitations and expanding learning opportunities (Suarlin et al., 2026).

The integration of interactive digital games and cognitive scaffolding is therefore particularly relevant in early childhood classrooms. Digital games provide stimulating visual and auditory experiences, while scaffolding ensures that learning remains purposeful and structured. Teachers play a critical role in guiding children's interactions with digital media, helping them interpret information and apply newly learned concepts. Without such guidance, children may engage with digital tools only at a surface level, limiting their educational benefits. Conversely, when teachers actively support children's learning through questioning, prompting, and feedback, digital games can become powerful tools for developing literacy and numeracy skills. At Mutiara Hati Kindergarten, teachers face the challenge of finding instructional methods that are both engaging and effective for young learners. The use of IFPD-based digital games offers a promising solution by combining interactive technology with meaningful learning activities. However, the effectiveness of these tools depends largely on how they are implemented in the classroom. The addition of cognitive scaffolding allows teachers to tailor instruction to children's individual needs and ensure that learning objectives are

ISSN [Online]: 2776-6411

achieved. Through guided interaction, children can better understand letters, words, numbers, and simple mathematical operations, both in school and at home.

Based on these considerations, this study aims to examine the effect of IFPD-based digital games with a cognitive scaffolding approach on early literacy and numeracy development in Mutiara Hati Kindergarten. Specifically, the study addresses two research questions: (1) whether the use of Interactive Flat Panel Display–based digital games with cognitive scaffolding can improve early literacy skills, and (2) whether the same approach can enhance early numeracy skills. The findings of this study are expected to provide practical contributions for teachers and schools in designing more effective and engaging learning strategies. In addition, this research is expected to contribute to the growing body of literature on the integration of digital technology and innovative pedagogical approaches in early childhood education.

II. Literature Review

Early literacy and numeracy development are widely recognized as fundamental components of early childhood education. Literacy in early childhood encompasses a range of skills, including vocabulary acquisition, phonological awareness, letter recognition, and early writing abilities, while numeracy includes number recognition, counting skills, and basic problem-solving abilities (Purpura et al., 2017). These foundational competencies are essential because they strongly predict later academic achievement and cognitive development. Children who develop early literacy and numeracy skills tend to demonstrate better readiness for primary school and greater confidence in learning activities (Duncan et al., 2019).

However, young children often struggle to grasp literacy and numeracy concepts when instruction relies heavily on traditional teaching methods. Conventional approaches, such as worksheets and rote memorization, are often less effective for children aged four to six because they do not align with children's developmental characteristics. At this stage, children learn best through play, exploration, and interactive experiences (Zosh et al., 2018). As a result, educators increasingly emphasize the importance of engaging learning environments that incorporate visual, auditory, and kinesthetic elements to support children's understanding of abstract concepts such as letters and numbers.

One approach that has gained significant attention is the use of digital learning media in early childhood education. Digital games, in particular, have been shown to enhance children's motivation and engagement by providing interactive and visually stimulating learning experiences. Research indicates that well-designed educational games can improve early literacy skills by reinforcing letter recognition and vocabulary development through repeated exposure and interactive feedback (Neumann, 2018). Similarly, digital learning tools can support numeracy development by allowing children to manipulate numbers and observe relationships between quantities in a concrete and meaningful way (Schindler et al., 2017). Interactive technologies such as touchscreen displays enable children to actively participate in learning activities rather than passively receiving information.

Interactive Flat Panel Displays (IFPDs) represent one form of interactive technology that is increasingly used in early childhood classrooms. These displays allow children to interact directly with digital content by touching and manipulating objects on the screen. Such interaction supports active learning and helps children maintain attention for longer periods. Studies have shown that interactive screens can enhance children's engagement and facilitate collaborative learning experiences in classroom settings (Kucirkova, 2020). By integrating multimedia elements such as images, sounds, and animations, IFPDs provide a multisensory learning environment that supports diverse learning styles.

In addition to the use of technology, instructional support plays a crucial role in ensuring effective learning outcomes. Cognitive scaffolding is an instructional approach in which teachers provide structured guidance to support children's learning and gradually reduce assistance as children gain independence. This approach is based on the idea that children learn best when they receive support that is tailored to their current level of understanding (Wood et al., 2016). Through scaffolding, teachers can guide children's attention, provide feedback, and encourage problem-solving strategies that deepen understanding.

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Recent studies highlight the importance of combining digital learning tools with scaffolding strategies. When teachers actively guide children's interactions with digital media, children are more likely to engage in meaningful learning rather than superficial exploration (Plass et al., 2020). Scaffolding helps children focus on relevant information and supports the development of both literacy and numeracy skills. Therefore, integrating interactive digital games with cognitive scaffolding represents a promising approach for enhancing early literacy and numeracy development in early childhood education.

III. Research Method

This study employed a qualitative approach with a case study design to explore the role of digital games based on an Interactive Flat Panel Display (IFPD) integrated with cognitive scaffolding in enhancing early literacy and numeracy skills at Mutiara Hati Kindergarten. The participants consisted of the principal, classroom teachers, and parents to obtain comprehensive perspectives on the implementation of digital learning media and the teacher's role in facilitating children's learning. Data were collected through semi-structured interviews with the principal, teachers, and parents, as well as classroom observations during learning activities using the IFPD.

The data were analyzed thematically by identifying patterns and recurring themes related to teacher–child interactions, the use of IFPD-based digital games, scaffolding strategies, and children's literacy and numeracy development. Cognitive scaffolding provided by teachers during digital play activities helped children gradually build understanding through guided interaction and feedback, which is considered essential in early childhood learning environments (Neumann, 2020). The integration of interactive digital media has also been shown to support early literacy and numeracy when combined with intentional teaching strategies and active adult involvement (Hirsh-Pasek et al., 2015; Zosh et al., 2018). Data validity was ensured through source triangulation by comparing information obtained from principals, teachers, parents, and classroom observations, thereby increasing the credibility and trustworthiness of the findings.

IV. Result and Discussion

4.1. Result

Based on the interviews, the principal stated that the use of Interactive Flat Panel Displays (IFPD) as an interactive learning medium had a positive impact on children's learning processes. The principal emphasized that children became more enthusiastic and focused during literacy and numeracy activities because of the engaging visual displays and interactive digital games. The colorful animations, sounds, and responsive touch features attracted children's attention and helped sustain their concentration for longer periods compared to conventional teaching methods. As a result, classroom activities became more dynamic and interactive, allowing children to participate actively rather than passively receiving information. The principal also noted that teachers were able to implement cognitive scaffolding more effectively when using the IFPD, as children tended to follow instructions more quickly and showed greater willingness to participate in guided activities. Compared to traditional approaches such as worksheets or verbal explanations, the digital format enabled teachers to provide step-by-step guidance in a way that was more concrete and visually meaningful for young learners.

Teachers reported that the implementation of cognitive scaffolding during digital game-based learning significantly supported children in understanding fundamental literacy and numeracy concepts. Through structured guidance, teachers helped children recognize letters, identify words, understand numbers, and perform simple arithmetic operations. The scaffolding process typically began with teacher modeling, where the teacher demonstrated how to complete a task on the IFPD, such as matching letters to pictures or counting objects on the screen. After modeling, the teacher guided children through the activity by providing prompts and hints, encouraging them to respond independently. Gradually, the teacher reduced

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the level of assistance as children became more confident and capable. This step-by-step support allowed children to build their understanding incrementally, reducing confusion and frustration. Teachers observed that children who initially struggled with letter recognition or counting became more confident after repeated guided practice using digital games.

In addition, teachers explained that the combination of IFPD technology and direct instructional support increased children's engagement in literacy and numeracy activities. The interactive nature of digital games encouraged children to participate actively, while the teacher's scaffolding ensured that learning remained meaningful and structured. For example, during literacy activities, children were asked to trace letters on the screen, match letters with corresponding sounds, or identify words associated with pictures. During numeracy activities, children practiced counting objects, recognizing numbers, and solving simple addition or subtraction problems presented in game format. Teachers found that children were more willing to attempt challenging tasks when they received immediate feedback and encouragement. This interactive environment not only improved children's recognition of letters and numbers but also strengthened their ability to perform simple calculations and understand basic mathematical concepts.

Interviews with parents revealed that children became more active and interested in learning both at school and at home. Parents noticed that their children often repeated the movements, songs, or concepts they had learned through IFPD activities. For instance, some children practiced saying the alphabet aloud while mimicking the gestures they used during digital games, while others counted objects at home using the same methods introduced by their teachers. Parents also reported that their children frequently talked about the games they played at school and expressed excitement about participating in similar activities again. This behavior suggests that the learning experiences provided through IFPD were memorable and meaningful for the children, making it easier for them to recall and apply what they had learned.

Furthermore, parents observed that the use of interactive digital media appeared to increase their children's motivation to learn. Some children voluntarily asked their parents to provide opportunities for reading or counting activities at home, indicating a growing interest in literacy and numeracy. In several cases, parents attempted to support their children's learning by using simple materials such as books, number charts, or everyday objects to replicate the activities introduced at school. This demonstrates that learning was not limited to the classroom but extended into the home environment, reinforcing children's early literacy and numeracy development. The transfer of learning from school to home is particularly important in early childhood education, as consistent exposure to literacy and numeracy experiences can strengthen children's cognitive development and academic readiness.

Classroom observations further confirmed the positive impact of using IFPD combined with cognitive scaffolding. During learning sessions, children followed the teacher's instructions enthusiastically and showed a high level of participation in digital game activities. Many children eagerly volunteered to come forward and interact with the IFPD, demonstrating curiosity and confidence in using the technology. In addition to interacting with the digital content, children also engaged with their peers by discussing answers, taking turns, and helping one another complete tasks. This collaborative interaction contributed to a supportive learning environment in which children felt comfortable exploring new concepts.

Teachers consistently applied scaffolding strategies throughout the activities. When children encountered difficulties, teachers provided hints or demonstrated the correct steps to solve the problem. For example, if a child struggled to identify a letter, the teacher might point to the letter, pronounce its sound, and encourage the child to repeat it. If a child had difficulty counting objects, the teacher might guide the child to count aloud while pointing to each item on the screen. As children began to understand the concepts, teachers gradually reduced their assistance, allowing the children to complete tasks independently. This gradual release of responsibility helped children develop confidence and autonomy in their learning.

The observations also showed that the use of digital games made literacy and numeracy learning more active, interactive, and enjoyable. Rather than sitting quietly and listening to explanations, children were able to move, touch, speak, and respond during the activities. This multisensory engagement supported different learning styles and helped children remain focused on the tasks. The playful nature of digital games

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reduced anxiety and made learning feel like an enjoyable experience rather than a demanding task. As a result, children were more willing to participate and persist in completing activities, even when they encountered challenges.

Overall, the findings from interviews and observations indicate that the integration of IFPD and cognitive scaffolding created a supportive and engaging learning environment for early literacy and numeracy development. The interactive features of the technology captured children's attention and encouraged active participation, while the scaffolding strategies provided by teachers ensured that learning remained structured and meaningful. The positive responses from both teachers and parents suggest that this approach not only enhanced children's academic skills but also increased their motivation and confidence in learning. Moreover, the transfer of learning experiences from the classroom to the home environment highlights the potential of interactive digital media to support continuous learning beyond the school setting. Together, these findings demonstrate that the use of interactive digital tools combined with effective instructional strategies can play a significant role in supporting young children's early literacy and numeracy development.

4.2. Discussion

The findings of this study indicate that the use of Interactive Flat Panel Display (IFPD) as an interactive learning medium significantly increased children's interest and engagement in early literacy and numeracy activities. During classroom observations, children appeared more focused and enthusiastic when participating in digital games that presented letters, numbers, and interactive quizzes. The visual and auditory features of the IFPD, combined with touch-based interaction, created a dynamic learning environment that encouraged active participation. This finding supports previous research suggesting that interactive digital media can enhance young children's motivation and attention during early learning activities, particularly when learning experiences involve active engagement and meaningful interaction (Hirsh-Pasek et al., 2015; Neumann, 2020). Increased engagement is particularly important in early childhood education because children learn most effectively when they are actively involved in the learning process rather than passively receiving information.

The implementation of IFPD-based digital games allowed children to interact directly with learning content through touching, dragging, matching, and selecting answers on the screen. These activities supported the development of early literacy skills such as letter recognition, phonemic awareness, and simple word identification. At the same time, numeracy skills such as number recognition, counting, and basic arithmetic operations were introduced in a playful and engaging manner. The combination of visual stimuli, sound effects, and immediate feedback helped children understand abstract concepts more concretely. Research has shown that interactive digital tools can provide immediate feedback that supports children's understanding and helps them correct mistakes in real time, which is beneficial for both literacy and numeracy development (Schindler et al., 2017; Zosh et al., 2018).

Another important finding of this study is the significant role of teachers in facilitating learning through cognitive scaffolding. Teachers acted as facilitators who guided children through instructions, demonstrations, and gradual corrections. Rather than allowing children to interact with the digital media independently without support, teachers provided structured assistance that helped children understand how to complete tasks and solve problems. This scaffolding process included giving hints, modeling correct responses, asking guiding questions, and providing encouragement. Observations showed that children who received consistent guidance from teachers were able to understand concepts related to letters, words, numbers, and simple operations more quickly than those who attempted to learn independently.

This finding aligns with the learning theory proposed by Lev Vygotsky, particularly the concept of the Zone of Proximal Development (ZPD), which emphasizes that children can achieve higher levels of understanding with the assistance of more knowledgeable individuals. Within this framework, scaffolding serves as a bridge between what children can do independently and what they can achieve with support. The

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use of IFPD in combination with teacher scaffolding created opportunities for guided learning experiences that were both engaging and developmentally appropriate. Recent studies have confirmed that digital learning environments are most effective when combined with adult guidance, as technology alone does not guarantee meaningful learning outcomes (Bird & Edwards, 2015; Neumann, 2020).

The integration of cognitive scaffolding into digital learning activities also helped maintain children's focus and reduce frustration. Some children initially experienced difficulty when interacting with new digital tasks, particularly those involving matching letters or solving counting problems. However, teacher support enabled them to overcome these challenges gradually. As children became more familiar with the tasks, the level of assistance was reduced, allowing them to work more independently. This gradual release of responsibility is a key principle of scaffolding and helps children develop confidence in their abilities. As a result, children not only improved their literacy and numeracy skills but also developed persistence and problem-solving abilities.

Interviews with parents revealed that learning experiences at school were often transferred to the home environment. Many parents reported that their children repeated learning activities at home, such as mimicking hand movements used on the interactive screen, mentioning letters they had learned, and practicing counting with enthusiasm. Some children even pretended that household objects were interactive screens, demonstrating how deeply they had internalized the learning experience. This transfer of learning indicates that the integration of IFPD and cognitive scaffolding not only influenced children's academic skills in the classroom but also fostered positive learning behaviors at home. Parental observations suggest that children developed increased curiosity and confidence in engaging with literacy and numeracy activities outside the classroom.

The involvement of parents in reinforcing learning at home is an important factor in early childhood education. When children share their learning experiences with their families, the learning process becomes more meaningful and sustained. Research indicates that home reinforcement can strengthen early literacy and numeracy development by providing additional opportunities for practice and exploration (Niklas & Schneider, 2017). In this study, the enthusiasm shown by children at home suggests that the interactive and engaging nature of IFPD-based learning made a lasting impression on them. This finding highlights the importance of designing learning experiences that not only engage children in the classroom but also inspire continued learning beyond school hours.

Furthermore, the findings demonstrate that the combination of interactive digital media and teacher scaffolding can be an effective instructional strategy for children aged 4–6 years. At this developmental stage, children benefit from learning experiences that integrate play, exploration, and guidance. Digital games presented on the IFPD provided opportunities for playful learning, while teacher scaffolding ensured that learning objectives were achieved. This balanced approach allowed children to enjoy the learning process while still developing essential academic skills. Studies on playful learning emphasize that children learn best when educational activities combine elements of play with intentional instruction (Zosh et al., 2018).

The effectiveness of IFPD-based learning also depends on the teacher's ability to implement scaffolding strategies effectively. Teachers need to understand when to provide assistance and when to allow children to work independently. Too much assistance may limit children's opportunities to explore, while too little support may lead to confusion and frustration. Therefore, teacher training is essential to ensure that scaffolding strategies are applied appropriately. Professional development programs can help teachers learn how to integrate digital technology into their teaching while maintaining a child-centered approach. Research has shown that teacher competence in using digital tools plays a crucial role in determining the effectiveness of technology integration in early childhood education (Schindler et al., 2017).

Based on these findings, schools may consider integrating IFPD technology into daily learning activities as part of their instructional strategy. However, successful implementation requires careful planning and support. Schools need to ensure that teachers receive adequate training and that digital content is appropriate for young learners. Additionally, digital activities should be integrated with traditional learning

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methods rather than replacing them entirely. A balanced approach that combines digital and non-digital activities can provide children with diverse learning experiences that support their overall development.

In conclusion, this study demonstrates that the integration of IFPD-based digital games and cognitive scaffolding is effective in improving early literacy and numeracy skills among young children. Interactive digital media increased children's engagement and motivation, while teacher scaffolding supported their understanding and skill development. The positive transfer of learning to the home environment further indicates that this approach can foster lasting learning behaviors. Therefore, the combination of interactive technology and guided instruction represents a promising strategy for enhancing early childhood education, particularly in the development of foundational literacy and numeracy skills.

V. Conclusion

The findings of this study indicate that the use of Interactive Flat Panel Display (IFPD)–based digital games combined with teachers' cognitive scaffolding has a positive impact on the development of early childhood literacy and numeracy at TK Mutiara Hati. The interactive learning activities increased children's enthusiasm and focus, enabling them to better understand letters, vocabulary, and storytelling skills as part of early literacy development. At the same time, the use of digital media supported by systematic teacher guidance effectively enhanced early numeracy skills, including number recognition, simple arithmetic operations, and basic problem-solving. Overall, children demonstrated improved accuracy and independence in recognizing numbers and performing counting activities, indicating that the integration of interactive digital games and cognitive scaffolding provides meaningful support for early literacy and numeracy learning.

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