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# The Effectiveness of Digital Collaboration through Interactive Flat Panel Displays in Stimulating Early Numeracy Skills

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**ABSTRACT**
This study aims to explore the effectiveness of digital collaboration through Interactive Flat Panel Displays (IFPD) in stimulating young children's early numeracy skills at TK Aisyiyah Ngunut, as well as the factors influencing its implementation. The study employed a qualitative case study approach, with data collected through semi-structured interviews with the principal, early childhood education teachers, and parents, as well as participatory classroom observations. The findings indicate that the use of IFPD increased children's engagement, motivation, independence, and numeracy skills. Children were able to understand number concepts, grouping, simple addition, and number sequences through direct interaction with digital media. Collaborative activities also strengthened children's social skills and teamwork. The successful implementation of IFPD was influenced by teacher competence, the quality of digital content, parental support, and device readiness. These findings suggest that IFPD is an interactive and effective learning medium for stimulating early childhood numeracy skills when supported by adequate enabling factors.

**Keywords:** Interactive Flat Panel Displays, Early Numeracy, Digital Collaboration, Early Childhood.

## I. Introduction

Early Childhood Education (ECE) plays a strategic role in shaping children's foundational competencies, including early numeracy skills. Early numeracy encompasses number recognition, understanding quantities, number sequencing, and basic arithmetic operations. These competencies are not merely cognitive abilities but also essential foundations for later success in mathematics learning and overall academic achievement. Research indicates that early numeracy development is closely linked to children's cognitive growth and readiness for formal schooling, emphasizing the importance of effective stimulation during the preschool years (Mastikawati, 2023). Ideally, numeracy learning in early childhood education should be delivered through creative, interactive, and contextual approaches. Such approaches enable children to develop logical thinking, creativity, and problem-solving skills from an early age. Interactive learning experiences allow children to construct knowledge actively rather than passively receiving information. Studies have shown that interactive and hands-on learning environments significantly enhance children's understanding of mathematical concepts and improve engagement during learning activities (Daryati, 2025; Narisa et al., 2025).

However, in many early childhood education institutions, including TK Aisyiyah Ngunut, conventional teaching methods still dominate numeracy instruction. Teachers often rely on printed books,

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whiteboards, and simple teaching aids to introduce numbers and basic counting concepts. While these traditional methods can be effective for initial exposure to numbers, they often fail to maintain children's interest and active engagement over extended periods. As a result, children's motivation to learn may decrease, and their participation in numeracy activities may remain limited. This situation may lead to uneven development in children's understanding of quantities and number concepts.

One of the main challenges in early numeracy instruction is the abstract nature of mathematical concepts. Young children tend to learn best through concrete experiences and visual representations. When learning materials are not sufficiently engaging or interactive, children may struggle to grasp numerical relationships and patterns. Previous studies have emphasized that early numeracy skills develop more effectively when children engage in meaningful and interactive activities that connect mathematical concepts with real-life experiences (Almulhim & Fujita, 2026). The rapid development of digital technology has created new opportunities to enhance learning experiences in early childhood education. Digital tools can transform traditional classrooms into interactive environments where children can explore concepts through visual, auditory, and kinesthetic experiences. Technology-based learning environments have been shown to support children's exploration and discovery of mathematical ideas by providing dynamic representations of numbers and quantities (Alsaeed & Aladil, 2024).

One technological innovation that has begun to be implemented in early childhood education is the Interactive Flat Panel Display (IFPD). This interactive screen allows children to engage directly with learning materials through touch-based interaction, movement, and digital collaboration. Unlike traditional media, IFPDs enable the integration of images, animations, sounds, and interactive tasks in a single platform. These features provide children with more concrete and engaging learning experiences compared to static learning materials. The use of touchscreen-based digital tools has been shown to increase engagement and provide efficient ways to introduce early academic concepts, including numeracy. Touchscreen interaction allows children to manipulate objects directly, which helps them understand quantities, counting, and number relationships more effectively (Apicerni et al., 2026). This type of interaction aligns with early childhood learning principles, particularly learning by doing and multisensory stimulation, which are essential for young learners.

Furthermore, digital technologies such as IFPDs support collaborative learning among children. Collaboration is an important component of early childhood education because it promotes social interaction and communication skills. Through collaborative activities, children can work together to solve problems, count objects, arrange numbers, and complete interactive tasks. Research on digital play technologies indicates that shared access to digital tools encourages cooperation, joint decision-making, and problem-solving among young learners (Torres et al., 2021). In numeracy learning contexts, collaborative digital activities may include grouping digital objects, counting items, arranging numbers in sequence, or solving simple arithmetic puzzles. These activities allow children to engage actively in the learning process while interacting with their peers. The immediate feedback provided by digital systems also encourages children to experiment and learn from their mistakes without fear of failure. This supportive learning environment fosters confidence and independence in young learners.

Previous studies support the effectiveness of digital media in improving early numeracy skills. Interactive learning media have been shown to significantly improve preschool children's counting abilities compared to conventional teaching methods (Daryati, 2025). Similarly, the integration of digital tools in preschool mathematics instruction has been associated with improvements in mathematical understanding and learning outcomes (Alkouri & Wardat, 2025). Digital technologies also help strengthen mathematical concepts by providing visual and interactive representations that make abstract ideas more accessible to young children (Kamiliyah et al., 2025). In addition to cognitive benefits, digital learning media can enhance children's motivation and engagement. Interactive applications and digital games create enjoyable learning experiences that encourage children to participate actively in learning activities. Research on interactive technologies in early childhood classrooms has shown that engaging digital content can increase children's interest and promote collaborative learning experiences (Farihah et al., 2025). Despite the potential benefits

ISSN [Online]: 2776-6411

of IFPDs, their successful implementation depends on several factors. Teacher competence plays a crucial role in determining how effectively technology is integrated into classroom instruction. Teachers need adequate training and support to design meaningful learning activities that utilize digital tools effectively. Studies indicate that teachers' beliefs and competencies significantly influence the successful integration of technology in early mathematics education (Alsaeed & Aladil, 2024).

In addition to teacher readiness, the quality of digital content is also a critical factor. Learning materials must be developmentally appropriate and aligned with children's cognitive abilities. Content that is too difficult may discourage children, while overly simple content may fail to stimulate learning. The availability of infrastructure, including reliable devices and technical support, also affects the effectiveness of digital learning implementation. Although Interactive Flat Panel Displays have considerable potential to enhance early numeracy learning, their use in Indonesian early childhood education settings remains relatively new. In particular, the implementation of IFPDs in institutions such as TK Aisyiyah Ngunut has not been widely studied. There is still limited empirical evidence examining how digital collaboration through IFPDs influences children's early numeracy skills in real classroom contexts.

Therefore, this study is important for evaluating the effectiveness of digital collaboration through Interactive Flat Panel Displays in stimulating children's early numeracy skills. In addition, this research aims to identify the factors that influence the successful implementation of IFPD-based numeracy learning. The findings are expected to provide practical guidance for teachers in designing interactive and engaging numeracy learning activities using digital technology. Based on the background described above, the research questions of this study are as follows: 1) How effective is digital collaboration through Interactive Flat Panel Displays in stimulating early numeracy skills among children at TK Aisyiyah Ngunut? 2) What factors influence the successful implementation of IFPD-based numeracy learning at TK Aisyiyah Ngunut?

## II. Literature Review

Early numeracy skills are fundamental components of early childhood education and serve as a strong predictor of later academic achievement, particularly in mathematics. Early numeracy includes number recognition, understanding quantities, number sequencing, and basic arithmetic operations such as addition and subtraction. These foundational skills support children's cognitive development and help them build logical thinking and problem-solving abilities from an early age. Research suggests that children who develop strong numeracy skills during preschool years are more likely to demonstrate better mathematical performance in primary education (Almulhim & Fujita, 2026). Early numeracy is therefore considered an essential aspect of school readiness and cognitive development in early childhood education settings.

The development of numeracy skills in early childhood is closely associated with interactive and meaningful learning experiences. Young children learn best through hands-on activities that allow them to manipulate objects and observe relationships between numbers and quantities. Constructivist learning theory emphasizes that children actively construct knowledge through interaction with their environment, making interactive learning environments particularly effective for early numeracy development. Studies have shown that children's understanding of mathematical concepts improves when learning activities involve visual representations, physical manipulation, and social interaction (Narisa et al., 2025). These approaches enable children to connect abstract numerical concepts with concrete experiences, thereby improving comprehension and retention. In recent years, digital technology has become an increasingly important tool in early childhood education. Digital learning environments offer interactive and engaging experiences that can enhance children's motivation and participation. Technology-based learning tools provide opportunities for children to explore mathematical concepts through visual and auditory stimulation, which can help make abstract ideas more concrete and understandable. Digital media also allow for dynamic representations of numbers and quantities, enabling children to experiment and learn through trial and error (Kamiliyah et al., 2025). As a result, digital technology has been widely recognized as a valuable resource for supporting early numeracy development.

ISSN [Online]: 2776-6411

One form of digital technology that has gained attention in early childhood education is the Interactive Flat Panel Display (IFPD). IFPDs are touchscreen-based devices that allow children to interact directly with digital content. These devices integrate multimedia elements such as images, animations, and sounds, creating a multisensory learning experience. Touchscreen interaction enables children to manipulate digital objects directly, which supports the development of numerical understanding and spatial awareness. Research indicates that touchscreen-based learning tools can enhance children's engagement and improve their understanding of early academic concepts, including numeracy (Apicerni et al., 2026). The use of interactive digital displays also supports collaborative learning among young children. Collaboration is an important component of early childhood education because it promotes communication, cooperation, and social development. Through collaborative learning activities, children can work together to solve problems, share ideas, and learn from one another. Digital collaborative environments encourage peer interaction by allowing multiple children to participate simultaneously in learning activities. This type of interaction has been shown to improve both cognitive and social outcomes in early childhood education (Torres et al., 2021).

In addition to supporting collaboration, digital learning tools can provide immediate feedback to learners. Immediate feedback helps children recognize mistakes and correct them in real time, which enhances the learning process. This feature is particularly beneficial in numeracy learning because it allows children to experiment with numbers and operations without fear of failure. Studies have found that interactive digital media can significantly improve children's motivation and engagement in learning activities, leading to better learning outcomes (Daryati, 2025). However, the successful implementation of digital technology in early childhood education depends on several factors. Teacher competence is one of the most critical factors influencing the effectiveness of technology integration. Teachers must be able to design meaningful learning activities that align with educational objectives and children's developmental levels. Without proper training and support, digital technology may be underutilized or used ineffectively. Research shows that teachers' beliefs and competencies play a significant role in determining how technology is integrated into early childhood classrooms (Alsaeed & Aladil, 2024).

Another important factor is the quality of digital learning content. Developmentally appropriate content is essential for ensuring that children benefit from digital learning experiences. Content that is too complex may overwhelm children, while overly simple content may fail to stimulate learning. Additionally, adequate infrastructure and technical support are necessary to ensure the smooth implementation of digital learning tools. Access to reliable devices and stable electricity or internet connections can significantly influence the effectiveness of digital learning environments. Overall, the literature suggests that interactive digital technologies such as Interactive Flat Panel Displays have the potential to enhance early numeracy learning by providing engaging, interactive, and collaborative learning experiences. However, the effectiveness of these technologies depends on careful implementation, including teacher preparation, appropriate content selection, and adequate infrastructure. Therefore, further research is needed to examine how digital collaboration through IFPDs can effectively support early numeracy development in specific educational contexts, particularly in early childhood education settings.

## III. Research Method

This study employed a qualitative approach using a case study design at TK Aisyiyah Ngunut to explore the effectiveness of digital collaboration through Interactive Flat Panel Displays (IFPD) in stimulating young children's early numeracy skills. A qualitative case study was selected to gain an in-depth understanding of how IFPD-based learning is implemented in a real classroom context and how it influences children's engagement and numeracy development. The research participants consisted of the school principal, early childhood education teachers, and parents, who were purposively selected to provide comprehensive perspectives on the implementation and impact of IFPD-supported learning activities.

Data were collected through semi-structured interviews that explored participants' experiences, perceptions, and views regarding the use of IFPD in numeracy learning. In addition, participatory observations

ISSN [Online]: 2776-6411

were conducted during classroom activities involving interactive digital games and collaborative tasks using the flat panel display. Supporting data were obtained from learning documentation, teacher notes, lesson plans, and digital learning materials used during instruction. This combination of data sources enabled a richer understanding of how digital technology supports early numeracy development and collaborative learning among young children (Neumann, 2018; Papadakis, 2021). 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, as supported by studies on game-based learning which demonstrate increased student participation and motivation (Nurfadila & Hajar, 2024).

Data analysis was conducted using thematic analysis, including transcription, coding, categorization, and interpretation to identify recurring themes related to effectiveness, challenges, and supporting factors in IFPD-based numeracy learning. Data validity was ensured through source triangulation and member checking to confirm the accuracy of interpretations. These strategies enhanced the credibility and trustworthiness of the findings and ensured that the results reflected participants' actual experiences (Creswell & Poth, 2018; Fleer, 2019).

The flow of this research can be seen in the following image:

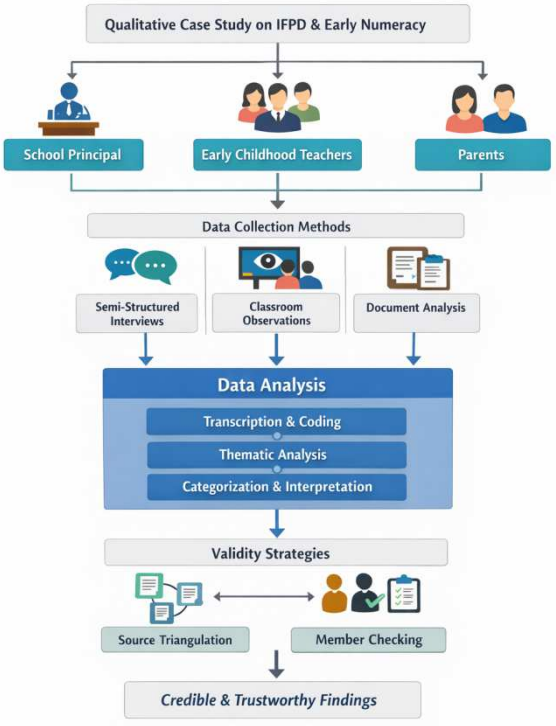


**Figure 1. Research Flow**

## IV. Result and Discussion

### 4.1. Result

Based on interviews with the school principal, the use of Interactive Flat Panel Displays (IFPD) was considered effective in stimulating children's early numeracy skills. The principal explained that interactive screens created a more engaging learning environment compared to conventional teaching media. According to the principal, children showed greater interest and participation when learning activities involved digital interaction. As the principal stated, *"Children are more interested and active when using the interactive screen; they do not only look at the material, but also move and count objects on the screen."* This

ISSN [Online]: 2776-6411

statement highlights how interactive technology can transform passive learning into active engagement by allowing children to manipulate digital objects directly. Such interaction supports the development of early mathematical understanding through visual and kinesthetic experiences, which are essential for young learners. The principal also emphasized that IFPD technology supports collaborative learning in the classroom. Through shared interaction with the screen, children are encouraged to work together to solve simple numeracy tasks, such as counting objects, matching numbers, and grouping items. This collaborative environment enables children to learn from their peers while also developing communication and social skills. Digital collaboration in early childhood settings has been shown to promote engagement and shared problem-solving, which are important components of meaningful learning experiences (Papadakis, 2021). The integration of interactive technology thus not only supports cognitive development but also strengthens social interaction among children.

Early childhood teachers also shared their experiences regarding numeracy instruction using IFPD. Teachers reported that children appeared more motivated and actively engaged during numeracy activities conducted with interactive screens. For example, children often discussed with their peers to solve counting tasks or worked together to arrange numbers in the correct order. One teacher explained, *"With the IFPD, children understand number concepts more quickly because they can practice them directly, and they enjoy learning while playing."* This observation suggests that interactive learning environments can make abstract mathematical concepts more concrete and accessible to young children. The visual and interactive features of IFPD allow children to see immediate results from their actions, which reinforces their understanding of numbers and counting. Teachers also observed that children became more confident when learning with IFPD. Many children were willing to try solving numeracy tasks independently and were not afraid of making mistakes because they could repeat the activities until they succeeded. This opportunity for repeated practice is particularly important in early childhood learning, as young children benefit from trial-and-error experiences that help them build confidence and persistence. Digital learning environments often provide immediate feedback, which helps children recognize mistakes and improve their performance (Neumann, 2018). As a result, children become more engaged and motivated to continue learning.

From the parents' perspective, respondents reported positive changes in their children after participating in numeracy learning activities using IFPD. Parents noticed that their children became more interested in numbers and counting activities at home. Some children began counting objects independently, such as toys or household items, and showed curiosity about numbers in their daily environment. One parent stated, *"My child often counts objects at home now and even asks to learn numbers while playing on a tablet or interactive screen."* This response indicates that learning experiences at school influenced children's behavior and interests outside the classroom. The integration of digital technology in early learning can extend learning experiences into the home environment, reinforcing children's understanding through everyday activities (Fleer, 2019).

Parents also reported that children frequently talked about their classroom activities involving interactive screens. This suggests that the learning experiences were meaningful and memorable for the children. When children are excited about what they learn, they are more likely to retain new knowledge and apply it in different contexts. The connection between school and home learning environments is particularly important in early childhood education, as parental involvement has been shown to support children's academic development (OECD, 2020). In this case, parents played an important role in reinforcing numeracy skills by encouraging children to practice counting and number recognition at home. Classroom observations further supported the findings from interviews. During numeracy activities using IFPD, children were observed working collaboratively, actively touching and moving digital objects, and following the teacher's instructions with enthusiasm. Children appeared happy and focused while completing counting games on the interactive screen. They often helped their peers and shared ideas about how to complete tasks. For example, some children suggested counting strategies, while others pointed to objects on the screen to help their friends find the correct answers. These interactions demonstrated a high level of engagement both individually and in groups.

ISSN [Online]: 2776-6411

The observations also revealed that children were willing to experiment with different strategies when solving numeracy tasks. Some children counted objects one by one, while others grouped objects to make counting easier. This variation in strategies reflects the natural development of mathematical thinking in early childhood. Interactive technology supports this process by providing flexible learning opportunities that allow children to explore different approaches to problem-solving. Such exploration is important for developing conceptual understanding rather than rote memorization (Papadakis, 2021). In addition to its effectiveness, the interview results also revealed several factors that influenced the successful implementation of IFPD in numeracy learning. The principal emphasized the importance of adequate infrastructure, including reliable electricity, functional devices, and appropriate digital learning content. Without proper infrastructure, the use of interactive technology in the classroom would be limited. The availability of suitable digital content is also essential, as learning materials must match children's developmental levels and learning needs.

Teachers highlighted the importance of technological competence in guiding children during IFPD-based activities. Teachers need to understand how to operate the technology effectively and how to integrate it into meaningful learning experiences. Without proper training, teachers may struggle to use digital tools effectively, which could reduce the potential benefits of the technology. Professional development and continuous training are therefore important to ensure that teachers can maximize the use of interactive learning media (Fleer, 2019). Parents also emphasized the importance of their involvement in supporting children's numeracy development. When parents encourage children to practice counting and number recognition at home, children have more opportunities to reinforce what they learn at school. This collaboration between school and home creates a supportive learning environment that enhances children's development. Parental involvement has consistently been identified as a key factor in children's academic success, particularly in early childhood education (OECD, 2020).

Overall, the data from interviews and classroom observations indicate that digital collaboration through IFPD enhances children's interest, engagement, and early numeracy skills. Children become more motivated to learn when they can interact directly with digital content and collaborate with their peers. The interactive features of IFPD make learning more engaging and meaningful, while collaborative activities encourage social interaction and shared problem-solving. However, the effectiveness of IFPD-based learning depends on several supporting factors, including teacher competence, adequate infrastructure, appropriate digital content, and parental support. When these factors are present, interactive technology can serve as a powerful tool for supporting early numeracy development. These findings suggest that integrating interactive digital technology into early childhood education can create a more engaging and effective learning environment. By combining visual, auditory, and tactile experiences, IFPD-based learning supports multiple aspects of children's development. Furthermore, digital collaboration encourages children to learn together, share ideas, and develop important social skills. As a result, IFPD has the potential to become an important component of early childhood education, particularly in supporting the development of foundational numeracy skills.

### 4.2. Discussion

The findings of this study indicate that the use of Interactive Flat Panel Displays (IFPD) at TK Aisyiyah Ngunut is effective in stimulating young children's early numeracy skills. Children demonstrated higher levels of engagement, enthusiasm, and participation compared to conventional learning methods. Interactive digital activities encouraged children to actively participate in counting, grouping, and ordering numbers, making abstract mathematical concepts more concrete and meaningful. Early numeracy skills—such as counting, number recognition, and simple arithmetic—are fundamental components of cognitive development and serve as the foundation for later mathematical learning . The results of this study confirm that interactive digital media can support the development of these foundational skills by providing engaging and meaningful learning experiences. From a theoretical perspective, these findings align with the constructivist theory of Jean Piaget, which emphasizes that children learn best through direct interaction with

ISSN [Online]: 2776-6411

their environment. In the preoperational stage, children develop symbolic thinking and begin to understand numbers through concrete experiences . The use of IFPD allows children to manipulate digital objects directly, such as dragging, counting, and grouping items on the screen. These activities resemble the use of physical manipulatives but provide additional visual and interactive features that enhance understanding. Research has shown that manipulative and interactive learning tools significantly improve children's numeracy skills by making learning more engaging and accessible .

The school principal emphasized that IFPD made it easier for teachers to present numeracy concepts visually and interactively. Instead of passively observing, children actively interacted with digital objects on the screen. This type of multisensory learning experience supports children's understanding by combining visual, auditory, and kinesthetic elements. Interactive learning media have been shown to significantly improve counting skills in early childhood education compared to conventional methods . The visual and interactive features of IFPD help children connect abstract number symbols with concrete representations, which is essential for early mathematical understanding. Teachers also reported that children were more willing to try and less afraid of making mistakes when using IFPD. Children could repeat activities multiple times until they succeeded, which reinforced their learning. This finding is consistent with the principles of behaviorism proposed by B. F. Skinner, which emphasize the importance of reinforcement and feedback in learning. Immediate feedback from digital activities allows children to recognize mistakes and correct them independently, which strengthens their understanding and confidence. The ability to repeat tasks without negative consequences encourages persistence and resilience, which are important aspects of early learning.

Classroom observations also revealed that children worked collaboratively when completing numeracy tasks using IFPD. They discussed strategies, shared ideas, and helped each other solve problems. This collaborative interaction supports the sociocultural theory of Lev Vygotsky, particularly the concept of the Zone of Proximal Development (ZPD), which suggests that children learn best through social interaction and guided support. Digital collaboration through IFPD provides opportunities for peer learning, where children can support each other in understanding numeracy concepts. Research on digital learning environments also indicates that collaborative activities enhance engagement and promote deeper understanding of mathematical concepts.

The findings also indicate that IFPD-based learning increased children's intrinsic motivation. Children appeared to enjoy numeracy activities and often asked to repeat them. Enjoyable learning experiences encourage children to develop positive attitudes toward mathematics, which can influence their long-term academic development. Studies on interactive digital learning tools have shown that engaging digital environments can increase children's interest and participation in learning activities . When children enjoy learning, they are more likely to remain engaged and persist in solving challenging tasks. Parents also reported positive changes in their children's behavior at home. Many children showed increased interest in numbers and counting activities and often practiced counting objects in their daily environment. This indicates that learning experiences at school influenced children's behavior beyond the classroom. Early numeracy experiences play an important role in children's cognitive development, and consistent stimulation both at school and at home can significantly improve learning outcomes . Parental involvement helps reinforce what children learn at school and provides additional opportunities for practice.

In addition to cognitive benefits, the use of IFPD also contributed to the development of children's social skills. During collaborative activities, children learned to take turns, communicate with peers, and work together to solve problems. These social interactions are essential for early childhood development and support both cognitive and emotional growth. Digital learning environments that encourage collaboration can promote both academic and social development simultaneously. The effectiveness of IFPD was also evident in children's ability to understand basic numeracy concepts such as grouping objects, simple addition, and number sequencing. These skills are essential components of early numeracy and serve as the foundation for more advanced mathematical learning. Through repeated interaction with digital activities, children gradually developed stronger cognitive structures related to numbers and counting. The interactive nature of IFPD allowed children to explore mathematical concepts in a playful and meaningful way.

ISSN [Online]: 2776-6411

Another important finding was the role of teacher competence in the successful implementation of IFPD. Teachers who were able to integrate technology effectively into their teaching practices were more successful in engaging children and supporting their learning. This finding aligns with the Technological Pedagogical Content Knowledge (TPACK) framework, which emphasizes the importance of integrating technology, pedagogy, and content knowledge in teaching. Teachers need to understand not only how to operate digital tools but also how to use them effectively to support learning objectives. The principal also emphasized the importance of infrastructure and digital content in supporting IFPD-based learning. Adequate equipment and appropriate learning materials are essential for effective implementation. Studies on the use of interactive flat panels in education have identified teacher competence, technological resources, and parental involvement as key factors influencing successful implementation . Without proper infrastructure and content, the potential benefits of interactive technology may not be fully realized.

Observations also indicated that children who were accustomed to using IFPD were able to follow instructions more quickly and complete numeracy activities more efficiently. Repeated exposure to interactive digital environments helps children become familiar with the learning process and improves their ability to focus on tasks. Interactive whiteboard research has shown that sustained use of interactive digital tools can improve mathematical performance over time . This suggests that consistent use of interactive technology can support long-term learning outcomes. The use of IFPD also allowed teachers to differentiate instruction based on children's abilities. Children with different levels of numeracy skills could engage in activities suited to their developmental level. This flexibility ensures that all children receive appropriate learning experiences. Differentiated instruction is particularly important in early childhood education, where children develop at different rates. Interactive digital tools provide opportunities for individualized learning that may be difficult to achieve through traditional methods.

The findings also suggest that IFPD supports the development of independent learning skills. Children were observed attempting to solve problems independently and experimenting with different strategies. The ability to explore and experiment is an important aspect of active learning. Digital learning environments provide opportunities for exploration while also offering guidance and feedback. This balance between independence and support is essential for effective learning in early childhood. In addition to promoting independence, IFPD also supported the development of problem-solving skills. Numeracy activities often required children to think logically, identify patterns, and determine solutions. Teachers reported that children began to use different strategies to solve problems, indicating the development of critical thinking skills. Early exposure to problem-solving activities can support the development of higher-order thinking skills later in life.

Another advantage of IFPD was its ability to support assessment and evaluation. Teachers could observe children's progress during digital activities and identify areas where additional support was needed. Real-time observation allows teachers to adjust their instruction and provide immediate assistance. This responsive approach to teaching helps ensure that all children receive the support they need to succeed. Despite its many benefits, several challenges were also identified. Some teachers reported difficulties related to technological readiness and the availability of appropriate digital content. If learning materials were not suitable for children's developmental levels, engagement decreased and learning activities became less effective. This finding highlights the importance of selecting high-quality digital content that aligns with curriculum goals and children's needs. Parental involvement was identified as another important factor influencing the success of IFPD-based learning. Parents who encouraged numeracy activities at home helped reinforce what children learned at school. This collaboration between school and home creates a supportive learning environment that enhances children's development.

Overall, the findings of this study indicate that digital collaboration through IFPD is effective in stimulating early numeracy skills while also supporting social interaction, motivation, independence, and problem-solving abilities. The successful implementation of IFPD depends on several factors, including teacher competence, digital content quality, parental support, and technological infrastructure. These findings support previous research demonstrating that interactive digital media can enhance children's

GOLDEN RATIO
ISSN [Online]: 2776-6411

numeracy skills and engagement in learning. Interactive technology is not merely a tool for delivering content but a medium that supports holistic learning by integrating cognitive, social, and motivational aspects of development. When implemented effectively, IFPD can serve as a powerful tool for early childhood education. In conclusion, the use of IFPD in early childhood numeracy learning provides a meaningful and engaging learning experience for children. Through interactive and collaborative activities, children develop foundational numeracy skills while also building social and cognitive abilities. With adequate support from teachers, parents, and schools, IFPD can become an effective alternative for numeracy learning in early childhood education.

The findings of this study can be clearly seen in the following table:

**Table 1. Research Findings**

| Research Question | Findings | Discussion (Interpretation) |
|---|---|---|
| How effective is digital collaboration through Interactive Flat Panel Displays (IFPD) in stimulating early numeracy skills among children at TK Aisyiyah Ngunut? | Children showed active engagement and enthusiasm during numeracy activities using IFPD. | Interactive digital media encourages active learning through direct manipulation of objects, making numeracy learning more meaningful and engaging. |
| | Children demonstrated higher learning motivation and interest in numbers and counting activities. | Enjoyable and interactive activities increase intrinsic motivation and support sustained engagement in learning. |
| | Children better understood numeracy concepts such as number recognition, grouping, simple addition, and number sequencing. | Visual and interactive representations help transform abstract number concepts into concrete experiences. |
| | Children were more confident and willing to try numeracy tasks without fear of making mistakes. | Immediate feedback and repeated practice support learning and build confidence. |
| | Children were able to complete numeracy tasks more independently. | Interactive learning promotes active exploration and independent problem-solving. |
| | Children collaborated with peers by discussing and solving numeracy tasks together. | Digital collaboration promotes social interaction and shared learning experiences. |
| | Children showed longer attention spans and remained focused during learning activities. | Interactive features help maintain children's attention and engagement. |
| What factors influence the successful implementation of IFPD-based numeracy learning at TK Aisyiyah Ngunut? | Teacher competence in operating and facilitating IFPD was a key factor. | Teachers' technological and pedagogical skills determine the effectiveness of digital learning implementation. |
| | Availability of infrastructure and functioning devices supported learning activities. | Adequate technological facilities ensure smooth and effective implementation. |
| | Availability of infrastructure and functioning devices supported learning activities. | Adequate technological facilities ensure smooth and effective implementation. |
| | Appropriate digital content supported children's engagement and understanding. | Age-appropriate and interactive content enhances learning effectiveness. |

GOLDEN RATIO
ISSN [Online]: 2776-6411

| Research Question | Findings | Discussion (Interpretation) |
|---|---|---|
| | Parental support reinforced numeracy learning at home. | Home involvement strengthens learning transfer from school to daily life. |
| | Repeated exposure to IFPD improved children's familiarity with numeracy activities. | Continuous practice strengthens early numeracy development. |
| | Classroom management and guidance influenced children's participation. | Structured facilitation helps children engage in collaborative learning effectively. |

## V. Conclusion

Based on the findings of the study, it can be concluded that digital collaboration through Interactive Flat Panel Displays (IFPD) is effective in stimulating early numeracy skills among children at TK Aisyiyah Ngunut. The children demonstrated active engagement, high learning motivation, confidence in trying new tasks, independence in completing numeracy activities, and the ability to collaborate with their peers. The use of IFPD also facilitated children's understanding of number concepts, grouping, simple addition, and number sequencing, making numeracy learning more concrete and enjoyable. These findings address the first research question concerning the effectiveness of digital collaboration through IFPD in stimulating early numeracy skills.

In addition, this study found that the success of IFPD-based numeracy learning is influenced by several key factors. Teachers' competence in operating and facilitating the use of IFPD emerged as a primary factor, followed by the availability of adequate infrastructure and digital content appropriate to children's developmental stages. Parental support at home also played an important role in reinforcing the numeracy stimulation that children received at school. These findings address the second research question regarding the factors influencing the success of IFPD-based numeracy learning. Therefore, the integration of teacher competence, high-quality digital content, parental support, and technological readiness constitutes the main determinants of successful digital collaboration in improving children's early numeracy skills. This conclusion highlights that IFPD can serve as an effective, engaging, and interactive learning medium for early childhood education, provided that these supporting factors are adequately fulfilled.

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