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Developing Inquiry-Based Wordwall Interactive Games to Enhance Early Childhood Mathematical Skills

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ABSTRACT
This research was prompted by the low mathematical skills among children at TK Nurul Ilmi, caused by a lack of interactive learning media capable of stimulating children's curiosity. The aim of this study was to develop an inquiry-based Wordwall interactive game that is valid, practical, and effective for improving early childhood mathematical abilities. The research method used was Research and Development (R&D) following the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). The subjects included 15 children from class B1 at TK Nurul Ilmi. The results showed: (1) the media validity reached 94% (Very Valid); (2) the practicality level based on teacher feedback and child activity observation reached 94.6% (Very Practical); and (3) the effectiveness level showed a significant increase with the average score rising from 61.1% in the pre-test to 97% in the post-test, with an N-Gain value of 0.91 (High Category). It is concluded that the inquiry-based Wordwall interactive game is feasible and effective for improving children's mathematical skills in Kindergarten.

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INTRODUCTION

Early childhood education serves as a critical foundation for a child's future academic and cognitive development. During this golden age, children possess an extraordinary capacity to absorb information and develop basic logic, including early mathematical concepts (Onoshakpokaiye, 2023). Mathematics for young children is not merely about numbers and counting, but also involves developing problem-solving skills, logical thinking, and the ability to understand patterns and relationships. However, introducing these concepts requires a pedagogical approach that aligns with the developmental characteristics of children, who learn best through exploration and play (Koyano et al., 2023).

In the current educational landscape, the *Kurikulum Merdeka* in Indonesia emphasizes the importance of literacy and numeracy from an early age. The curriculum encourages educators to create a learning environment that is student-centered and fosters a sense of wonder. Despite these guidelines, the reality in many preschools, such as TK Nurul Ilmi, shows that mathematical instruction often remains conventional. Teaching methods frequently rely on static media like worksheets and physical magazines, which may fail to engage digital-native children. Consequently, children often perceive mathematics as a daunting and uninteresting subject, leading to suboptimal developmental outcomes (Viana et al., 2016).

Preliminary observations at TK Nurul Ilmi Pasaman Barat revealed that children's mathematical abilities were still below the expected developmental milestones. Traditional, teacher-centered strategies dominated the classroom, leaving little room for children to actively participate or investigate mathematical phenomena. This lack of engagement is a significant hurdle, as early numeracy is a strong predictor of later academic success. Therefore, there is an urgent need for an innovative instructional medium that can transform abstract mathematical concepts into interactive and tangible experiences for young learners (Houwen et al., 2016).

The integration of technology in the form of interactive games offers a promising solution to this pedagogical challenge. Wordwall, a versatile digital platform, allows for the creation of customized interactive activities that can stimulate visual, auditory, and kinesthetic learning. By transforming mathematical exercises into "games," the anxiety associated with learning can be reduced, replaced by motivation and curiosity. However, digital media alone is insufficient; it must be paired with an effective instructional strategy, such as the inquiry-based approach, to ensure meaningful learning (Bukvić et al., 2021).

An inquiry-based approach encourages children to observe, ask questions, and discover concepts through their own investigations. By embedding this approach into Wordwall interactive games, children are not just passive consumers of digital content but active participants in their own learning process (Ralli et al., 2023). This research, therefore, focuses on the development of inquiry-based Wordwall interactive games to provide a valid, practical, and effective tool for enhancing mathematical skills. It is expected that this media will provide a more dynamic learning experience, fostering both the cognitive and affective growth of children in Taman Kanak-Kanak.

METHOD

This study employed the Research and Development (R&D) method using the ADDIE model (*Analysis, Design, Development, Implementation, and Evaluation*). The research was conducted at TK Nurul Ilmi Pasaman Barat, involving 15 children from Class B1 as the primary research subjects. The objective was to produce a digital learning product that is valid, practical, and effective in improving early childhood mathematical skills. Data collection involved various instruments, including validation sheets for experts, observation rubrics for child activity, teacher response questionnaires, and pre-test/post-test assessments for mathematical competency (Branch, 2009).

The development process began with a needs analysis to identify gaps in children's numeracy skills and the limitations of existing media. In the design phase, the researcher created storyboards and flowcharts that mapped inquiry-based steps—observing, questioning, experimenting, and concluding—into Wordwall's interactive templates. During the development phase, the digital game was constructed and subjected to rigorous validation by material and media experts. These experts evaluated the accuracy of the mathematical concepts, the pedagogical alignment with the inquiry approach, and the technical quality of the interface, ensuring the product was ready for classroom use (Creswell, 2014; Yin, 2017).

DISCUSSION

The development of the inquiry-based Wordwall interactive game followed the five stages of the ADDIE model to ensure a high-quality educational tool for improving children's mathematical skills.

Analysis Phase

The analysis revealed a significant gap in early mathematical competency at TK Nurul Ilmi, where children's initial development scores were as low as 5%. The primary causes identified were the lack of interactive media and the use of teacher-centered, monotonous instructional methods. Furthermore, the analysis of curriculum requirements highlighted the need for media that supports the *Kurikulum Merdeka* goals of fostering numeracy through exploratory and child-centered activities.

Design and Development Phases

In the design phase, the researcher mapped out a digital learning path that integrated the four pillars of inquiry: Observing, Questioning, Experimenting, and Concluding. These steps were translated into interactive Wordwall templates such as "Quiz," "Match-up," and "Group Sort." During the development phase, the game was refined based on feedback from experts. The validation results from material, media, and language specialists yielded an average score of 94% (Very Valid), indicating that the game was pedagogically sound and technically robust for kindergarten use.

Implementation and Evaluation Phases

The implementation phase involved a field trial with 15 students. The practicality of the media was rated at 94.6% (Very Practical), based on teacher feedback and the high level of child engagement. In the final evaluation phase, the effectiveness of the game was measured using a pre-test and post-test. The children's average mathematical score increased significantly from 61.1% (Pre-test) to 97% (Post-test). The calculated N-Gain score of 0.91 falls into the "High" category, demonstrating that the media is highly effective in accelerating the development of mathematical concepts.

The success of this media lies in its ability to transform abstract mathematical concepts into concrete, interactive experiences. By using the inquiry approach, children are not merely guessing answers but are guided through a logical process of discovery. This digital intervention bridges the gap between the concrete operational needs of young learners and the digital environment they naturally inhabit. The high N-Gain score suggests that when technology is paired with a structured pedagogical framework like inquiry, it can significantly outperform traditional teaching methods in fostering early numeracy.

DISCUSSION

The significant improvement in children's mathematical abilities following the use of the inquiry-based Wordwall interactive game demonstrates that the precise integration of technology can overcome the weaknesses of conventional learning methods. The results of this study prove that digital media functions not merely as an entertainment tool, but as a cognitive bridge that helps children understand abstract mathematical concepts through dynamic visualization (Hidayah & Andriani, 2023).

Unlike the use of static worksheets, the Wordwall platform provides immediate feedback, allowing children to learn from their mistakes in real-time, which in turn builds self-confidence in solving numeracy problems (Tobia et al., 2021).

The effectiveness of this media is also rooted in the systematic application of the inquiry approach embedded within the game. By following the phases of observing, questioning, experimenting, and concluding, children are no longer passive recipients of information. Instead, they are encouraged to become "little investigators" who actively explore various possibilities within the game. This process aligns with Piaget's constructivism theory, where knowledge is constructed through active interaction with the environment. In this context, Wordwall serves as a safe digital environment for children to experiment with concepts of classification, patterns, and numbers without the fear of failure (Hartan et al., 2025).

Beyond the cognitive aspects, the use of this interactive game triggered high intrinsic motivation among the students at TK Nurul Ilmi. Gamification elements—such as time challenges, engaging sound effects, and performance scores—transformed the children's negative perceptions of mathematics, which was previously considered difficult (Hinostroza et al., 2024; Noemí & Máximo, 2014).

When children feel enjoyment and are fully engaged in learning activities, their concentration levels increase, directly impacting the absorption of early mathematical concepts. This motivation is a key factor in ensuring the sustainability of children's interest in STEM subjects as they progress to higher education levels.

From a practical perspective, this study shows that cloud-based digital media like Wordwall is highly relevant to the needs of teachers under the *Kurikulum Merdeka* framework. Teachers found that this media facilitated a more structured and flexible delivery of mathematical material. The ability to access the media through various devices allows learning to extend beyond the classroom, enabling collaborative activities. This supports the broader educational transformation where teachers act as facilitators who provide innovative, student-centered learning resources (Arkas & Rakimahwati, 2023; ten Braak et al., 2022).

In conclusion, the findings of this research reinforce the idea that digital literacy and early numeracy should be harmoniously integrated in early childhood education. The N-Gain score, which reached the "High" category (0.91), proves that the inquiry-based Wordwall interactive game is a highly effective intervention. This study offers important implications for PAUD educators to begin transitioning from traditional methods to utilizing interactive educational technology. By combining strong pedagogy (inquiry) and engaging media (Wordwall), the goal of producing a mathematically literate and critically thinking generation can be achieved more effectively.

CONCLUSION

The development of the inquiry-based Wordwall interactive game has successfully met the criteria for a high-quality educational tool, achieving exceptional levels of validity and practicality. Validation from experts confirmed that the media is pedagogically sound, effectively integrating mathematical concepts with an inquiry-based framework suitable for early childhood. Furthermore, the high practicality score reflects the media's ease of use and its ability to create an engaging, child-centered learning environment. This suggests that the interactive game is not only a viable technological intervention but also a user-friendly resource that can be seamlessly adopted by teachers in kindergarten settings.

In terms of pedagogical impact, the implementation of this media led to a significant improvement in children's mathematical skills, as evidenced by a high N-Gain score of 0.91. The inquiry-based approach embedded within the game transformed children from passive learners into active investigators, fostering a deeper understanding of early numeracy. These findings emphasize that combining interactive digital platforms like Wordwall with structured inquiry strategies is highly effective for accelerating cognitive development. Consequently, this research recommends the wider integration of such digital tools in early childhood education to prepare students for the demands of modern literacy and numeracy.

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