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Development of the Educational Game Tool "Fun Mathematic Board" as a Numeracy Learning Medium for 5–6-Year-Old Children at Al Azhar Islamic Kindergarten Tulungagung

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ABSTRACT

Teaching numeracy in early childhood significantly influences cognitive and academic development. Insufficient numeracy stimulation during the golden age may lead to future difficulties in learning mathematics and long-term life challenges. Early childhood education serves as a bridge to introduce foundational numeracy skills, making it essential to implement effective teaching strategies. A play-based approach using educational game media is an effective solution for numeracy learning in children aged 5–6 years. This research and development study produced the Fun Mathematic Board, an educational board game designed to enhance early numeracy skills. The game's feasibility was evaluated by game experts, subject matter experts, and users. The validation results showed that material experts rated it 89.06%, while game experts gave it 98.44%. The feasibility test results confirmed the game's suitability without revision, with a 93.1% approval rating in small-group trials and 91.5% in large-group trials. These findings highlight the Fun Mathematic Board as an effective tool for early numeracy learning.

1. Introduction

Early Childhood Education (ECE) is crucial in assisting children's cognitive development, particularly learning numeracy (Ningrum et al., 2023). Early childhood numeracy is a fundamental determiner of their cognitive and academic development as it is the foundation for logical and mathematically based reasoning that they will utilize throughout their lives (Junaedah et al., 2020; Nawaila et al., 2022; Nazarova, 2020). Children aged 5-6 years fall in the development phase known as the golden age when their brains absorb information most effectively and the development of deep patterns of thought (UNESCO, 2020). A study conducted by Bar & Shaul, (2021); Chang, (2023); Hossain et al., (2023); Lestari et al., (2022);

Salminen et al., (2021); and Shvartsman & Shaul, (2024) indicates that the right stimulation in numeracy early on can maximize future academic achievement and refining practical skills such as operating an allowance or measuring something. Proper stimulation at this stage can leave a lasting impression on the logical and analytical skills of a child (Yafie et al., 2020).

Despite the known significance of numeracy education, the status of Indonesia shows that the early childhood numeracy education is prone to various issues. In most developing countries as well as in Indonesia, however, access to quality numeracy learning is still an issue (Ministry of Education, Culture, 2023). This is a critical concern considering that numeracy is not merely critical in school but even in daily life with its basic math concepts. Figures from the Central Bureau of Statistics (Badan Pusat Statistik (BPS) Indonesia, 2020) indicate that a mere 60% of young children have access to an appropriate education.

It is thus necessary to develop learning media that can resolve this issue, particularly in communicating numeracy in an effective and enjoyable manner to children aged 5-6 years (Bali et al., 2023; Hidayah et al., 2023; RK & Watini, 2022). Moreover, most regions continue to experience inequality in the standard of education in the urban and rural areas. In the topic of numeracy education specifically, most schools continue to apply textbooks and worksheets that less effectively transmit elementary math among young children (Colliver et al., 2021; S. et al., 2023; Surya Sari Faradiba et al., 2024; Susperreguy et al., 2020; Sutama et al., 2023).

In some schools of early childhood education such as Al Azhar Islamic Kindergarten in Tulungagung, learning methods continue to rely on textbook- and worksheet-based that is monotonous and boring for children. Moreover, the utilization of appropriate learning media that is in accordance with the nature of the children is still limited. Therefore, the children become bored and cannot absorb the material fully. Therefore, innovation on the development of more fun and enjoyable learning media of numeracy is required to activate the activity of the children in the learning process.

Some of these studies have shown that the use of innovative and creative media has a key role in the development of early childhood. Bustamante et al., (2020) and Lange et al., (2021) presented that the use of board games in early childhood education enables kids to learn fundamental math concepts such as numerals and geometry in a fun way. Gasteiger & Moeller, (2021) study equally revealed that the use of board games accelerates the kids' understanding of early math skills as the games not only enable kids to engage in academic learning but facilitate communication, teamwork, and critical thinking. Arimbi et al., (2024); Smirnova et al., (2022) and Widyasari et al., (2019) study equally revealed that the incorporation of features such as QR codes in the board game can unlock the logical thinking potential of kids, enhance their cognitive skills, and accelerate their learning of fundamental math skills.

Based on these findings, the solution devised in this work is the development of the Fun Mathematic Board as a learning game medium with a board game format that

is aimed to support children developing numeracy when they are 5–6 years of age. By applying the principles of active learning as well as learning with others, the children learn through interactions and discussions as well as develop social skills. Using fun games, this medium enables the increased interest of children in learning as well as comprehension of the fundamentals of mathematics. Along with Vygotsky's constructivist concept of 1978 (Vygotsky, 1978) that productive learning involves social contact as well as immediate experience, the Fun Mathematic Board enables this with a facility for group learning as well as the development of social skills and communication.

Fun Mathematic Board development is further supported by applicable learning theories of early childhood education. Piaget (in Koocher, 1973) emphasized that children learn from directly interacting with the immediate environment, such as playing. Therefore, children's games should have the capacity to test their intelligence. Vygotsky's (1978) constructivist learning approach that is concerned with the role of collaboration when learning that forms the basis of the enhancement of the interactions of children with one another in the context of the Fun Mathematic Board is also applicable (Vygotsky, 1978). Moreover, the choice of such a board game is further justified by Widiastuti & Kirono, (2022) learning media theory that accounts for the reality that the curiosity and interest of children and mastery of a subject matter might grow with an appropriate and enjoyable media. Therefore, it is not a tool for learning numeracy but one that enhances social learning, skill in cooperating with others as well as mastery of the subject matter of mathematics among children.

The following article is an innovation contribution towards numeracy learning media in early childhood with the inclusion of the Fun Mathematic Board as a learning game medium that combines math learning with fun playing games. Board games have long dominated learning in early childhood. However, the inclusion of the Fun Mathematic Board brings with it a new idea with the incorporation of extensive learning of core math concepts such as number, geometry, and measurement. Further, the media is concerned with the development of the social and cooperative skills of the children as opposed to the common learning media.

The aim of this paper is to document the result of the development of Fun Mathematic Board as a functional and enjoyable medium of numeracy learning for 5-6-year-old kindergarten pupils of Al Azhar Islamic Kindergarten Tulungagung. The paper aims to add to the body of knowledge of innovative learning media within the framework of early childhood education as well as provide information to parents, teachers, and schools of how the quality of numeracy learning is increased with the tools of learning games. In addition, the paper aims to add to the body of evidence of the implementation of board games within the framework of early childhood math education and provide a starting point for conducting similar such research.

2. Methodology

Research Design

The approach used in the study is an R&D approach with the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) used in the development and piloting of the Fun Mathematic Board as an educational game tool for enabling the learning of numeracy among 5-6-year-olds (Ghirardini, 2011). The process of the research involves needs analysis of the population, prototype development and design, and recurrent testing with true users. The utilization of the ADDIE model is because the model is a systematic, flexible, and iterative one that accommodates continuous improvement through expert review and pilot testing with the focus of ensuring the product is fun and informative for young learners.

Research Procedure

This research begins with an analysis: in this phase, the researcher analyzes the current state of numeracy learning. Two types of analysis were conducted: (a) a needs analysis through interviews with teachers at Al Azhar Islamic Kindergarten, Tulungagung, conducted on March 29, 2024, to assess the existing numeracy teaching methods, and (b) a case analysis through observations of children's current play activities, revealing the decline in physical board games due to increased dependence on electronic devices, which hinder their development. The limited variation of educational tools for numeracy was also identified. this research begins with analysis as shown in figure 1.

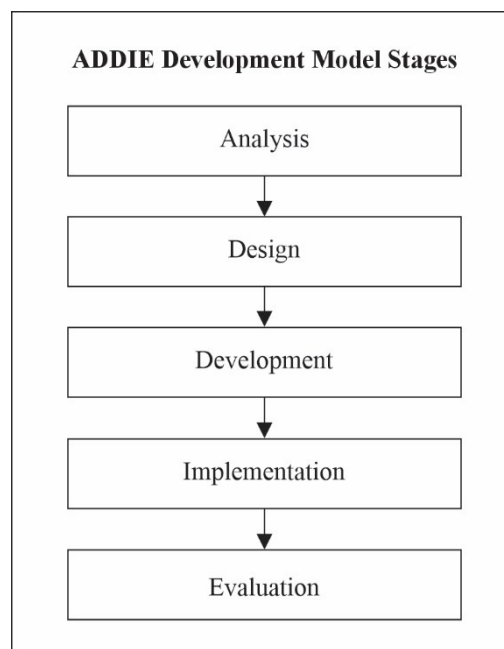


Figure 1. Research Procedure Process

The second is design: this phase involves designing the Fun Mathematic Board product, outlining its specifications, content, and visual design. The third is development: the product design is then developed and validated by subject matter and media experts to ensure its educational value and usability. The fourth is implementation: after validation, a trial run is conducted in two stages: a small-scale trial with 8 children at Al Azhar Islamic Kindergarten, and a larger trial involving 30 children. The final phase is evaluation: following the trials, feedback is collected from teachers to evaluate the product's effectiveness, user engagement, and educational impact. The whole process follows the ADDIE model, which consists of Analysis, Design, Development, Implementation, and Evaluation.

Product Trial

The product trial is carried out to determine the viability of the product as a learning medium for early childhood numeracy. The trial is carried out in three phases, starting with validation by early childhood education media experts and content experts. Once the product has passed the validation phase, the trial is carried out in two phases: a small group trial and a large group trial in Al Azhar Kindergarten Tulungagung. Children aged 5-6 years, teachers, media experts, and content experts are the subjects of the trials. Content and appearance of the product are evaluated by media and content experts and teachers give their feedback using questionnaires. The evaluation evaluates the effectiveness, efficiency, and attractiveness of the product. The product trial was conducted to the test subjects as in table 1.

Table 1. Trial Product

Type of Trial	Subjects	Purpose
Content Validation Trial	Content experts	Assess the feasibility of the content based on expertise in early childhood cognitive development
Media Validation Trial	Media experts	Assess the feasibility of the media based on expertise in early childhood learning media
User Trial	Teachers	Assess the effectiveness, efficiency, and attractiveness of the product using questionnaires
Small Group Trial	8 children aged 5-6 years	Test the feasibility of the product with a small group
Large Group Trial	30 children aged 5-6 years	Test the feasibility of the product with a large group

Data Collection Technique

Data collection techniques used in the development of the Fun Mathematic Board learning game as a learning tool for 5-6-year-olds' numeracy in Al Azhar Islamic Kindergarten in Tulungagung include observation, interview, questionnaires, and checklists. Structured interview with the principal and teachers of the kindergarten in the early phase of the research and the experts' ratings and comments provide qualitative data. Quantitative data come from questionnaires completed by media and early childhood education content experts, observation sheets completed by teachers conducted in small and large group trials, and pretest and posttest checklists.

Data Analysis Technique

The data analysis technique employed in this study involves both qualitative and quantitative methods to evaluate the effectiveness and feasibility of the Fun Mathematic Board as an educational tool. Qualitative data is gathered through structured interviews with teachers and experts, along with feedback on the product's usability and content. This data is analyzed thematically to identify key issues, suggestions for improvement, and general feedback on the product's performance in real-world educational settings. Quantitative data, on the other hand, is collected through expert validations and user feedback regarding the effectiveness, efficiency, and attractiveness of the product. The responses are converted into percentages, which are interpreted using a validation criterion. The product's validity is determined based on the following ranges, as shown in the table 2.

Table 2. Percentage of Product Feasibility Criteria

Criteria for Achievement	Validity Level
81.00% - 100.00%	Very valid, can be used without revisions
61.00% - 80.99%	Valid, but minor revisions needed
41.00% - 60.99%	Less valid, major revisions needed
21.00% - 40.99%	Invalid, cannot be used
00.00% - 20.99%	Very invalid, should not be used

Additionally, the effectiveness of the product is tested using pretest and posttest data. The gain score, which measures improvement in numeracy skills, is calculated from the difference between pretest and posttest scores. Based on the gain score, the product's effectiveness is categorized into high (≥ 0.7), medium ($0.3 \leq g \leq 0.7$), and low (< 0.3). This analysis allows for a comprehensive assessment of the product's impact on children's numeracy learning.

3. Result and Discussion

The Development of the Educational Game "Fun Mathematic Board"

The result of this research and development is a board game educational game tool. This educational game tool is specifically designed to develop the numeracy skills of children aged 5-6 years. The components of this game are developed based on the principles of active learning and the approach of playing while learning. The use of contrasting colors, interesting cartoon images, and interactive game elements aims to stimulate children's interest in learning and facilitate learning numeracy in a fun way. Here are the results of the development of some parts of the "Fun Math Board" seen in figure 2.

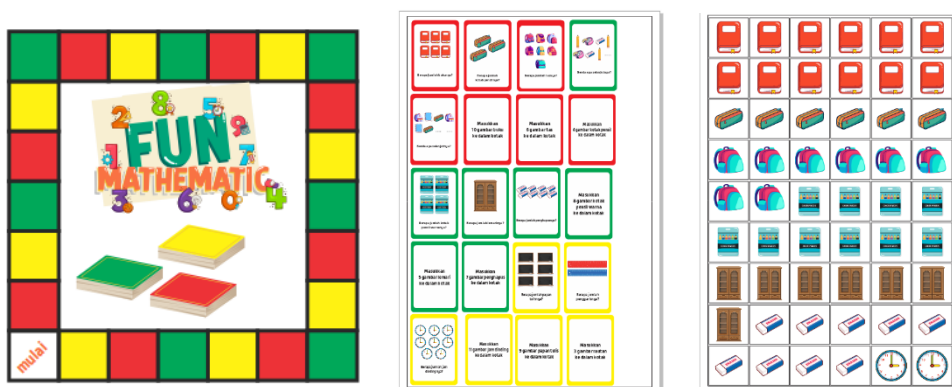


Figure 2. The result of developing some parts of the “Fun Mathematic Board”

Product Feasibility Test

Based on the results of the material expert validation, the Fun Mathematic Board educational game tool in terms of effectiveness, efficiency, and attractiveness obtained a percentage of 89.06% which was included in the very feasible category. While the results of the validation of PAUD game experts on the Fun Mathematic Board educational game tool obtained a percentage of 98.44% which was included in the very feasible category. The results of the small group test also obtained a percentage of 93.1%, so it can be concluded that the Fun Mathematic Board is suitable for use as a learning media for children aged 5-6 years. The results of the validity test are shown in table 3.

Table 3. Validity Test Result

No	Expert Validation	Result	Description
1	Material Expert Validation	89,06%	Very Valid
2	Game Expert Validation	98,44%	Very Valid
3	User validation	93,1%	Very Valid

Product Effectiveness Test

Test the effectiveness of Fun Mathematic Board educational game tools in numeracy learning for children aged 5-6 years through pre-test and post-test in small and large groups. Overall, in the large group trial at Al Azhar Islamic Kindergarten there was an increase in children's ability to learn numeracy based on numeracy development indicators between before and after the use of Fun Mathematic Board educational game tools. Children's ability to learn numeracy experienced a moderate increase after using the Fun Mathematic Board educational game tool, namely with an average gain score of 0.56. So, it can be said that the use of Fun Mathematic Board educational game tools has a moderate level of effectiveness to be used in learning numeracy for children aged 5-6 years. The results of the pre-test and post-test are shown in table 4.

Table 4. Pre-test and Post-test Result

Group	N	Pretest	Posttest	Gain
Small	8	8,25	13,42	0,68
Large	30	7,9667	12,3667	0,56

Discussion

The Development of the Educational Game "Fun Mathematic Board"

The development of the Fun Mathematic Board involved an advanced process of creating and designing an interactive board game that is suitable for play by individuals alone or in small groups. The game was developed according to developmental milestones for the age group 5-6 years in an effort to make the content cognitively appropriate. The game comprises a board with fascinating designs printed on it, challenge cards, cartoon-style graphics, and other board materials such as dice, number boards, and measuring tools. The incorporation of vibrant images and common animations was intended to capture the interest of young kids and make learning numeracy fun and fruitful. The game's design was created using Corel Draw 21 software for high-quality production. The game board was built with thick cardboard and laminated to withstand the process of repetitive use, while the cards and other materials were printed on high-quality art paper.

The Fun Mathematic Board has been rigorously tested and validated as an effort towards proving its effectiveness in learning 5-6-year-olds' numeracy. Validation results from education experts revealed that the game content scored highly at 89.06% and media design scored highly at 98.44%. User testing was conducted with children and teachers and the tool's attractiveness, effectiveness, and efficiency were gauged. User testing revealed that the product successfully delivered the desired learning outcomes as it scored 93.1% at the small group trial stage. The results show that the Fun Mathematic Board is enjoyable and yet a good early childhood numeracy learning tool.

Evidence of such similar learning tools testifies to the effectiveness of board games in supplementing early childhood education. Chen & Chi, (2022) confirmed that board games can engage young children in learning fundamental math skills such as geometry and number sense in a manner that is enjoyable. Moreover, Balladares et al., (2024) and Lange et al., (2021) provided evidence that the use of board games speeds up the process of learning early math skills among children by encouraging socialization and analytical skills. The Fun Mathematic Board took these fundamentals into consideration and created a new and interactive platform for learning numeracy and thereby adhered strictly to the best practices in early childhood education.

The Effectiveness of the "Fun Mathematic Board" as a Numeracy Learning Medium for 5–6-Year-Old Children

The effectiveness of the Fun Mathematic Board was assessed using pre-test and post-test experiments. The pre-test was conducted before the utilization of the Fun Mathematic Board and the post-test after using the board. The tests were conducted in the small-group trial phase and the large-group trial phase. During the small-group trial phase, the gain score between the pre-test and the post-test had a value of 0.68, and the large-group trial had a value of 0.56. According to Hake's criteria, this indicates that the Fun Mathematic Board depicts a moderate level of

effectiveness in improving the numeracy of the 5-6-year-olds. Even though the game has proved to be helpful, it shows that there is a need for improvement in some area for the game to become even more effective.

Other studies affirm the positive role of interactive learning materials in the development of children's numeracy. Retno Utami & Nur Inayah, (2022) explained that the employment of board games in early childhood learning fully complements the learning of fundamental math principles such as geometry and counting. This agrees with the current research that the learning of numeracy using an interactive and enjoyable approach is enhanced by the Fun Mathematic Board. More importantly, Novita et al., (2024) and Widi Astuti et al., (2023) explain that board games enhance analytical and problem-solving skills by enhancing social interactions that have an essential role in the cognitive growth of young children. These studies affirm the role of play-based learning materials such as the Fun Mathematic Board in the growth of early childhood numeracy.

Despite the positive outcomes, the moderate effectiveness level observed in the current study is evidence that potential enhancement could make the tool even more effective. It might target the blend of the material and game interactions in ways that engage a wider range of cognitive capacities and learning styles within groups with more children. However, the Fun Mathematic Board is an efficient learning instrument that not only consolidates numeracy skills but also enforces an enjoyable learning process that is supported by growing evidence of the use of board games when teaching young children.

4. Conclusion

The Fun Mathematic Board is an innovative and effective method of early childhood numeracy. Developed with clear educational goals in mind, it is designed with the intention of addressing the 5-6-year-olds' development needs and makes learning fun. The use of colors, cartoons, and interactive features is intended to keep the children captivated and interested in continued play throughout the learning process. The fact that the game is multifaceted makes it reusable over a long duration of time in the classroom as well as the home setting, hence a long-term learning process. The game also has its weaknesses. The cognitive development nature of the game is such that it restricts its use in the remainder of the children's development aspects, and the game format is such that it is best suited for small groups comprising less than 30 children. The numerous numbers of items used in the game is also subject to loss, an aspect that makes its long-term use a challenge. Despite these constraints, the Fun Mathematic Board has managed to engage children and promote their numeracy levels. The moderate effect on the development of numeracy shows potential for greater improvement such as scale up to more children as well as its transferability to other development domains. The Fun Mathematic Board is nonetheless an innovation in early childhood numeracy materials development that presents a valuable tool for parents and teachers alike in involving children in productive learning experiences.

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