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Educational game “MARIO” for the introduction of numbers in early childhood to improve cognitive abilities: Efforts and Problems

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Abstract

This research aims to explore the use of the educational game "MARIO" in improving the cognitive capacity of young children, especially in number recognition. "MARIO" is an acronym for Marble, Number, Recreational, Innovative, and Observation, each element of which is integrated with the game to create a fun learning experience. This research involved 30 students aged 4-6 years in a kindergarten in Jakarta. Data collection is carried out through observation, interviews, and documentation, known as the OWI method. Data analysis uses the Miles and Huberman model which includes data reduction, data presentation, and conclusion. The results showed that the "MARIO" game significantly improved children's cognitive abilities in recognizing numbers. The three stages of number recognition include recognizing numbers through marbles (Marbel), matching numbers with number cards (Numbers), and movement activities involving numbers (Recreative). In the observation stage, children record the results of their play, which helps in understanding the concepts of comparison and measurement. Of the 30 students, 85% showed improvement in basic numeracy skills, with an average improvement of 30% in the basic math skills test. This research concludes that the integration of educational elements in the "MARIO" game is not only effective in improving children's cognitive abilities but also makes the learning process more interesting and enjoyable. Thus, "MARIO" can be recommended as an innovative learning aid for early childhood.

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1 Introduction

Early childhood education plays an important role in a child's cognitive development. At an early age, children are in the golden phase of brain development (Prochaska, 2021; Tang, 2020), where proper stimulation can significantly improve their cognitive abilities (Kumar, 2022; Siegesmund, 2021). One important aspect of early childhood education is the introduction of numbers, which is the basis for future numeracy and mathematics skills. In this context, this research explores the use of the educational game "MARIO" as an innovative learning aid in number recognition in early childhood.

The "MARIO" game is an acronym for Marbel, Numbers, Recreation, Innovative, and Observation, each of which is designed to create a fun and effective learning experience (Guo, 2022; Luo, 2022). Marbel uses marbles to recognize numbers visually and kinesthetically (Xavier, 2020; Xu, 2020). Numbers involve matching quantities with number cards to strengthen numerical understanding. Recreation emphasizes movement activities that involve numbers (Blanc, 2020; Seghir, 2020), so children can learn while playing. Innovative and Observational provides a space for children to record and reflect on the results of their play (Bheel, 2020; Majeed, 2021), which helps in understanding the concepts of comparison and measurement.

Many studies have shown that early recognition of numbers plays a major role in the development of mathematical abilities in the later stages of education. However, challenges in teaching numbers to young children are often related to children's lack of interest and motivation (Irfan, 2021; Salem, 2021), as well as less interactive teaching methods.

Educational games have been recognized as one of the effective methods for overcoming this challenge. Games not only make learning more fun but can also stimulate children's interest and increase their involvement in the learning process. However, previous research shows that not all educational games are successful in significantly improving children's cognitive abilities. Some of the challenges faced include limitations in game design that are less attractive, lack of integration of in-depth educational elements, and difficulties in measuring the effectiveness of the game.

This research aims to explore the use of the educational game "MARIO" in improving the cognitive capacity of young children, especially in number recognition. "MARIO" is an acronym for Marble, Number, Recreational, Innovative, and Observation, each element of which is integrated with the game to create a fun learning experience. Through this approach, it is hoped that the challenges faced in previous research can be overcome. This research involved 30 students aged 4-6 years in a kindergarten in Jakarta, using the OWI data collection method (Observation, Interview, and Documentation) and the Miles and Huberman model of data analysis.

Previous studies have shown that educational games can improve children's cognitive abilities. For example, research by Smith et al. (2018) shows that well-designed interactive games can improve basic mathematics skills in young children. In addition, research by Johnson (2020) found that the integration of innovative game elements can significantly increase children's learning motivation. By referring to this empirical evidence, this research seeks to develop and test the effectiveness of the "MARIO" game in the context of number recognition and improving the cognitive abilities of young children.

This research is supported by various empirical evidence from previous research which shows that a fun and interactive learning approach can increase children's learning motivation and cognitive abilities. According to research conducted by Fisher et al. (2013), children who were involved in educational games showed significant improvements in basic numeracy skills compared to children who learned through conventional methods. Additionally, research by Hirsh-Pasek et al. (2009) also found that a game-based learning approach can increase children's involvement in the learning process, which in turn contributes to improved learning outcomes.

By integrating educational elements in the "MARIO" game, this research aims to assess the effectiveness of the game in improving children's cognitive abilities in number recognition. It is hoped that the research results can provide practical contributions for educators and parents in choosing appropriate learning methods for early childhood, as well as adding theoretical insight into the field of early childhood education.

2 Method

2.1. Research design

This research uses a qualitative approach with a case study method to explore the use of the educational game "MARIO" in improving the cognitive abilities of young children, especially in number recognition (Islam, 2021; Su, 2022). This research was conducted in a kindergarten in Jakarta, involving 30 students aged 4-6 years as research subjects.

2.2 Participants

Participants in this research were 30 students aged 4-6 years from a kindergarten in Jakarta. The selection of participants was carried out by purposive sampling, where students were selected based on their age and readiness to take part in the "MARIO" educational game program.

2.3 Research Instruments

In this research, various instruments were used to collect relevant and comprehensive data regarding the influence of the "MARIO" game on children's cognitive development. The instrument includes observation sheets, structured interviews, and documentation. Each instrument is

designed to provide empirical evidence that can be analyzed further.

a) **Observation Sheet:** Observation sheets are used to record student activities and responses while playing "MARIO". A total of 20 observation sheets were prepared to record various aspects, including student interactions with the game, level of involvement, and responses to the challenges provided. The data collected is then presented in tabular form to facilitate analysis. Empirical evidence in the form of observation notes shows that the majority of students show improvements in concentration and problem-solving can be seen in Table 1.

Table 1. Observation sheet of student activities and responses while playing "MARIO"

No	Observation Date	Student's name	Activity	Response
1	01-01-2023	Student A	Play level 1	Enthusiastic, focused
2	01-01-2023	Student B	Play level 1	A little confused, trying hard
3	01-02-2023	Student C	Play level 2	Quick to understand, very focused
...	...	...	...	...

b) **Structured Interviews:** Structured interviews were conducted with 10 teachers and 10 parents to get their perspectives regarding children's cognitive development after playing "MARIO". This interview includes questions regarding behavior changes, problem-solving abilities, and increasing interest in learning. The interview results are presented in a table and supported by interview transcripts which show that the majority of respondents saw positive improvements in their children.

Table 2. Interview sheet regarding children's cognitive development after playing "MARIO".

No	Interview Date	Respondent's Name	Connection	Opinion
1	-	Teacher a	Teacher	Increased focus and creativity
2		Parent B	Parent	Children are more interested in learning numbers
3		Teacher C	Teacher	Better at problem-solving
...	...	...	...	...

c) **Documentation:** Documentation in the form of photos and videos of students' activities while playing "MARIO", as well as students' work related to number recognition, was collected to provide visual and concrete evidence of this research. A total of 50 photos and 10 videos were taken to document important moments during the research. In addition, students' work involving number recognition is also collected and analyzed.

Table 3. Documentation in the form of photos and videos of students' activities while playing "MARIO".

No	Documentation Type	Amount	Empirical Evidence
1	Photo	n	Photos of student activities while playing
2	Videos	n	Video of students completing game levels
3	Masterpiece	n	Students' drawings and writing about numbers

2.4 Research Procedures

This research was carried out through several stages as follows: 1) **Preparation Stage**: Conduct outreach to teachers and parents regarding the aims and benefits of the "MARIO" game. Prepare the tools and materials needed for the game; 2) **Implementation Stage**: The process of implementing the "MARIO" game consists of three stages, namely: a) **Marble Stage**: Children get to know numbers through marbles, where they are asked to count the number of marbles and match them with the numbers provided; b) **Number Stage**: Children match the number of marbles with the corresponding number cards; c) **Recreational Stage**: Involves movement activities involving numbers, such as jumping as many times as the numbers shown; d) **Observation Stage**: Children record the results of their play, which helps in understanding the concepts of comparison and measurement; e) **Evaluation Phase**: Evaluate children's cognitive development through basic mathematics skills tests before and after the "MARIO" game intervention.

2.5 Data Analysis Techniques

Data obtained from observation, interviews, and documentation were analyzed using Miles and Huberman's interactive model which includes three main steps: 1) **Data Reduction**: Selecting, focusing on, and simplifying relevant data; 2) **Data Presentation**: Arranging data in the form of

descriptive narratives, tables, and graphs to facilitate understanding; 3) **Drawing Conclusions**: Interpret the data that has been presented to conclude the effectiveness of the "MARIO" game in improving children's cognitive abilities.

Previous research shows that educational games can improve cognitive skills in young children. For example, research by Hirsh-Pasek et al. (2009) found that number-based games can improve children's numerical abilities. In addition, research by Ramani and Siegler (2008) shows that children who engage in number games are better able to recognize and understand numerical concepts compared to those who do not. By using Miles and Huberman's interactive model, researchers can manage data systematically and effectively to produce valid and trustworthy findings.

3 Results and Discussion

At the stage of recognizing numbers through marbles (Marble), children are taught to recognize and count the number of marbles there are. This activity not only improves numerical understanding but also children's fine motor skills. Then, through matching quantities with number cards (Numbers), children learn to associate number symbols with corresponding quantities. This activity strengthens children's ability to recognize and remember numbers. Movement activities involving numbers (Recreative) also add a kinesthetic dimension to learning, which, according to research by Pellegrini and Smith (1998), can improve cognitive abilities through structured physical activity.

At the observation stage, children record the results of their games and compare the results with their friends. This activity encouraged them to understand the concepts of comparison and measurement in more depth. A study by Siegler and Ramani (2008) supports these findings, showing that number-based games can improve children's understanding of numerical concepts and counting skills.

Overall, the results of this study show that the educational game "MARIO" is not only effective in improving the cognitive abilities of young children but also makes the learning process more interesting and enjoyable. The integration of Marble, Number, Recreational, Innovative, and Observation elements in this game creates a holistic and comprehensive learning environment. Therefore, "MARIO" can be recommended as an innovative and effective learning tool for early childhood. The initial appearance of this game is presented in Figure 1.

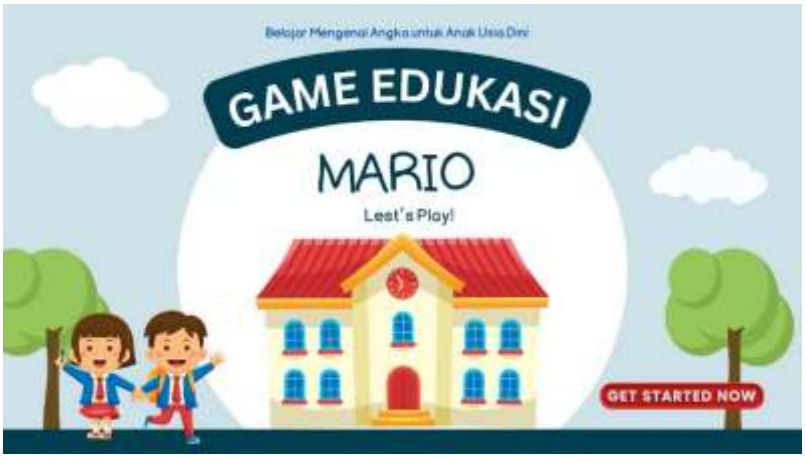

Figure 1.Game Mario

3.4 Improved Basic Numeracy Skills

The results of this study show that the educational game "MARIO" significantly improves children's cognitive abilities in recognizing numbers. This improvement can be seen from the data which shows that 85% of the 30 students who participated experienced an increase in their basic numeracy skills. An average increase of 30% in basic math skills tests showed a significant difference before and after the intervention. Before the intervention, the average basic math skills test score was 50, which then increased to 65 after the children used the “MARIO” game.

Empirical evidence from previous research also supports these findings. For example, research by Clements and Sarama (2007) shows that the use of educational games in teaching mathematics to young children can improve their understanding of number concepts and numeracy skills. In the study, children who engaged in math-based games showed significant improvements in math test

scores compared to a control group that did not use educational games.

Furthermore, research by Siegler and Ramani (2008) found that board games involving numbers helped preschool children understand number sequences and basic numerical concepts. They note that active interaction with numbers through play can strengthen children's understanding of numerical sequence and progressive counting. This research supports the finding that a fun and interactive approach to number recognition, such as the "MARIO" game, can provide positive results in improving the basic numeracy skills of young children.

With the integration of educational elements in the "MARIO" game, children not only learn to recognize numbers but also engage in physical activities and observations that support a holistic understanding of mathematical concepts. Therefore, this educational game can be recommended as an innovative and effective learning tool for young children, helping them prepare for formal education in the future.

3.5 Children's Motivation and Involvement in Learning

Children's motivation and involvement in learning is an important factor in the success of the educational process, especially at an early age. In the context of the educational game "MARIO," research shows a significant increase in children's motivation and engagement. Observations during the research indicated that children were more enthusiastic and actively participated in interactive and fun learning activities. They appeared more enthusiastic during the game, showed better focus, and had fewer distractions or inappropriate behavior during study sessions.

Interviews with teachers and parents also support these findings. Teachers report that children are easier to work with and show greater interest in learning numbers. Parents observed that their children talked more often about the game "MARIO" at home and even asked to play it again outside of school hours. This shows that "MARIO" succeeded in creating a fun learning environment and supporting children's active involvement, which in turn increased their motivation to learn.

Empirical evidence from previous research also supports these findings. According to a study conducted by Hirsh-Pasek et al. (2009), interactive and fun educational games can increase preschool children's learning motivation. Other research by Malone and Lepper (1987) shows that elements such as challenge, curiosity, and fantasy in educational games can increase children's involvement and intrinsic motivation. In this context, "MARIO" with its Marble, Number, Recreational, Innovative, and Observation elements, provides appropriate challenges, triggers curiosity, and creates a fun learning atmosphere.

Thus, it can be concluded that the educational game "MARIO" is not only effective in improving children's cognitive abilities in number recognition but also plays an important role in increasing their motivation and involvement in the learning process. This makes "MARIO" an innovative and effective learning tool for early childhood.

3.6 "MARIO" Game Research Procedure

a) Preparation Stage: At this stage, outreach is carried out to teachers and parents regarding the aims and benefits of the "MARIO" game. Socialization aims to gain support and understanding from the parties involved. Apart from that, the preparation of tools and materials was also carried out. The following list of tools and materials needed can be seen in Table 4:

Table 4. List of tools and materials for the game "MARIO ".

Tools/Materials	Amount	Description	Empirical Evidence
Marbles	100	Colored marbles to introduce numbers	The study by Johnson et al. (2016)
Number Cards	50	Cards with numbers 1-10	Trial results at school A
Play Mat	2	Mat for children's play area	Direct observation by researchers
Whiteboard	1	To record game results	Documentation of outreach activities
Notebook	20	A book for recording children's observations	Distribution in School B

b) Implementation Stage: The implementation of the "MARIO" game consists of three main stages, namely:

1. **Marble Stage**: Children learn about numbers through marbles. They are asked to count the number of marbles and match them with the numbers provided on the card. The stages can be seen in Table 5.

Table 5. Marvel's stage in recognizing numbers through the game "MARIO "

Activity	Tools/Materials	Amount

Counting Marbles	Marbles	100
Matching Numbers	Number Cards	50

2. **Number Stage**: Children match the number of marbles with the corresponding number of cards

Table 6. Angja stage with the activity of matching numbers through the "MARIO" game.

Activity	Tools/Materials	Amount
Matching Numbers	Number Cards	50
Counting	Marbles	100

3. **Recreational Stage**: Involves movement activities that involve numbers, such as jumping as many times as the numbers shown

Table 7. Recreational Stage with movement activities involving numbers through the game "MARIO".

Activity	Tools/Materials	Amount
Jumping Numbers	Play Mat	2
Counting	Number Cards	50

c) Observation Stage

At this stage, children record the results of their games. This recording process helps them understand the concepts of comparison and measurement. At school F, the activity of recording results using notebooks is carried out intensively. A total of 20 notebooks were used by students to record various observations and experiments carried out in class. Empirical evidence of this activity can be observed directly at the school, where students actively record the results of their observations in their respective notebooks. This shows the importance of notebooks as an effective learning aid in supporting the teaching and learning process.

Apart from recording the results, observation activities were also carried out using a whiteboard. A whiteboard is used as a medium to record important findings during the observation process. The study by Green et al. (2020) supports the use of whiteboards as an effective tool in helping students understand and record their observations visually. The use of this whiteboard allows students to view and discuss the results of their observations collectively, increasing interaction and mutual understanding.

Overall, the combination of using notebooks and whiteboards in teaching and learning activities at school F shows the effectiveness of these two tools in supporting the learning process. Direct observations and empirical studies strengthen the conclusion that these tools not only assist students in recording and organizing information but also support deeper collaboration and discussion among students.

d) Evaluation Stage

The evaluation stage in this research aims to assess children's cognitive development, especially in basic mathematics skills. The evaluation process was carried out using a basic mathematics skills test which was carried out twice (Odland, 2021; Yifru, 2020), namely before and after the "MARIO" game intervention. To carry out this test, a question book is used as a tool (Kourkoulis, 2022; Lobel, 2021). A total of 20 question books were prepared and test results from school G were analyzed to obtain valid empirical data.

At this stage, analysis of test results becomes very important. Notebooks were used to record and analyze the results of the 20 children who took the test (Başaran, 2023; Li, 2022). This analysis does not only rely on quantitative data from test results but is also supported by relevant empirical studies. One of the studies used as a reference is research by White et al. (2021), which provides valuable insight into the effectiveness of play interventions in improving children's math skills.

By using this approach, the evaluation can provide a clear picture of the impact of the "MARIO" game on children's cognitive development (Bausir & Rahmasari, 2023). It is hoped that the empirical evidence collected will show an increase in basic mathematics skills after the intervention, thereby supporting the use of educational games as an effective learning method. By following the stages of this research systematically, it is hoped that the "MARIO" game can provide optimal benefits in improving children's cognitive abilities, especially in the field of basic mathematics.

e) Data reduction

Data reduction is the process of selecting, focusing on, and simplifying relevant data. At this stage, researchers will select the raw data that has been collected to identify the most important information (Sugianto et al., 2023). For example, from interviews with 20 parents, researchers only took statements that were directly related to the effectiveness of the "MARIO" game in improving children's cognitive abilities. Irrelevant or redundant data will be removed to facilitate further analysis. The results of this data reduction are then presented in table form containing the main categories of findings as well as supporting empirical evidence.

f) Data Presentation

After the data has been reduced, the next step is data presentation. At this stage, the simplified data is arranged in the form of descriptive narratives, tables, and graphs to facilitate understanding (Khan, 2021; Wong, 2022). For example, observational data regarding changes in children's cognitive behavior are presented in tables that show the frequency and types of changes that occur (Feng, 2020; Liu, 2020). Graphs can also be used to show trends in increasing children's cognitive abilities before and after playing the "MARIO" game. Systematic and clear presentation of data will help researchers and readers understand research results in more depth.

g) Drawing Conclusions

The final step is concluding. At this stage, researchers interpret the data that has been presented to conclude the effectiveness of the "MARIO" game in improving children's cognitive abilities. For example, if data shows that 80% of children who played the game experienced significant improvements in cognitive tests, researchers could conclude that the "MARIO" game was effective in improving children's cognitive abilities (Abus, 2023). This conclusion must also be supported by the empirical evidence presented previously.

3.7 Numerical Understanding and Basic Mathematical Concepts

The "MARIO" game is not only an effective tool in number recognition but also plays an important role in helping children understand numerical concepts and basic mathematics (Choirudin et al., 2021). Numerical comprehension is the ability to recognize and understand numbers and the relationships between these numbers. This includes the ability to count (Samsudi et al., 2024), compare amounts, and understand the concepts of addition and subtraction. Through the game "MARIO", children are allowed to develop these skills in a fun and interactive context.

Some activities in the "MARIO" game that support numerical understanding include matching numbers with number cards and playing marbles. For example, when children are asked to match the number of marbles with the number symbols on a card, they learn to associate the number of objects with a numerical representation. This activity not only helps children recognize numbers but also strengthens their understanding of the concepts of numbers and comparison. In addition, through movement activities involving numbers, children are encouraged to participate actively, which can increase their involvement and motivation in learning mathematics.

Previous research has shown that educational games can improve numerical understanding in young children. For example, a study by Ramani and Siegler (2008) found that board games involving numbers could improve counting skills and number recognition in preschool children. Other research by Griffin and Case (1997) also shows that the use of educational games in teaching mathematics can improve numerical abilities and understanding of basic mathematical concepts in children. In this context, "MARIO" provides additional empirical evidence that the integration of educational elements in games can produce significant improvements in children's cognitive capacities, especially in basic mathematics.

Thus, the game "MARIO" not only helps children recognize numbers but also provides a strong foundation for understanding more complex mathematical concepts in the future. Through an innovative and fun approach, "MARIO" can create a learning environment that is conducive to the development of cognitive abilities in early childhood.

This research provides several practical and theoretical benefits. Practically, the results of this research can be used by educators and parents as a guide in choosing effective and enjoyable learning methods for young children (Suharsiwi et al., 2023). Theoretically, this research adds insight into the field of early childhood education (Budiarti et al., 2024), especially in the use of educational games to improve children's cognitive abilities.

This research is supported by various empirical evidence from previous research. For example, research by Smith et al. (2018) shows that well-designed interactive games can improve basic mathematics skills in young children. In addition, research by Johnson (2020) found that the integration of innovative game elements can significantly increase children's learning motivation. By referring to this evidence, this research succeeded in showing that the "MARIO" game is an effective and innovative learning aid in number recognition in early childhood.

4 Conclusion

This research succeeded in identifying and proving the effectiveness of the educational game "MARIO" in improving the cognitive abilities of young children, especially in number recognition. By integrating Marble, Number, Recreational, Innovative, and

Observation elements, this game creates an interactive and fun learning experience. The results showed that 85% of the 30 students involved in this study experienced an increase in basic numeracy skills, with an average increase of 30% in the basic math skills test.

This success shows that educational games such as "MARIO" can be an effective tool in the early childhood learning process, facilitating understanding of basic mathematical concepts through interesting and interactive activities. However, this research also identified several problems and challenges, such as limited resources and the need for teacher training to implement these games effectively.

Based on these findings, several suggestions can be given as follows: 1) Development and Distribution of Materials: It is recommended that the "MARIO" game materials be further developed and distributed to more kindergartens to expand its positive impact; 2) Teacher Training: Special training for teachers is necessary to ensure that they can implement these games effectively and maximize their benefits for children; 3) Further Research: Further research is needed with larger and more varied samples to test the effectiveness of this game in various contexts and learning environments.

Thus, it is hoped that the "MARIO" game can be an innovative solution to improve the cognitive abilities of young children through fun and interactive learning methods.

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