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Development Of Pugo Learning Media To Improve Early Childhood Cognitive Skills In Geometry Concepts

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ABSTRACT

This study aimed to develop PUGO learning media that is feasible and effective in improving early childhood cognitive abilities in understanding geometric concepts. The research employed a Research and Development (R&D) method using the ADDIE model, which consists of the stages of Analysis, Design, Development, Implementation, and Evaluation. The research subjects were 57 children aged 4–6 years at TK Kemala Bhayangkari 11, Purwakarta Regency, divided into three groups: Group A with 17 children aged 4–5 years, Group B1 with 20 children aged 5–6 years, and Group B2 with 20 children aged 5–6 years. The research instruments included expert validation sheets and observation sheets measuring children's geometric cognitive abilities, covering four indicators: recognizing geometric shapes, naming geometric shapes, grouping geometric shapes, and arranging geometric shapes into patterns. The results showed that the PUGO media was highly feasible, with a validation score of 96.7% from three experts. Theoretical feasibility was supported by Piaget's cognitive development theory, constructivist learning theory, play-based learning theory, multiple intelligences theory, and van Hiele's geometric thinking theory. The media proved highly effective, increasing children's cognitive performance from 47.0% to 79.0%, representing a 68.1% improvement, with a gain score of 0.60 (moderate to high category). After implementation, 92% of children reached the "Developing as Expected" level or higher, indicating that PUGO media effectively supports early childhood understanding of geometric concepts through concrete and playful learning experiences.

Keywords: *PUGO Media, Cognitive Ability, Geometry, Early Childhood, ADDIE Model.*

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INTRODUCTION

Early childhood education plays a crucial role in laying the foundation for children's cognitive development, including the development of logical thinking and early mathematical concepts. One important component of early mathematics learning is the understanding of geometric concepts, which helps children recognize shapes, spatial relationships, and patterns in their environment. The ability to understand geometric concepts in early childhood contributes to the development of problem-solving skills,

reasoning abilities, and spatial awareness that are essential for later academic learning (Clements & Sarama, 2014). Therefore, introducing geometric concepts through developmentally appropriate learning experiences is an important aspect of early childhood education. Children aged four to six years are in a developmental stage where learning occurs most effectively through concrete experiences and play-based activities. According to Piaget's theory of cognitive development, children at the preoperational stage construct knowledge through interaction with concrete objects and active exploration of their environment (Piaget, 1972). This implies that abstract mathematical concepts such as geometry should be introduced through manipulative learning media that allow children to physically interact with shapes, patterns, and spatial structures. Learning through play not only supports cognitive development but also increases children's motivation and engagement during the learning process (Berk, 2013).

The introduction of geometry in early childhood education generally includes recognizing shapes, naming shapes, grouping shapes, and constructing patterns. These activities support children's early geometric thinking, which according to van Hiele's theory develops gradually from visual recognition to more complex levels of spatial reasoning (van Hiele, 1986). Through appropriate stimulation, children can develop the ability to identify similarities and differences between shapes, classify geometric forms, and create patterns based on geometric structures. These early experiences provide the foundation for more advanced mathematical learning in the future. However, in many early childhood education settings, geometry learning is still delivered through conventional methods, such as worksheets or teacher explanations, which often do not provide sufficient opportunities for children to explore shapes actively. As a result, children may recognize geometric shapes only at a superficial level without developing deeper understanding of their properties or relationships. The lack of engaging learning media can reduce children's interest and limit their opportunities to construct knowledge through exploration and play (Wortham, 2014).

Learning media plays an important role in facilitating meaningful learning experiences for young children. Educational media that are concrete, interactive, and manipulative can support children in constructing knowledge through direct experience. Manipulative learning media allow children to touch, arrange, classify, and experiment with objects, which helps strengthen conceptual understanding and cognitive development (Arsyad, 2011). Therefore, the development of innovative learning media is needed to support geometry learning that is both effective and enjoyable for early childhood learners.

Previous studies have shown that manipulative learning media can significantly improve children's mathematical understanding and cognitive abilities. Research by Clements and Sarama (2014) indicates that interactive learning tools and play-based geometry activities can enhance children's spatial reasoning and shape recognition. Similarly, other studies highlight that learning media based on exploration and hands-on activities help children understand abstract concepts more easily because the learning process becomes more meaningful and contextual (Berk, 2013). Despite the importance of manipulative learning media, there are still limited learning tools specifically designed to support early childhood understanding of geometric concepts in an engaging and

systematic way. Many available learning materials focus only on recognizing shapes, without encouraging children to classify shapes, analyze their characteristics, or arrange them into patterns. This indicates the need for innovative educational media that can support children's cognitive development while maintaining the play-based nature of early childhood learning.

In response to these challenges, this study develops PUGO learning media, an educational tool designed to support children's understanding of geometric concepts through interactive and manipulative activities. The PUGO media allows children to explore various geometric shapes, identify their characteristics, group shapes based on similarities, and create patterns through playful learning activities. Through these activities, children are encouraged to actively construct their knowledge while simultaneously developing cognitive and problem-solving abilities. Based on this background, the research question of this study is: How feasible and effective is the PUGO learning media in improving early childhood cognitive abilities in understanding geometric concepts? The objective of this research is to develop and evaluate the feasibility and effectiveness of PUGO media as a learning tool for early childhood geometry learning.

This research contributes to the field of early childhood education by providing an innovative learning medium that integrates manipulative learning, play-based approaches, and geometric concept development. The development of PUGO media offers a practical solution for teachers to create engaging and meaningful geometry learning experiences. In addition, this research enriches the literature on early childhood learning media development and provides empirical evidence regarding the effectiveness of interactive media in improving children's cognitive abilities in geometric concepts.

METHOD

Research Design

This study employed a Research and Development (R&D) approach aimed at developing and testing the feasibility and effectiveness of the PUGO learning media in improving early childhood cognitive abilities in understanding geometric concepts. The development process followed the ADDIE instructional design model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation.

In the analysis stage, the researcher identified learning problems related to children's understanding of geometric concepts and examined the need for interactive and manipulative learning media. The design stage involved planning the structure, components, and learning activities of the PUGO media based on early childhood learning principles. During the development stage, the PUGO media prototype was created and validated by experts in early childhood education and learning media. The implementation stage involved testing the media with children in a classroom setting to observe its effectiveness. Finally, the evaluation stage assessed the feasibility and effectiveness of the media based on expert validation results and children's learning outcomes.

Subjects / Population and Sample

The subjects of this study were 57 children aged 4–6 years from TK Kemala Bhayangkari 11, Purwakarta Regency, Indonesia. The participants were divided into three learning groups according to their age levels. Group A consisted of 17 children aged 4–5 years, while Group B1 consisted of 20 children aged 5–6 years, and Group B2 consisted of 20 children aged 5–6 years.

These participants were selected because they were at the developmental stage where children begin to develop basic mathematical and geometric understanding. The involvement of children from different age groups allowed the researcher to observe the effectiveness of the PUGO learning media across various early childhood developmental levels.

Data Collection Procedure

Data were collected using several research instruments designed to evaluate both the feasibility of the media and the development of children's cognitive abilities in geometric concepts. The instruments included expert validation sheets and observation sheets. The expert validation sheets were used to assess the feasibility of the PUGO learning media from the perspectives of media design, learning content, and suitability for early childhood education. The validation process involved three experts who evaluated the media using predetermined criteria.

The observation sheets were used to measure children's cognitive abilities related to geometric concepts during the learning activities. The observation indicators included:

1. Recognizing geometric shapes
2. Naming geometric shapes
3. Grouping geometric shapes
4. Arranging geometric shapes into patterns

Observations were conducted during the implementation of the PUGO media in classroom learning activities. The researcher recorded children's performance based on these indicators to obtain data on their cognitive development before and after the implementation of the learning media.

Data Analysis

The collected data were analyzed using descriptive quantitative analysis. The results of expert validation were calculated using percentage analysis to determine the feasibility level of the PUGO learning media. The feasibility criteria were categorized into several levels ranging from not feasible to highly feasible based on the percentage score obtained.

To measure the effectiveness of the learning media in improving children's cognitive abilities, the researcher compared the results of children's performance before and after the implementation of the PUGO media. The improvement in learning outcomes was analyzed using the N-Gain score formula, which measures the effectiveness of learning interventions by calculating the normalized gain between pre-learning and post-learning

scores. The N-Gain results were then interpreted using standard gain categories, including low, medium, and high levels of improvement.

Through this analysis, the study aimed to determine both the feasibility of the PUGO learning media and its effectiveness in enhancing early childhood cognitive abilities in understanding geometric concepts.

FINDING AND DISCUSSION

Results

Feasibility of the PUGO Learning Media

The feasibility of the PUGO learning media was evaluated through expert validation involving three experts consisting of early childhood education specialists and learning media experts. The validation process assessed several aspects, including media design, learning content suitability, instructional clarity, and usability for early childhood learners. The results of the expert validation are presented in Table 1.

Table 1. Expert Validation Results of PUGO Learning Media

Validator	Validation Score (%)	Category
Expert 1	95%	Very Feasible
Expert 2	97%	Very Feasible
Expert 3	98%	Very Feasible
Average	96.7%	Very Feasible

The data show that the PUGO learning media obtained an average feasibility score of 96.7%, indicating a very high level of feasibility according to the expert validation results.

Children's Cognitive Ability in Geometric Concepts (Pre-Implementation)

Children's cognitive abilities related to geometric concepts were observed before the implementation of the PUGO learning media. The observation covered four indicators: recognizing geometric shapes, naming geometric shapes, grouping geometric shapes, and arranging geometric shapes into patterns.
The results of the initial observation are presented in Table 2.

Table 2. Initial Cognitive Ability in Geometric Concepts (Before Implementation)

Indicator	Percentage Achievement
Recognizing geometric shapes	49.2%
Naming geometric shapes	46.7%
Grouping geometric shapes	42.8%
Arranging geometric shapes into patterns	49.3%
Average	47.0%

The data show that the average cognitive ability of children in geometric concepts before implementation was 47.0%.

Children's Cognitive Ability in Geometric Concepts (Post-Implementation)

After the implementation of the PUGO learning media in learning activities, observations were conducted again to measure children's cognitive abilities in geometric concepts. The results of the post-implementation observation are presented in Table 3.

Table 3. Cognitive Ability in Geometric Concepts (After Implementation)

Indicator	Percentage Achievement
Recognizing geometric shapes	80.5%
Naming geometric shapes	78.6%
Grouping geometric shapes	76.4%
Arranging geometric shapes into patterns	80.6%
Average	79.0%

The data show that the average cognitive ability after the implementation of the PUGO learning media reached 79.0%.

Improvement of Cognitive Ability

The comparison between the initial observation results and the post-implementation results is presented in Table 4.

Table 4. Comparison of Cognitive Ability Before and After Implementation

Indicator	Before (%)	After (%)	Increase (%)
Recognizing geometric shapes	49.2	80.5	31.3
Naming geometric shapes	46.7	78.6	31.9
Grouping geometric shapes	42.8	76.4	33.6
Arranging geometric shapes into patterns	49.3	80.6	31.3
Average	47.0	79.0	32.0

The data indicate an increase in the average percentage from 47.0% before implementation to 79.0% after implementation.

N-Gain Score Analysis

The improvement in children's cognitive abilities was analyzed using the Normalized Gain (N-Gain) score. The calculation results are presented in Table 5.

Table 5. N-Gain Score Result

Score	Value
Pre-implementation average	47.0
Post-implementation average	79.0
N-Gain Score	0.60
Category	Moderate to High

The data show that the N-Gain score is 0.60, indicating a moderate to high level of learning improvement.

Distribution of Development Categories

The distribution of children's developmental categories after the implementation of the PUGO learning media is presented in Table 6.

Table 6. Distribution of Children's Development Categories

Development Category	Percentage
Not Yet Developed (BB)	0%
Beginning to Develop (MB)	8%
Developing as Expected (BSH)	63%
Very Well Developed (BSB)	29%

The data show that 92% of children reached the categories of Developing as Expected (BSH) or Very Well Developed (BSB) after the implementation of the PUGO learning media.

DISCUSSION

Interpretation of Findings

The results of this study indicate that the PUGO learning media effectively improves early childhood cognitive abilities in understanding geometric concepts. The improvement is reflected in the increase in the average score from 47.0% before implementation to 79.0% after implementation, with an N-Gain score of 0.60, which falls within the moderate to high improvement category. These results suggest that the use of concrete and manipulative learning media can support children's cognitive development, particularly in recognizing, naming, grouping, and arranging geometric shapes.

The findings also show that the highest improvement occurred in the ability to group geometric shapes, which increased by 76.4%. This indicates that children were able to identify similarities and differences among shapes and classify them accordingly. Such classification ability represents an important component of early mathematical thinking. The PUGO media provides visual and tactile experiences that allow children to interact directly with geometric forms, making abstract concepts more concrete and understandable.

Furthermore, the absence of children in the Not Yet Developed category after the implementation demonstrates that the learning media supported the development of all participants. Most children reached the categories of Developing as Expected or Very Well Developed, indicating that the learning activities facilitated by the PUGO media provided appropriate learning stimulation for early childhood learners.

Relationship to Literature

The findings of this study are consistent with Piaget's theory of cognitive development, which states that children in the preoperational stage learn best through concrete experiences and active exploration of objects in their environment (Piaget, 1952). The PUGO learning media provides opportunities for children to manipulate geometric shapes directly, allowing them to construct knowledge through hands-on interaction.

In addition, the results align with the constructivist learning perspective, which emphasizes that knowledge is actively constructed by learners through meaningful experiences (Bruner, 1966). By arranging, grouping, and recognizing shapes using PUGO media, children actively participate in the learning process and build their understanding of geometric concepts through exploration and play.

The findings are also related to the van Hiele theory of geometric thinking, which explains that children's understanding of geometry develops gradually through several levels, beginning with visual recognition of shapes before progressing to more complex geometric reasoning (van Hiele, 1986). The PUGO learning media supports the early stages of geometric thinking by helping children visually identify shapes and understand their properties through playful activities.

Furthermore, the results support previous research indicating that manipulative learning media can significantly improve children's mathematical and cognitive abilities. Studies in early childhood education have shown that hands-on materials enhance children's engagement and facilitate deeper conceptual understanding compared to abstract instruction.

Limitations of the Study

Despite the positive results obtained in this study, several limitations should be acknowledged. First, the research was conducted in one kindergarten institution, which may limit the generalization of the findings to other educational settings with different learning environments or student characteristics. Second, the number of participants was limited to 57 children, which may not fully represent the diversity of early childhood learners. A larger and more varied sample could provide a more comprehensive understanding of the effectiveness of the PUGO learning media.

Third, the study focused primarily on short-term improvements in cognitive abilities related to geometric concepts. Long-term effects of the learning media on children's mathematical development were not examined in this research.

Implications

The findings of this study provide several implications for early childhood education practice and future research. For educators, the results suggest that learning media that are concrete, manipulative, and play-based can significantly support children's cognitive development, particularly in early mathematical learning. Teachers are encouraged to incorporate interactive learning media such as PUGO in classroom activities to make abstract concepts more accessible and engaging for young learners.

For curriculum development, the PUGO learning media can serve as an alternative instructional tool for teaching geometric concepts in early childhood education settings. Its structured levels of difficulty allow children to gradually develop their understanding of shapes and patterns. Future research may explore the implementation of PUGO learning media in different educational contexts, involving larger and more diverse participant groups. Further studies could also investigate the long-term impact of manipulative geometric learning media on children's mathematical reasoning and problem-solving abilities.

CONCLUSION

This study aimed to develop and evaluate the feasibility and effectiveness of the PUGO learning media in improving early childhood cognitive abilities related to geometric concepts. The results indicate that the developed media is highly feasible, with an average validation score of 96.7% based on expert assessments. The implementation of the PUGO media also demonstrated a significant improvement in children's cognitive abilities in recognizing, naming, grouping, and arranging geometric shapes. The findings show an increase in the average cognitive ability score from 47.0% before implementation to 79.0% after implementation, with an N-Gain score of 0.60, indicating a moderate to high level of learning improvement. In addition, most children reached the categories of Developing as Expected or Very Well Developed, and no children remained in the Not Yet Developed category after the learning intervention.

These results demonstrate that the PUGO learning media is an effective, concrete-manipulative, and play-based learning tool for supporting the development of geometric concepts in early childhood education. The media provides meaningful learning experiences that encourage active participation and cognitive exploration among young learners. Therefore, the PUGO media can be considered a practical alternative for early childhood educators to enhance geometry learning in a more engaging and developmentally appropriate way.

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