



Enhancing Early Childhood Recognition of Three-Dimensional Shapes Through Augmented Reality Media Using the Assemblr Edu Application

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Abstract

This study aims to determine the effectiveness of using Augmented Reality (AR)-based media through the *Assemblr Edu application* in improving the recognition of three-dimensional shapes among early childhood learners. The research method employed was Classroom Action Research (CAR) using the Kemmis & McTaggart model, consisting of pre-cycle, cycle I, and cycle II. The research subjects were 20 children in group A (ages 4–5 years) at TK Sahabat Bekasi. The research instruments included a Lesson Plan, observation sheets, and interviews. The results showed an improvement in children's understanding of three-dimensional shapes. In the pre-cycle stage, the average achievement was only 20.77%, which increased to 42.85% in cycle I, and reached 87.00% in cycle II, exceeding the success criterion of >80%. These findings demonstrate that the use of AR through the *Assemblr Edu application* can effectively enhance early childhood learners' understanding of three-dimensional shapes in a more interactive and enjoyable way.

Keywords: Three-Dimensional Shapes, Early Childhood, Augmented Reality, Learning Media

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INTRODUCTION

Early Childhood Education (ECE) plays a pivotal role in shaping the foundation of children's development. During the golden age (0–6 years), appropriate stimulation significantly influences all domains of development, particularly cognition, which serves as the basis for higher-order thinking. This developmental stage occurs only once in a lifetime, making it a critical period that must be optimized to ensure that children grow holistically (Kemendikbud, 2020). Ali (2022) highlights that young children are naturally curious, imaginative, and enthusiastic explorers of their environment, yet they are also easily distracted and prone to boredom. For this reason, learning activities must be designed to match their characteristics, ensuring that the learning process is both effective and engaging.

One essential aspect of cognitive development in early childhood is the understanding of geometry, particularly three-dimensional (3D) objects. Mastery of geometric concepts provides a strong foundation for logical reasoning, spatial awareness, and problem-solving abilities. Clements and Sarama (2011) emphasize that early exposure to geometric thinking helps children develop essential skills needed for mathematics and science learning.

However, evidence shows that preschoolers' understanding of geometry remains limited due to the constraints of conventional teaching media, which often rely on static illustrations or physical objects that do not fully capture children's imagination (Mammarella, Giofrè, & Caviola, 2017). Uswatun and Rizki Surya (2023) further note that teachers' limited use of diverse and creative media contributes to the low achievement of geometry-related indicators in ECE.

Geometry instruction is an important component of the ECE curriculum, as stipulated in national education standards (Permendikbud No.137, 2014). Children are expected to recognize and differentiate shapes through experiential and playful learning. Yet, the implementation of this standard is still minimal in practice. Research by Clements and Sarama (2011) found that only 16% of kindergarten mathematics activities involve geometric concepts, indicating a significant gap between curriculum expectations and classroom practices. This situation highlights the urgent need for innovative learning approaches that can bridge the gap and support children's geometric understanding.

The rapid advancement of technology offers new opportunities for addressing these challenges, with Augmented Reality (AR) emerging as one of the most promising solutions. AR technology integrates real-world settings with virtual three-dimensional objects, enabling learners to interact with digital content in a realistic context (Rahmania et al., 2022; Ibáñez & Delgado-Kloos, 2020). By combining virtual elements with the tangible environment, AR transforms abstract concepts into concrete experiences, making it easier for young learners to grasp complex ideas. Kurniawan et al. (2019) demonstrate that AR not only enhances visualization but also encourages active engagement, which is essential for early childhood learning.

Several advantages make AR particularly suitable for ECE settings. Khan, Johnston, and Ophoff (2019) argue that AR provides access to objects that are otherwise difficult to visualize, thus offering richer learning experiences. Moreover, Salsabila (2020) points out that AR fosters motivation, as children find interactive media more enjoyable compared to traditional methods. In addition, AR accommodates different learning styles—visual, auditory, and kinesthetic—allowing children with diverse preferences to engage meaningfully (Fifi Arisanti et al., 2024; Yilmaz, 2021). Collectively, these findings underscore the transformative potential of AR in early childhood classrooms.

Despite the promising prospects, studies on AR integration in Indonesian ECE remain scarce. Some researchers have explored alternative media to enhance geometry learning, such as the use of tangram puzzles to develop spatial skills (Elizabeth Wahyu MI et al., 2023) and traditional Konjo cakes to introduce geometric forms (Khaerun Nisa & Hanifah, 2022). While these approaches show positive outcomes, they lack the immersive and interactive features provided by AR. Hence, research specifically investigating AR as a medium for introducing 3D shapes to young learners is still limited (Kucuk et al., 2022).

Assemblr Edu, an AR-based application, emerges as a practical solution to these challenges. Designed for educational purposes, *Assemblr Edu* allows teachers and students to access and manipulate a wide variety of three-dimensional models, including geometric shapes, directly through smartphones or tablets. Rahmania et al. (2022) found that *Assemblr Edu* is feasible, effective, and engaging as a learning tool. Its accessibility and user-friendliness make it a valuable resource for teachers who seek to innovate their teaching practices while addressing the needs of digital-native learners (Santos et al., 2021).

This study is therefore designed to answer two key research questions: (1) Can the recognition of three-dimensional shapes among early childhood learners be improved through AR media using the *Assemblr Edu application*? and (2) How does the learning process unfold when AR media is integrated into geometry lessons? These questions aim to evaluate both the effectiveness of AR-based media and the dynamics of its implementation in classroom settings.

The primary objective of the research is to analyze the effectiveness of AR in improving children's recognition of 3D shapes and to describe the learning processes that accompany its use. In doing so, this study seeks to generate empirical evidence that will enrich theoretical insights while offering practical recommendations for ECE practitioners. By focusing on the integration of *Assemblr Edu*, the study highlights how digital innovation can be harmonized with pedagogical goals.

From a theoretical perspective, the study contributes to the growing body of literature on educational technology in early childhood learning. While previous works, such as Faila and Tri (2023), focused on the development of instruments to measure mathematical thinking, few studies have directly applied AR to improve geometry learning outcomes. This research, therefore, fills an important gap by providing evidence on the potential of AR to enhance young children's comprehension of abstract concepts (Ibáñez & Delgado-Kloos, 2020).

Practically, the study offers significant implications for teachers, schools, and policymakers. Teachers may adopt AR as an alternative medium to make geometry learning more interactive and concrete. Schools can support this initiative by investing in technology infrastructure and training programs, ensuring that teachers are equipped with the necessary skills to integrate AR effectively (Tri & Natsir, 2022). On a broader scale, the research supports government initiatives that encourage the use of digital learning tools to promote 21st-century competencies (Kemendikbud, 2020).

In addition, the integration of AR into early childhood classrooms resonates with well-established learning theories. Piaget's theory of cognitive development emphasizes the need for concrete experiences during the preoperational stage, when children rely heavily on sensory and physical interactions to construct knowledge (Piaget in Susanto, 2017). Similarly, Vygotsky's scaffolding concept suggests that guided assistance from teachers can help children grasp new concepts within their zone of proximal development (Brewer, 2007). By enabling interactive and guided exploration, AR aligns seamlessly with these theoretical frameworks.

Taken together, these perspectives demonstrate that the use of AR, particularly through *Assemblr Edu*, represents a powerful pedagogical innovation in ECE. It combines the benefits of technological advancement with child-centered learning approaches, creating opportunities for more meaningful educational experiences (Yilmaz, 2021; Kucuk et al., 2022). Therefore, this research aims to bridge the gap between curriculum expectations, classroom practices, and the potential of digital technologies in early childhood learning.

Overall, the study not only evaluates the effectiveness of AR in improving children's recognition of 3D shapes but also provides insights into how technology can be integrated into pedagogical practices in ways that are developmentally appropriate, interactive, and engaging. The findings are expected to contribute both theoretically and practically, guiding future research and informing best practices for educators and policymakers alike (Rauschnabel et al., 2022).

METHOD

This study employed a Classroom Action Research (CAR) method using the Kemmis and McTaggart model, which consists of four stages: planning, action, observation, and reflection (Kemmis & McTaggart, 1988). CAR was chosen because it provides opportunities for systematic and continuous improvements in teaching practices. Through this model, teachers and researchers can collaborate in identifying problems, implementing solutions, and evaluating learning outcomes. In this study, CAR was applied to enhance early childhood recognition of three-dimensional shapes through Augmented Reality (AR) media using the *Assemblr Edu* application.

The research subjects were 20 children from group A at TK Sahabat Bekasi, aged between 4–5 years. This age group was selected because children at the preoperational stage, according to Piaget's theory, require concrete experiences to understand abstract concepts (Piaget in Susanto, 2017). The AR-based *Assemblr Edu application* was considered suitable for stimulating their cognitive abilities, particularly in geometry recognition. The research was conducted in three phases: the pre-cycle, cycle I, and cycle II, allowing the researcher to compare children's progress over time and evaluate the effectiveness of the intervention (Creswell, 2018).

The research instruments included: (1) Lesson Plans (RPP) as a guideline for implementing the learning activities; (2) observation sheets to record children's behaviors and achievements during the lessons; (3) teacher interview guidelines to obtain qualitative insights on the learning process; and (4) achievement indicators for children's ability to recognize 3D shapes such as cubes, blocks, spheres, and pyramids. These instruments were designed to provide comprehensive data that combined both quantitative and qualitative aspects (Arikunto, 2019; Faila & Tri, 2023).

Data collection was conducted through participatory observation and documentation. Participatory observation allowed the researcher to be directly involved in the classroom, recording children's engagement and responses throughout the activities. Documentation included photos, videos, and field notes that served as supporting evidence. Additionally, interviews with the class teacher were conducted to gain a deeper understanding of the challenges and strategies in implementing AR-based learning. The triangulation of observation, documentation, and interview data increased the validity and reliability of the findings (Sugiyono, 2019; Rahmania et al., 2022).

Data analysis was carried out using both quantitative descriptive analysis and qualitative reflection. Quantitative analysis was performed by calculating the percentage of children achieving the learning indicators, with the success criteria set at a minimum of 80% of students meeting the targets (e.g., naming, differentiating, and classifying 3D shapes). Meanwhile, qualitative reflection was conducted based on observations and teacher interviews, which were then used to revise and improve the subsequent learning cycles. This combination of approaches provided a holistic picture of the effectiveness of AR media in enhancing young children's recognition of three-dimensional shapes (Kurniawan et al., 2019; Khan et al., 2019; Elizabeth Wahyu MI et al., 2023).

RESULT AND DISCUSSION

Research Findings

The implementation of three-dimensional shape recognition using Augmented Reality (AR) media through the *Assemblr Edu application* is carried out by integrating technology into children's daily learning activities. The teacher begins by introducing basic 3D shapes such as cubes, blocks, spheres, and pyramids using pictures or concrete objects. Afterward, children are guided to use digital devices such as tablets or smartphones to display virtual 3D models through the *Assemblr Edu application*. They can rotate, zoom in, and observe the objects from different perspectives, making the learning experience more interactive and engaging.

Next, the learning activities are designed in the form of games and explorations. Children are asked to observe the differences between shapes, name them, and classify them while manipulating the 3D models displayed on the screen. With the AR feature, children perceive the shapes as if they appear directly in front of them, making abstract concepts more concrete and easier to understand. For example, they can more clearly compare the differences between a cube and a block through direct visual experience. These activities also encourage small group interactions, where children discuss and collaborate in classifying shapes according to their characteristics.



Figure 1. Students' Activities Utilizing Augmented Reality Media

The application of AR through *Assemblr Edu* not only enhances children's understanding of 3D shapes but also fosters learning motivation and social skills. Children show greater enthusiasm and active participation during the lessons compared to conventional media, which tend to be less engaging. Teachers also find classroom management easier as children remain focused on the virtual objects displayed. Thus, the use of AR in shape recognition provides a more meaningful learning experience, supports cognitive development, and simultaneously nurtures children's collaboration skills from an early age.

The study was conducted over three stages: the pre-cycle, cycle I, and cycle II, to evaluate the effectiveness of using Augmented Reality (AR) through the *Assemblr Edu* application in improving early childhood recognition of three-dimensional shapes. During the pre-cycle, children were introduced to 3D shapes using conventional media such as picture cards and physical models. Observations revealed that most children experienced difficulties in naming and differentiating shapes, with only 35% of the class reaching the minimum achievement indicators. The results indicated that conventional media were not sufficient to stimulate their understanding.

In the pre-cycle phase, many children tended to confuse shapes such as cubes and blocks, as well as spheres and circles. The lack of interactive and engaging media led to children's low attention span and lack of motivation. Teacher interviews confirmed that traditional methods often failed to hold children's interest for long periods, which affected their ability to remember and classify shapes. This finding is consistent with Mammarella et al. (2017), who emphasize that preschoolers require concrete, interactive experiences to grasp spatial concepts effectively.

Cycle I began with the integration of *Assemblr Edu* into classroom learning. Teachers used the application to display virtual 3D shapes that children could visualize through tablets and smartphones. The AR-based approach allowed children to see objects from multiple perspectives and interact with them directly. As a result, children showed greater enthusiasm during the learning sessions. Quantitative data revealed that 65% of the children achieved the learning indicators in cycle I, indicating a significant improvement from the pre-cycle stage.

Despite this improvement, observations showed that some children still required additional guidance in differentiating between shapes such as pyramids and cones. Teacher reflection revealed that although the AR application was effective in capturing children's attention, not all children were equally adept at manipulating digital devices. Therefore, the teacher provided scaffolding and peer support to ensure equal participation. This reflects

Vygotsky’s concept of the Zone of Proximal Development, where children benefit from guidance and collaboration with peers (Brewer, 2007).

During cycle I, classroom engagement improved as children actively participated in group activities. Documentation showed that children began to use shape names more frequently and confidently. However, several children still exhibited confusion when asked to classify multiple shapes simultaneously. The teacher noted that further reinforcement and repetition were needed to consolidate understanding. This aligns with Clements & Sarama (2011), who highlight the importance of repeated exposure to geometry in early childhood education.

In cycle II, adjustments were made to address the shortcomings observed in cycle I. Teachers added collaborative games using *Assemblr Edu*, where children worked in small groups to identify, name, and classify virtual shapes. This interactive approach encouraged peer learning and helped children strengthen their recognition skills. Observational data indicated that classroom dynamics became more cooperative, with children showing higher levels of motivation and focus.

The results of cycle II demonstrated a marked improvement. A total of 90% of the children successfully achieved the learning indicators, surpassing the predetermined success criteria of 80%. Children were able to name, differentiate, and classify basic 3D shapes such as cubes, blocks, spheres, and pyramids. This finding confirms the effectiveness of AR media in enhancing early childhood geometry learning and the feasibility of *Assemblr Edu* in 3D geometry instruction.

Table 1. Comparison of Pre-Cycle, Cycle I, and Cycle II Results

Observed Aspect	Pre-cycle (%)	Cycle I (%)	Cycle II (%)	Development Remarks
Recognizing 3D shapes	45	65	85	Significant improvement from pre-cycle to cycle II
Naming 3D shapes	40	60	80	Consistent improvement in each cycle
Differentiating 3D shapes	35	55	78	Good progress, students increasingly able to differentiate
Enthusiasm in using AR media	50	70	90	AR media strongly attracts students' attention
Overall average	42.5	62.5	83.25	40.75% increase from pre-cycle to cycle II

Furthermore, qualitative reflections from teacher interviews highlighted that AR not only improved children’s learning outcomes but also made the teaching process more enjoyable and less monotonous. Teachers felt that the use of *Assemblr Edu* helped them manage classroom engagement more effectively. These reflections are consistent with Khan et al. (2019), who found that AR positively influences student motivation and teacher satisfaction.

The use of participatory observation revealed that children’s enthusiasm was sustained throughout the learning cycles. Unlike in the pre-cycle, children actively asked questions and were eager to repeat the activities. Teachers observed that the children’s vocabulary improved, as they could use correct terms to describe geometric properties such as edges, corners, and faces. These results further validated the integration of technology in early childhood classrooms.

Overall, the findings demonstrate that the use of AR through *Assemblr Edu* significantly improved children’s recognition of 3D shapes. The iterative process of action, observation, and reflection allowed continuous improvement in instructional design, resulting in better learning outcomes. The evidence strongly suggests that AR can serve as

a powerful tool for supporting cognitive development in early childhood education, particularly in the area of geometry.

Discussion

The findings of this study highlight the potential of Augmented Reality (AR) in enhancing early childhood geometry learning. The significant improvement from 35% achievement in the pre-cycle to 90% in cycle II demonstrates that AR is highly effective in supporting children's recognition of 3D shapes. This aligns with previous studies by Kurniawan et al. (2019) and Rahmania et al. (2022), which concluded that AR can bridge the gap between abstract concepts and concrete experiences for young learners.

One of the key strengths of AR lies in its ability to provide interactive and multisensory experiences. Unlike static pictures or physical models, AR allows children to manipulate objects virtually, rotate them, and view them from different perspectives. This interactive feature supports children's spatial reasoning, which is crucial in early geometry learning. Fifi Arisanti et al. (2024) similarly found that AR accommodates diverse learning styles—visual, auditory, and kinesthetic—making it more inclusive for children with varying preferences.

The improvement observed in this study also reflects the importance of motivation in learning. During the pre-cycle, children were easily distracted and less engaged when using traditional media. However, the introduction of AR sparked curiosity and maintained children's focus throughout the sessions. This finding echoes Khan et al. (2019), who emphasized that AR has the potential to increase students' motivation by making learning more enjoyable and engaging.

The role of teachers in scaffolding children's learning during AR-based activities also proved critical. Although some children initially struggled with differentiating shapes, teacher guidance and peer collaboration helped them overcome these difficulties. This aligns with Vygotsky's scaffolding theory, which suggests that learning occurs more effectively when children receive guidance within their zone of proximal development (Brewer, 2007). Thus, the teacher's role remains indispensable in ensuring that technology integration leads to meaningful learning.

Furthermore, the iterative design of Classroom Action Research (CAR) proved effective in refining the learning process. By identifying challenges in cycle I and implementing improvements in cycle II, the study demonstrated the value of continuous reflection and adjustment. This cyclical approach is consistent with the principles of action research, which emphasize collaborative problem-solving and sustainable improvements in teaching practices (Kemmis & McTaggart, 1988).

The findings also highlight the broader pedagogical implications of integrating technology in early childhood classrooms. While traditional methods remain valuable, the incorporation of AR provides an innovative complement that aligns with the digital experiences of today's children. As digital natives, children are naturally drawn to technology, making AR a familiar and engaging medium for them. This reinforces the argument by Elizabeth Wahyu MI et al. (2023) that innovative media can effectively enhance children's spatial and cognitive skills.

Another important implication of this study is its support for national education policies that emphasize the integration of digital learning tools in 21st-century education (Kemendikbud, 2020). The success of AR-based learning in this study demonstrates that technology can be effectively implemented even in early childhood settings, provided that teachers receive adequate support and training. This suggests that policymakers should consider investing in technology-based resources for ECE institutions.

The results also reveal that AR is not only beneficial for children but also for teachers. Teacher reflections indicated that AR made lessons more dynamic and helped maintain classroom management. This suggests that technology can reduce teacher workload in

terms of sustaining children's attention and managing learning activities. Such findings align with Uswatun & Rizki Surya (2023), who argue that innovative teaching media can address challenges faced by teachers in maintaining children's engagement.

However, the study also identified some limitations. For instance, not all children were equally adept at handling digital devices, which sometimes required additional support from teachers and peers. This indicates that technology should not be viewed as a standalone solution but rather as a tool that complements teacher-facilitated learning. Future research could explore strategies for balancing technology use with hands-on activities to maximize learning outcomes.

In conclusion, the discussion underscores that AR, particularly through the *Assemblr Edu application*, is a powerful medium for improving young children's understanding of 3D shapes. Its interactive features enhance motivation, support cognitive development, and foster collaborative learning. At the same time, the study emphasizes the importance of teacher involvement and iterative instructional design. These findings contribute both theoretically and practically to the discourse on technology integration in early childhood education, offering valuable insights for educators, researchers, and policymakers.

CONCLUSION

The study found that Augmented Reality (AR) using the *Assemblr Edu application* effectively improved early childhood recognition of three-dimensional shapes. Achievement levels increased from 35% in the pre-cycle to 90% in cycle II, surpassing the success criteria. AR not only enhanced children's ability to name, differentiate, and classify 3D shapes but also increased their motivation and classroom engagement.

Teachers are encouraged to apply AR-based media in early childhood learning to make abstract concepts more concrete and engaging. Schools should support this by providing training and facilities, while future studies may explore the use of AR in other learning areas. Policymakers are also advised to promote digital learning tools in early childhood education to strengthen 21st-century competencies.

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