Jurnal Inovasi Teknologi Pendidikan
Volume 12, No. 3, September 2025 (341-352)
Online: http://journal.uny.ac.id/index.php/jitp

The effect of augmented reality-based Snake and Ladder game on early childhood cognitive development

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ARTICLE INFO

Article History
Received:
15 July 2025;
Revised:
19 October 2025;
Accepted:
20 October 2025;
Available online:
30 September 2025

Keywords
ADDIE models; Augmented reality; Board games; Early childhood cognition; Snake ladder

ABSTRACT

This study examines the impact of an Augmented Reality (AR)-based Snake and Ladder board game on improving early childhood cognitive abilities. Conventional learning often causes boredom and limits children's creativity, so innovative media that stimulate reasoning and imagination are needed. Using the Research and Development (R&D) method with the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation), this research involved 26 children at Bustanul Athfal Sragi Kindergarten. The analysis phase revealed that children were active, competitive, and curious. The AR-based Snake and Ladder game was designed by integrating physical boards with AR question cards connected to 3D objects in the Assemblr EDU application. Media and material experts validated the product with feasibility scores of 84% and 80%, both categorized as "Highly Valid." Implementation results showed that the AR-based game effectively increased children's interest, enthusiasm, curiosity, and cognitive stimulation through an engaging blend of digital and real-world interaction, aligning with the "learning while playing" principle and fostering early technological literacy. Further research is recommended to explore similar technology-based learning media across different educational contexts, age groups, and subjects to enhance understanding of its effectiveness and long-term educational benefits.

How to cite:
Winasari, Nugroho, D. A., & Zubaidi, M. F. b. (2025). The effect of augmented reality-based Snake and Ladder game on early childhood cognitive development. *Jurnal Inovasi Teknologi Pendidikan, 12*(3), 341-352. https://doi.org/10.21831/jitp.v12i3.88473

INTRODUCTION

The development of education today can be characterized by technological advances. In the increasingly competitive and digitally connected global era, early childhood education is faced with a great challenge to ensure that children get optimal developmental stimulation that is utilized by educators as a means in the learning process (Pratiwi et al., 2024). In recent years, the gaming industry, which is looking for a more immersive interactive experience, has developed a series of new devices and technologies that provide users with a more natural interaction compared to a gamepad, keyboard, or a regular mouse (Alzubi et al., 2018). At an early age, the use of games or interactive media can be more effective in supporting their cognitive development. With Information Technology has become very rapidly, it can cause anyone who can access the internet itself quite so, especially for children who are of school age (Purnamasari & Verano, 2024). Understanding how

family dynamics, economic conditions, and social factors shape cognitive ability behaviors is essential for developing targeted interventions, especially for children aged 0–6 years (Khun-inkeeree & Puti, 2025).

In this context, children will have an easier time remembering the information conveyed, thus contributing to the sharpening of their cognitive abilities. However, there are still many educators who rely on manual learning methods or only use guidebooks as a teaching medium. This kind of approach has the potential to create a sense of boredom among students, which in turn can hinder their cognitive development. This can be seen when the teacher delivers the material, where children are often more interested in playing with their friends in the back of the class, without heeding the explanation given by the teacher in front. To provide effective and efficient education for early childhood, educators must understand the factors that can affect their development (Salamah & Sarjiyem, 2025). Therefore, it is important to implement teaching materials that can stimulate children's creativity in the learning process (Ritonga et al., 2022).

Over time, children's development can change according to their way of thinking, solving problems, and understanding concepts (Mulyati & Suryani, 2023). Improving cognitive abilities is one of the aspects that can be developed in kindergarten. In this development, there are many things that can be done to achieve a goal in improving children's learning, one of which can be through games. Board Games (board game) are a type of game that involves moving or placing pieces on a predetermined surface or board. This game is carried out according to the rules that have been set (Mulyati & Suryani, 2023). Deep Board games, the player interacts with a marked board, either by moving pieces or placing them, and all game activities are governed by a set of rules of the game that are set at the beginning (Ningtyas, 2023).

The snake and ladder game is an effective method in increasing students' absorption and understanding of the subject matter, especially for topics that are difficult to understand without the help of the media (Setiawati & Suyadi, 2021). Snakes and ladders are like an interesting educational medium, children are happy, children feel like playing even though in reality this game is learning while playing (Nurhidayati & Imron, 2021). In the Snakes and Ladders game, there are many versions. To make children more interested, this game has been modified; modifications are made by changing the rules of the game (Lestari, 2021).

The snake and ladder game that will be carried out by the researcher is combined with AR (Augmented Reality), which is included in the category of 3D interactive technology. Augmented Reality is a technology that integrates the real world with two-dimensional or three-dimensional elements, which are poured into a container and then projected into the real environment. Through Augmented Reality, users can gain a more immersive interaction experience with the real environment in the form of Virtual (digital) Real-time, so that the experience gained feels more real (Rahma & Ekawati, 2024).

With the help of AR technology, learning materials can be delivered and explained in a more specific and detailed way. Examples of research that implement AR technology in the field of education are the development of AR applications for learning about ancient animals, the development of learning media for the introduction and learning of animals, plants, or others by displaying 3D objects from the learning as researchers are doing today. And many more studies study the implementation of AR technology in learning media (Aji et al., 2023). AR technology can help early childhood learning as a support to get optimal developmental stimulus.

Children aged 0 to 6 years experience a tremendous acceleration in growth and development. This period, which is often called the Golden Age, became the foundation for their future. Accurate and targeted stimulation at this age is vital so that the child's potential can be fully realized. The role of educators and parents is key to ensuring optimal stimulation and alignment with the stages of child development at this golden age. One of the main focuses is cognitive development. At the kindergarten (PAUD) level, cognitive development is designed to equip children with the ability to solve simple challenges, hone their creativity, and understand the world around them. As an illustration in the context of technology-based cognitive stimulation, children can be introduced to interactive picture guessing games, such as counting numbers, mentioning traits with puzzles. Counting activities are carried out to find out the number or quantity and characteristics of an object

(Putri et al., 2024). So that in the explanation of early childhood and children's cognitive abilities, the researcher made a comparison with relevant studies by several previous researchers.

This relevant research will help researchers to improve the validity of the research. The research conducted by the researcher with the title "Influence Board Game Snake Ladder Based Augmented Reality To Improve Children's Cognitive Abilities in Early Childhood Education", while the previous research journal was titled "Development of Media-Based Learning Augmented Reality on the theme of ancient animals to develop cognitive abilities in early childhood group B (5-6) years". The difference between previous researchers and current researchers is that, in the implementation, the previous researchers implemented using AR directly on the theme of ancient animals, while the current researchers implemented using Board games and combined with AR-based technology in all categories according to the age of the child.

The similarities in previous research and current research are that they both use AR-based and improve early childhood cognition. In 2023, Linda Winarni, Rachma Hasibuan, and Umi Anugerah Izzati conducted a study entitled "The Application of Educational Snake and Ladder Game Media in Improving Word Recognition Skills." The difference between the study and the researcher lies in the goal of the researcher, aiming to improve children's cognitive skills, and previous researchers to improve word recognition skills (Winarni et al., 2023). In 2024, a journal entitled "The Use of Causal Snake and Ladder Games in Improving Cognitive Abilities in Early Childhood" was researched by Imamah and Harmiasih, the research has similarities in the goal category, namely to improve early childhood cognition, but there is a difference between the journal and the researcher, namely in the method taken, the previous researcher used the qualitative method while the researcher used the R&D method (Reaseacrh and Development) (Imamah & Harmiasih et al., 2024).

The purpose of the research conducted by the researcher is to find out how the implementation of AR-based board games affects improving early childhood cognition. In addition, by using the concepts that have been designed, it is hoped that children can understand and improve their reasoning and thinking power about animals or others in board games. With the combination of board games and AR, it will be very beneficial for children, in addition to improving the learning process, so that they don't get bored easily. With this implementation, it is hoped that children can understand the technology-based learning process provided with concrete material through the implementation process between the real world and the virtual world.

METHOD

This research adopts the type of R&D research (Research and Development). At the research stage, data collection was carried out with a qualitative approach. The results of the data collection analysis will be processed at the concept and design development stage using the ADDIE model, which consists of five stages, namely: Analysis, Design, Development, Implementation, and Evaluation (Adnas & Veren, 2023).

The Analysis stage focuses on identifying the learning problems, goals, and needs of early childhood education, as well as the characteristics of learners. The Design stage involves creating learning objectives, determining content, and planning the structure and flow of the AR-based Snake and Ladder game. The Development stage is carried out by producing and integrating physical and digital components of the learning media using the Assemblr EDU application. The Implementation stage involves testing the developed media on early childhood learners to observe its practicality and effectiveness in the learning process. Finally, the Evaluation stage is conducted to assess the overall quality, feasibility, and learning outcomes through expert validation and feedback from users, ensuring that the product meets the desired educational standards.

In R&D (Research and Development) research, the measure of strength found in the demonstration of the research will later explore problems arising from the events experienced, with an example in the kindergarten to be studied does not have many media, with this research expected to meet cognitive needs.

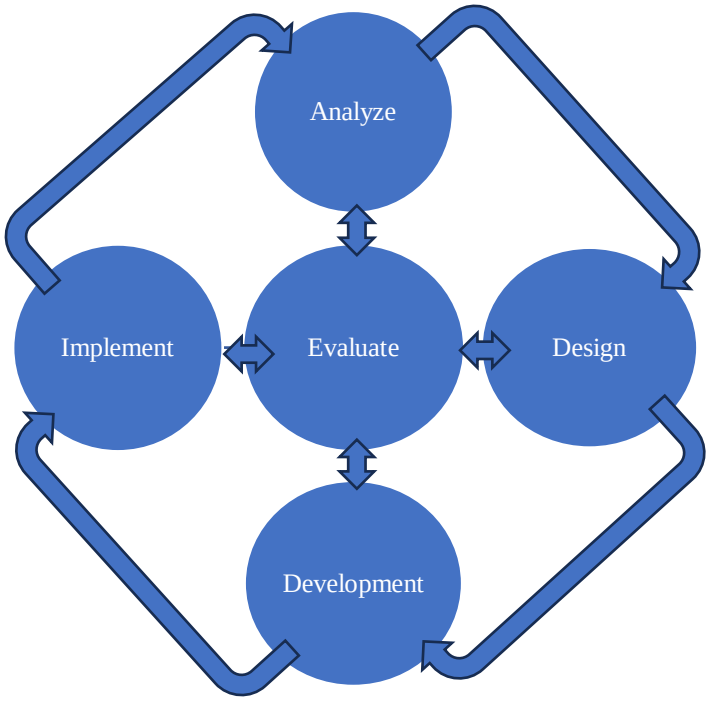

Figure 1. Model ADDIE

In the above stage of the ADDIE development model, it can show the following information:

Analysis

The first stage in the ADDIE development research model is analysis. At this stage, the researcher conducts observations, interviews, and analysis of problems that occur by collecting information to show the basis of the problem and what is needed for early childhood. Observations and interviews were carried out at Bustanul Athfal Sragi Kindergarten with the Principal. The researcher conducted an exploration by asking how the implementation was carried out by the school to attract children so that they could follow learning properly. Thus, the exploratory findings that the researcher got were a form of learning with technology-based games. The selection of technology-based games is also carried out according to the right early childhood needs and the learning goals achieved.

Design

The research model was carried out after the researcher conducted an analysis and learning needs at Bustanul Athfal Sragi Kindergarten, at this stage the researcher conducted an AR (Augmented Reality) based board game learning design, the stage of designing the researcher's board game using a board according to the required size, game rules, questions behind the cards, and dice as support to run the game, as for the AR part, The researcher uses Assembler Edu with 3D & AR technology, in this Assembler EDU feature will help researchers to create a design question or something that can be raised through the QR barcode available on the question card.

Development

The next stage after the researcher models a product is an augmented reality-based board game. Validation on a product will be carried out after this learning media has been completed. This validation will later be carried out by a validator, or it can be called a media expert, to find out the eligibility criteria. Next, the researcher collected data through a questionnaire to see the children's response to a product implemented and several teachers and principals at Bustnaul Athfal Sragi Kindergarten.

Using the questionnaire data that the researcher will later conduct, namely with the assessment criteria of the scale (Likert scale) in Table 1, strongly disagree, disagree, neutral, agree, and strongly agree, as follows:

Table 1. Likert Scale

No.	Category	Range
1	Strongly disagree	1
2	Disagree	2
3	Neutral	3
4	Agree	4
5	Strongly agree	5

The researcher then conducted a validation test using a validation questionnaire through the results of media validation, materials, and validation *post-implementation* from teachers. After the score results appear, the score is calculated as quantitative data to determine the scale of the assessment expressed in percentages. The calculation uses the following formula (Yahya et al., 2020).

$$P = \frac{\sum R}{N} \times 100\% \quad (1)$$

Information :
P : Percentage of the score sought
∑R : Number of answers given by the validator/selected choice
N : Maximum number of scores

After obtaining the score percentage, it can then be converted so that the researcher can find out whether the learning tool is valid or not, with the categories of very valid, moderate, less valid, and invalid can be seen in Table 2 in the score percentage category (Setiawan & Rahman, 2025).

Table 2. Score Percentage Categories

No.	Percentage	Description	Category
1	75.01% - 100%	Excellent	Very Valid, can be applied immediately
2	50.01% - 75.00%	Good	Quite valid, usable, and in need of a bit of revision
3	25.01% - 50.00%	Not Good	Invalid, recommended not to use, and needs revision
4.	0.00% - 25.00%	Bad	Invalid, not allowed to be used.

Implementation

The researcher conducted a product trial stage as a learning medium. The trial was carried out with children at Bustanul Athfal Sragi Kindergarten group B1, with a total of 26 children. At this stage, the researcher also conducts an assessment of the child to provide a product result, which will later be continued at the evaluation stage, where this response and assessment will later determine whether the researcher to conduct an evaluation.

Evaluation

The final research phase of ADDIE development, this stage is carried out to determine the value of the results of the trial on the implementation of product trials. The data collection instrument carried out by the researcher was to make a questionnaire filled out by teachers and principals at Bustanul Athfal Sragi Kindergarten.

The learning process is one of the things that can be encouraged through technology in the field of science, so that it can strive for an innovation that can advance learning. Along with its rapid development in the digital era, Augmented Reality (AR) can provide learning and added value in the process, especially in the context of educational games. AR is one of the learning technologies that can improve and attract children to be able to participate in learning in a conducive way and increase children's interactivity. This provides an opportunity to present information more visually and dynamically, so that it can enrich children's creative imagination. This technology is very suitable for use in play groups at Bustanul Athfal Sragi Kindergarten to improve children's cognition (Basri

et al., 2024). In this analysis plan, the researcher creates questionnaire data that will be validated by media experts and material experts, and later, the researcher will obtain data through a questionnaire, which will be analyzed for validity and reliability tests. The purpose of validity test analysis is the purpose of assessing the quality of questions or items in the instrument (questionnaire/questionnaire), while the purpose of reliability is to find out the extent to which the instrument can provide consistent results when used repeatedly.

RESULTS AND DISCUSSION

Results

Research and trial development of learning media products at Bustanul Athfal Sragi Kindergarten group B1. Through quantitative methods with questionnaires and learning development through media, combined with AR (Augmented Reality). The results of the quantitative method and development stages are as follows:

The analysis stage carried out by the researcher to meet the needs of early childhood, the analysis was carried out through observation and interviews of B1 group teachers. On the results of observations carried out in class, the researcher found the active, competitive, and curious nature of the character of the B1 class children. Through these observations, the researcher can conclude that the games to be implemented can arouse the enthusiasm of B1 grade children, because the media mixed with games can provide a challenge for children, by packaging technology using Augmented Reality can make children have reasoning and make cognitive development work better.

In addition to observation, the researcher carried out an interview stage with the classroom teacher, in the interview session the researcher found that there was learning relative to books or just videos, so that the use of less innovative learning media made the child unable to explore further, this refers to the child's cognitive development process, therefore at the analysis stage the researcher provided a solution in the form of board games AR-based snake and ladder for early childhood at Bustanul Athfal Sragi Kindergarten group B1.

Furthermore, the researcher carried out the design stage for Augmented Reality-based media after the implementation of the needs analysis. The media design stage for AR-based snake and ladder board game products is as follows:

1. Snake and Ladder board game design
   The design of the Snakes and Ladders board game in this media uses a box-shaped board. This Snakes and Ladders board game consists of:
   a. Box-shaped board with a size of 40cmx40cm
   b. 7 Rules
   c. The stop is carried out when the child enters a box with a snake's head and a ladder up. Two dice, 10 questions.
2. Augmented Reality Design
   The use of technology in this Augmented Reality design in the Snakes and Ladders board game has a question card, on the back, some questions will be answered by the child, this is done so that the child can train his cognition by guessing from the questions asked, and the child's answers will be corrected using a barcode that already has the correct answer.

The learning media developed are Board games, snake ladder-based Augmented Reality. Board game made through a combination of manual and technology, while augmented reality is created using an app, Assemblr edu: create 3D and AR. On the manufacturing Board, games can be seen in Figures 1 to 4.

Figure 1. Board Game Snakes and Ladders

Figure 2. Cube

Figure 3. Pawn

Figure 4. Question Card

In digital media, researchers use an Assemblr edu application. This application can be used and downloaded through the Google Play Store, and can be used on a smartphone or laptop, according to conditions. In making question cards or barcodes, you can see the steps in Figures 5 to 10 below.

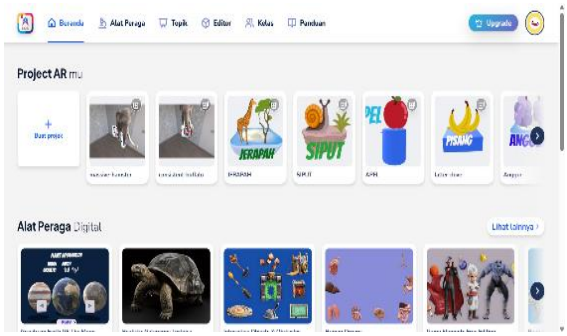

Figure 5. Initial View of the Edu Assembly

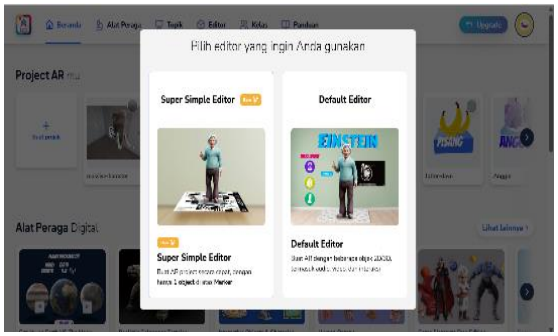

Figure 6. Edit Options Menu

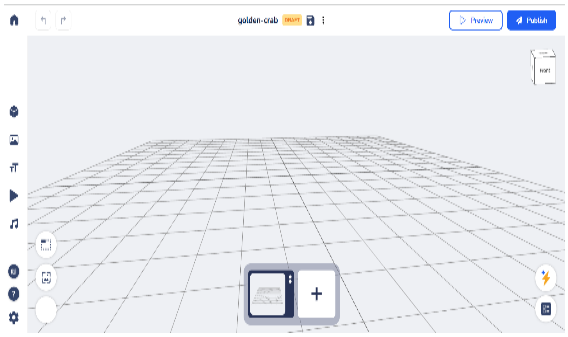

Figure 7. Assemblr Worksheet

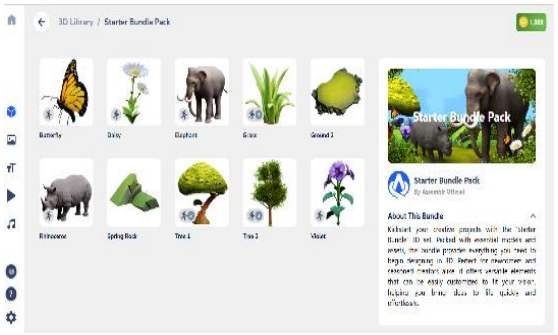

Figure 8. Assemblr Edu Worksheet Selection Menu

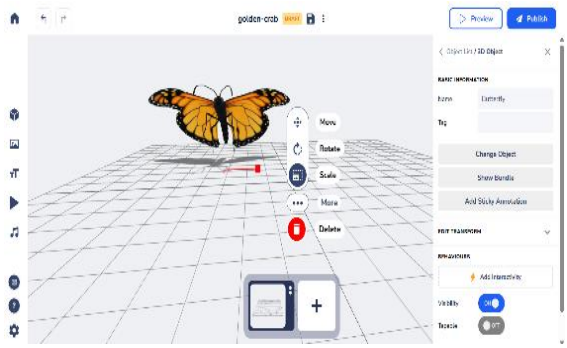

Figure 9. Editing Process

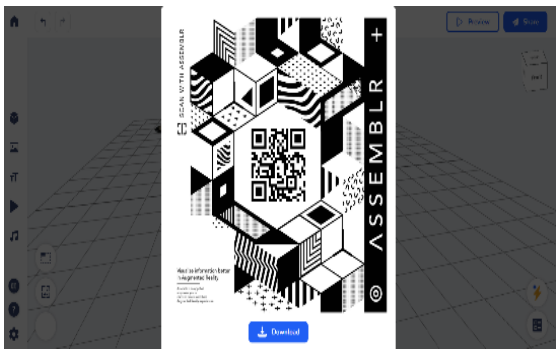

Figure 10. Barcode

After the development media have been created, the next stage is validation by media experts and material experts. The implementation of this validation was carried out with media experts and material experts filling out questionnaires and providing suggestions and improvements to researchers. The results of media and material validation can be seen in Tables 3 and 4. The following are the results of validation by media experts and material experts.

Table 3. Media Validation Results

No.	Indicators	Percentage
1	Design and visualization aspects	86%
2	Feasibility aspects of use in various conditions	86%
3	Security and privacy aspects	90%
4	Media aspect	80%
5	Image quality	80%
Sum		**84%**

Table 4. Material Validation Results

No.	Indicators	Percentage
1	Suitability of the material to the child's age and cognitive development	76%
2	Diversity of materials and challenges in *board games*	75%
3	Simplicity and clarity of material	80%
4	Influence on the understanding of learning materials	90%
Sum		**80%**

After being declared valid by media experts and material experts, the researcher implemented a question-and-answer learning model using an Augmented Reality-based Snakes and Ladders board game media. In the learning session, the researcher conducts learning about the theme that will be carried out as referred to the implementation of the Augmented Reality-based snake and ladder board game to improve cognition through exploration of learning that is innovated through the digital world in the form of a barcode and behind it is a question in the form of a puzzle question that will be answered by B1 grade children, and the answer through a barcode can be seen in Figure 11 below.

Figure 11. Barcode Implementation

Table 5. Board Game Implementation Questionnaire Results

No.	Indicators	Percentage
1	Gaming board media display	80%
2	Ease of access and use of media	80%
3	AR media interactivity	80%
4	The effectiveness of using AR media	80%
5	Utilization of media in cognitive development	80%
Sum		**80%**

At the implementation stage, learning media in the form of Augmented Reality-based board games need to go through an evaluation process. This evaluation aims to improve the final product by considering the input and suggestions for improvement provided by teachers during the implementation stage in schools. In this study, the evaluation process is carried out by referring to the results of assessments and recommendations from experts (validators), which are then submitted to teachers as feedback on the media that has been developed. The assessment is an important reference in evaluating and perfecting Augmented Reality-based board game learning media for development in the next stage. The results of the implementation questionnaire that were forwarded at the evaluation stage showed a figure of 80% which, if referring to the percentage category of score, was declared to be very valid, but there is little that must be revised so that board game learning media can be implemented for a long time.

Discussion

On the implementation of the use of technology through the Snakes and Ladders board game learning, Augmented Reality is a way to make the child's curiosity grow, and it can improve the child's cognition. Students are interested in the visualization of objects that are difficult to see in real life and appear on smartphones that teachers use (Nasution et al., 2022). The use of media as a learning tool is essentially an integral part of early childhood learning management planning (Rais et al., 2024). Rapid technological advances have brought significant changes to educational media, which were traditionally based on conventional methods but can now be implemented more practically using digital tools (Mukhlisin et al., 2025). To identify the impact of AR game-based learning on children, the app was evaluated to determine the efficiency, effectiveness, user engagement, and learning ability of children (Farooq et al., 2022). AR designers can use new technologies, but make sure they don't interfere with the logical narrative, the player's imagination, and their social relationships. Therefore, at least at this stage, AR should be used to support, not replace, the human imagination (Laato et al., 2021). So it is very important that teachers can use learning that can make children interested and enthusiastic to carry out learning, by involving the digital world into learning it can be concluded that children are very interested in digital-based learning resulting from the use of assemblr edu, with the opportunity to learn directly with assemblr edu, children can establish direct interaction with virtual objects that seem to be present in the real world, which is certainly in line with the principle of "learning while playing" with 3D drawings (Hafifah & Marlina, 2025).

The results of media and material validation are the percentages that can produce feasible and unfeasible ones. The result of the percentage score of the researcher after going through several stages in the media validation category was 84% with the very valid category, from the results of the material validation was 80% with the very valid category, from the final percentage results both were very valid and could be implemented in early childhood, so the researcher hopes that with a good percentage, both media and material can be done well it aims to improve children's cognition. The final results of the researcher concluded that children's learning combined with the digital world can make children more curious and more active in participating in learning, thus many benefits can be gained and developed through digital-based learning, one of which is that it can improve children's cognition. AR technology can serve as a very effective tool not only to improve cognitive abilities but also to encourage creative thinking and active learning (AlAli & Al-Barakat, 2024).

The researcher agrees with a journal study by Alzahrani (2025), who, in his research, found that one of the unexpected findings is that many teachers use technology and are ineffective in their lessons. Although teachers claim to use technology, its use is limited to administrative purposes or to provide knowledge as a means of supporting traditional methods (Alzahrani, 2025).

The benefits of Assemblr Edu certainly do not escape the curiosity of children can be paid off by presenting a virtual learning experience, so that this can include children's learning with exploration through the digital world. By utilizing Assemblr Studio, children not only learn about learning materials but also hone technological skills that will be useful in their lives in the future (Hamidah et al., 2024). The effectiveness of integrating technology in the assessment and learning

process demonstrates the feasibility of similar use in other subjects or educational environments (Darmawan & Septyanti, 2024).

The results of the study show that the application of Augmented Reality (AR)-based Assembler EDU technology is effective in increasing involvement, interest in learning, and understanding of early childhood concepts. The integration of this technology is able to create a more interactive, visual, and contextual learning experience, thus encouraging the creation of a meaningful and enjoyable learning process. Thus, Assembler EDU can be used as an innovative learning medium that supports the application of 21st-century learning in early childhood education.

This study still has limitations on the limited scope of subjects and the relatively short duration of application, so the results cannot be generalized widely. In addition, the study has not examined in depth the effect of the use of Assembler EDU on other aspects of development, such as children's social-emotional and motor skills. Therefore, further research is recommended to involve a more diverse sample, longer implementation duration, and more comprehensive measurement of variables to obtain more in-depth and representative results.

CONCLUSION

The implementation of the Augmented Reality (AR)-based Snake and Ladder board game has a significant positive influence on improving early childhood cognitive abilities at Bustanul Athfal Sragi Kindergarten. Through the Research and Development (R&D) approach with the ADDIE model, innovative learning products have been developed and validated with very satisfactory results from media experts (84%) and subject matter experts (80%), confirming their feasibility of use. The use of AR technology in the board game Snake and Ladders has proven to be effective in overcoming children's learning saturation that often arises from conventional methods. Children show higher enthusiasm, curiosity, and engagement due to the interactive and dynamic visualization of 3D objects that appear on smartphones. The learning process becomes more interesting and concrete, allowing children to understand and develop their reasoning and thinking power optimally, especially related to the material presented in the game. The integration of physical board games with AR digital elements creates an immersive "learning as play" experience, supporting the stimulation of cognitive development that is essential in a child's golden age. Therefore, digital-based learning media such as the AR-based Snake and Ladder board game are highly recommended to be applied to encourage educational innovation and optimize early childhood cognitive development. In the next study, it is recommended that wider development be carried out on the application of similar technology-based learning media in various contexts, age levels, and fields of learning, in order to gain a deeper understanding of its effectiveness and sustainability in supporting the children's education process.

ACKNOWLEDGMENT

I would like to thank my supervisor and my collaborators; without his support, this journal would not have been formed.

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