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Development of an Augmented Reality-Based Body Parts Concept Book for Early Childhood

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ABSTRACT
Introducing body parts is an important basic concept for early childhood; however, the available learning media are still dominated by two-dimensional images that are less interactive. This study aimed to develop and examine the feasibility of an Augmented Reality (AR)-based body parts concept book integrating three-dimensional (3D) object visualization and interactive audio in accordance with the learning characteristics of early childhood. The novelty of this study lies in the integration of marker-based AR, full-body 3D visualizations, and learning activities within a single concept book specifically designed for children aged 4–5 years. This study employed a Research and Development (R&D) method using the ADDIE model. The research subjects consisted of 17 children aged 4–5 years at TKIT Baitushalihin Banda Aceh. The research instruments included expert validation sheets (material and media experts) and children's response observation sheets. Data were analyzed using quantitative descriptive percentage analysis and qualitative descriptive analysis. The results showed that the validation by material experts and media experts reached 100% (very feasiable). Children's responses in the small-group trial (n=8) obtained a percentage of 91.25% (very feasible), while the large-group trial (n=17) obtained 80.88% (feasiable). These findings indicate that AR media can support children's attention, engagement, and understanding of body parts concepts through more concrete visual and auditory experiences. Therefore, the developed media is appropriate to be used as an innovative alternative in early childhood learning, although further effectiveness testing using an experimental design is still needed.

Keywords: *Augmented Reality, ADDIE Model, Learning Media, Body Parts Introduction, Early Childhood*

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INTRODUCTION

Early childhood education is an important stage in children's development that requires appropriate learning stimulation in accordance with children's developmental characteristics. Therefore, the introduction of basic concepts related to children themselves needs to be provided from an early age as part of a meaningful learning process (Hilda, 2026). One of the important basic concepts that should be introduced to early childhood is body parts. Introducing body parts helps children understand the functions of their bodies, improve language skills and motor coordination, and develop self-awareness in maintaining body health and safety (Maarang et al., 2026).

However, in practice, the introduction of body parts to early childhood is still commonly carried out using conventional media such as pictures and simple verbal

explanations (Wulandari, 2021). The use of such media has not been fully effective in providing meaningful learning experiences for children. Initial observations showed that some children still experienced difficulties in identifying and pointing to body parts correctly. In addition, children appeared less focused during learning activities using picture book media (Asmara et al., 2023).

Early childhood is a stage characterized by rapid cognitive development. According to Jean Piaget's theory of cognitive development, children aged 2–7 years are in the preoperational stage, during which they begin to develop symbolic thinking but still require visual support and direct experiences to understand concepts (Al Munawaroh et al., 2023). Therefore, the use of learning media capable of presenting more realistic visualizations is essential to support children's learning processes.

However, the process of teaching body parts in schools still tends to be teacher-centered and has not provided optimal opportunities for children to explore learning experiences independently. Therefore, innovative learning media are needed to support children's engagement through more contextual learning experiences (Ningrum & Nur, 2023).

In line with this, various studies have developed innovative technology-based learning media to support the learning needs of early childhood, one of which is through the use of Augmented Reality (AR). Ningrum & Nur (2023) developed the ARBO Interactive Book based on Augmented Reality (AR) for number recognition and demonstrated that it was appropriate for use in early childhood learning. In addition, Anggreani & Satrio (2021) found that Augmented Reality-based flashcards were valid and practical for supporting children's learning focus. These findings indicate that Augmented Reality-based media have the potential to enhance children's engagement during the learning process. AR technology enables the integration of real objects with virtual visualizations in real time, thereby providing children with more visual and contextual learning experiences (Oktaviati, 2026). The use of AR-based media has the potential to support children's attention, motivation, and learning comprehension during the learning process (Rondi & Amrullah, 2026).

Nevertheless, previous studies have generally focused on topics such as numbers, animals, and science, while the development of Augmented Reality-based concept books for introducing body parts to early childhood remains limited (Avdillah Ardi & Suhendar, 2023). In addition, the integration of 3D visualizations and interactive audio in concept book-based learning media has not been widely developed in accordance with the learning characteristics of early childhood. In fact, introducing body parts is an important basic concept because it is closely related to children's language development, motor skills, and self-awareness (Fathur Rojib & Ratnawati, 2024). Therefore, this study offers novelty through the development of an Augmented Reality-based body parts concept book integrating 3D visualizations and interactive audio in accordance with children's learning characteristics.

Therefore, innovative Augmented Reality-based learning media are needed to provide more contextual learning experiences in accordance with the characteristics of early childhood (Cheysa & Latupeirissa, 2026). In this study, the innovation was realized through the development of an Augmented Reality-based body parts concept book equipped with 3D visualizations and interactive audio to support early childhood learning processes. Based on

these needs, this study aimed to develop and examine the feasibility of an Augmented Reality-based body parts concept book as a learning medium for children.

RESEARCH METHODOLOGY

Research Design

This study employed the Research and Development (R&D) method to develop an Augmented Reality-based body parts concept book as a learning medium for early childhood. The development model used was ADDIE (Analysis, Design, Development, Implementation, and Evaluation) because it provides systematic stages that are suitable for the development of interactive learning media. The analysis stage was conducted to identify learning needs and the characteristics of early childhood, the design stage involved the planning of the media, the development stage consisted of the media production and validation process, the implementation stage was carried out through trials involving children, while the evaluation stage was conducted to assess the feasibility of the developed media.

Figure 1. ADDIE Model Research Framework

Media Development Procedure

The media development process began with an analysis of learning needs and the characteristics of early childhood, followed by the design of an Augmented Reality-based concept book. The media were developed using the Assemblr Edu application by utilizing three-dimensional (3D) object features and interactive audio. Each page of the book was equipped with markers that functioned to display interactive visualizations of body parts through the device used. After the media had been fully developed, validation was conducted by material and media experts before the product was tested on children.

Participants and Research Setting

This study was conducted at Baitushalihin Islamic Kindergarten, Banda Aceh, during the second semester of the 2026/2026 academic year, involving 17 children aged 4–5 years from Group A1 as the research subjects. In the large-group trial, all children in Group A1 were included using a total sampling technique. Meanwhile, the small-group trial involved 8 children selected through simple random sampling. The inclusion criteria were: (1) children aged 4–5 years and (2) children who had never previously used AR-based learning media.

Expert Validation

The validation process involved two permanent lecturers from the Faculty of Tarbiyah and Teacher Training, namely from the Early Childhood Islamic Education Study Program and the Information Technology Education Study Program, who served as the material expert and media expert. The validation instruments used the Guttman scale with "yes" and "no" response options for each assessment indicator. Material validation covered content suitability, concept accuracy, clarity of presentation, and appropriateness for early childhood characteristics, while media validation focused on visual appearance, design attractiveness, audio quality, and ease of use.

Research Instruments

The research instruments consisted of: (1) a material expert validation sheet containing 12 indicators, (2) a media expert validation sheet containing 17 indicators, and (3) a children's response observation sheet consisting of 4 indicators using a 4-point Likert scale. The instruments were developed based on feasibility indicators for early childhood learning media, covering content quality, media design, and developmental appropriateness.

Before implementation, all instruments were reviewed by expert validators to ensure content validity. The reliability of the children's response observation sheet was tested using inter-rater agreement between the researcher and the classroom teacher, resulting in an agreement percentage of 85%, indicating high reliability. Reliability testing for the expert validation sheets was not conducted due to the limited number of validators.

Media Trial Procedures

The media trial was conducted in two stages, namely small-group and large-group trials. The small-group trial involved 8 children who were randomly selected to obtain preliminary information regarding children's responses to the developed media. Subsequently, the large-group trial was conducted in a classroom setting involving all children in Group A1 to evaluate the practicality and feasibility of the media in actual learning activities.

Data Collection and Analysis

Data were collected through observation and questionnaires. Observation was used to identify children's engagement, interest, participation, understanding of the material, and responses during learning activities. Children's responses were assessed using a four-point Likert scale adapted to early childhood characteristics. The collected data were analyzed descriptively using percentage calculations to determine the feasibility level of the developed

learning media based on expert validation results and children's responses during the implementation stage. The assessment categories are presented in Table 2:

Table 1. Assessment Categories

Total Score	Category
4	Very Good
3	Good
2	Poor
1	Very Poor

The research data were analyzed using quantitative and qualitative descriptive analysis. Qualitative descriptive analysis was used to describe the media development process as well as the results of observations during the learning activities. Meanwhile, quantitative descriptive analysis was employed to calculate the percentage of media feasibility based on expert validation results and user trials. The percentage technique was used to determine the level of feasibility of the developed media. The formula used was as follows:

$$X = \frac{\sum M}{\text{Mm}} \times 100\%$$

Description:
X = Percentage
ΣM = Total score for each assessment aspect
Mm = Maximum score for each assessment aspect (Pangestu, 2026).

Table 2. Feasibility Criteria

Total Score	Category
82%-100%	Very Feasible
63%-81%	Feasible
44%-62%	Less Feasible
25%-43%	Not Feasible

RESULTS AND DISCUSSION

This research produced an Augmented Reality (AR)-based body parts concept book for early childhood following the ADDIE model: Analysis, Design, Development, Implementation, and Evaluation.

Analysis

Needs analysis revealed that body parts introduction in schools still relies on two-dimensional images and verbal explanations, which lack interactivity and fail to provide concrete learning experiences. This finding aligns with Piaget's theory that early childhood requires visual support and direct experiences to understand concepts (Al Munawaroh et al., 2023).

Furthermore, market analysis across YouTube, Shopee, and Google indicated that AR-based media specifically for body parts introduction in children aged 4–5 years remains unavailable. This gap confirms the novelty and urgency of the current research.

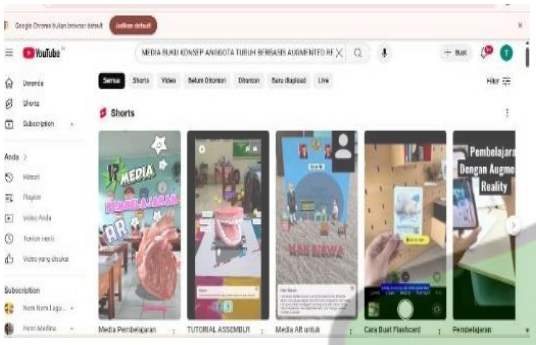


Figure 2. *YouTube Market Analysis*

Figure 3. *Shopee Market Analysis*

Figure 4. *Google Market Analysis*

The analysis results indicate that no AR-based media have been found that introduce body parts to children aged 4–5 years. These findings suggest that the development of Augmented Reality-based media for introducing body parts still has potential to be developed as an innovative learning tool for early childhood education. The selection of body parts as the learning content in this concept book was aligned with the Profile of Pancasila Students in the Merdeka Curriculum, particularly the dimension of independence, which emphasizes self-awareness (Gunawan et al., 2017). Through the introduction of body parts, children are able to recognize body parts and their functions, thereby supporting the development of self-awareness as a foundation for independence (Sartini et al., 2024). This indicates that the introduction of body parts not only supports children's cognitive development but also contributes to character building and self-awareness in line with the independent dimension of the Profile of Pancasila Students.

Based on the results of needs analysis, market analysis, and curriculum analysis, students require learning media that not only present static images but also provide more concrete learning experiences through animated visualizations, audio, and direct interaction (Wahidin, 2026). The analysis results also show that AR-based body parts introduction media for children aged 4–5 years are still limited, particularly those that integrate 3D visualizations

and interactive audio in the form of concept books. In contrast, early childhood learning characteristics require media that can simultaneously engage visual and auditory stimulation to make learning more engaging and meaningful (Fitriani, 2021). Therefore, the development of this Augmented Reality-based body parts concept book is designed as a learning innovation that enables students to see, hear, and understand the concept of body parts in a more concrete and interactive way (Mansour et al., 2026).

Design

After completing the analysis stage, the next stage was the design phase of the developed media. At this stage, the researcher developed the initial design of the body parts concept book and planned the integration of Augmented Reality (AR)-based media as a reference for product development (Samudra et al., 2023). The design process included organizing the material structure in accordance with early childhood characteristics, determining the sequence of content presentation, and designing visual elements such as images, colors, and layouts that are attractive and easy to understand (Dahlan et al., 2026). The selection of an attractive visual design aims to enhance children's attention and engagement during the learning process. The presented material not only introduces the names of body parts but also their basic functions, such as eyes for seeing, ears for hearing, hands for holding, and feet for walking (Husna & Soeandri, 2017). The presentation of the material aims to enable children to relate concepts to real-life experiences, thereby supporting cognitive development and contextual learning in accordance with the learning outcomes of early childhood education (Kemendikbud, 2022).

In addition, the researcher designed the Augmented Reality (AR) components by assigning markers on each page of the book, selecting full-body 3D models of body parts, and adding interactive audio in the form of simple explanations of the names and functions of body parts (Achmad et al., 2020). The integration of interactive audio in the media aims to help children understand the material through simultaneous visual and auditory stimulation. The use of AR in learning is designed to enhance children's engagement and provide a more concrete and interactive learning experience (Annisa, 2026). In addition, the researcher developed a user guide for the book as a reference to help users utilize the media effectively. The guide includes step-by-step instructions, starting from opening the book, scanning the markers using the application, to observing the displayed 3D visualizations and audio outputs. The results of this design stage served as the basis for the media development process to ensure alignment with the learning objectives.

In addition to designing the learning media, the researcher also developed research instruments used to assess the feasibility of the product being developed. The instruments included validation sheets from material experts and media experts to evaluate content relevance, presentation quality, visual appearance, and technical aspects of the media (Kurnia & Sunaryati, 2023). In addition, the researcher also developed a user response instrument through media trials involving early childhood participants, aiming to obtain data on the level of understanding, interest, and perceived usefulness of the developed media (Annisa, 2026).

Table 3. Initial Design of an Augmented Reality-Based Body Parts Concept Book for Early Childhood Education

Initial Design	Description
	Cover display of the Augmented Reality-based body parts concept book for early childhood education. The cover features illustrations of three children along with several images of body parts.
	Design of the AR-based body parts concept book page that contains body parts introduction material and AR markers as a medium for displaying 3D object visualizations.
	Design of the AR-based body parts concept book page that presents learning material about the human body and includes AR markers as a medium for displaying 3D object visualizations.
	An activity page in the Augmented Reality (AR)-based body parts concept book is designed to enhance children's engagement through matching activities, where children match body parts (chest and stomach) with the correct images.

Development

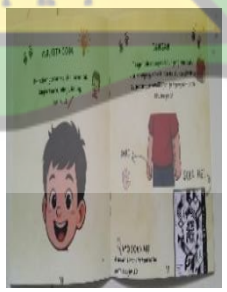
In the development stage, the initial design of the Augmented Reality (AR)-based body parts concept book was transformed into a functional learning media product. The development process included organizing body parts content along with their functions, creating attractive illustrations in accordance with early childhood characteristics, and designing learning activities that promote active child engagement. The development of

activities within the media aims to help children understand the concept of body parts through more interactive and enjoyable learning experiences.

The resulting product is an Augmented Reality (AR)-based body parts concept book measuring 15 × 15 cm, designed in accordance with early childhood learning characteristics. The book consists of a cover, foreword, user guide, introduction, body parts concept pages with AR markers, activity pages, references, author profile, and back cover, totaling 24 pages. The components of the book are systematically arranged to facilitate both independent and guided use by students and teachers in the learning process.

Next, the researcher integrated Augmented Reality (AR) technology into the book by adding markers on each page that are linked to three-dimensional (3D) objects and interactive audio. The AR media development was carried out using the Assemblr Edu application, which provides various features such as images, videos, audio, and 3D objects (Pangestu, 2026). In the development process, the researcher utilized 3D object and audio features to display visualizations of body parts along with interactive naming and explanation of their functions (Zulfikar, 2020). The integration of 3D visualization and interactive audio aims to help children understand the learning material through simultaneous visual and auditory stimulation, making the learning process more concrete and engaging for early childhood learners. The implementation of Augmented Reality (AR) in the media is demonstrated through the process of scanning markers using a device, which produces interactive three-dimensional (3D) visualizations as shown in the following figure:

Table 4. Augmented Reality (AR)-Based Body Parts Concept Book Media

Before	After
	
	

The developed product was then validated by material experts, media experts, and instrument experts (child response/try-out sheets) to assess the feasibility of the media in terms of content, appearance, developmental appropriateness, and ease of use of the Augmented Reality (AR)-based concept book. The validation process was conducted to ensure that the developed media aligns with early childhood characteristics and is suitable for use in the learning process. In addition, the validation process also aimed to obtain feedback and suggestions from the validators before the media was tested with students. The validation results were used as a basis for revising and improving the product so that the developed media would have better quality and align with the learning objectives. The following table presents the results of the material expert validation:

Table 5. Results of Material Expert Validation

No	Validation stage	Maximum score	Obtained score	Percentage of result
1.	Stage 1	12	6	50%
2.	Stage 2	12	12	100%

Based on the material expert validation results of the Augmented Reality (AR)-based body parts concept book, the first stage obtained a score of 6 out of a maximum score of 12, with a percentage of 50%, which falls into the "less feasible" category. These results indicate that the developed media still requires several improvements before being used in the learning process. The validator provided several suggestions for revision, including improvements to the foreword and introduction content, clarification of the user guide, and the addition of activities that can support children's engagement while using the learning media.

After revisions were made according to the validator's suggestions, the second stage obtained a score of 12 out of a maximum score of 12, with a percentage of 100%, which falls into the "very feasible" category. This improvement indicates that the developed media has undergone significant revisions and meets the feasibility criteria as an early childhood learning medium. Based on the validation results, the presented material was considered appropriate for children's developmental stage and characteristics. In addition, the simple, clear, and contextual presentation of the material was found to support children's understanding and engagement in the learning process.

Next, media validation was carried out by media experts as an assessment of the display aspects, technical usability, and quality of the developed learning media. The results of the media expert validation are presented in the following table:

Table 6. Results of Media Expert Validation

No	Validation stage	Maximum score	Obtained score	Percentage of result
1.	Stage 1	17	16	94,11%
2.	Stage 2	17	17	100%

Based on the first-stage media expert validation results, a score of 16 out of a maximum score of 17 was obtained, with a percentage of 94%, which falls into the "very feasible" category. These results indicate that the developed media has met the feasibility criteria in terms of display, visual quality, and ease of use. However, the validator still provided several suggestions for improvement, namely replacing the images with more appropriate visuals to better support children's learning so that the media becomes more optimal and aligned with early childhood characteristics.

After revisions were made in accordance with the validator's suggestions, the second stage obtained a score of 17 out of a maximum score of 17, with a percentage of 100%, which falls into the "very feasible" category. The improvement in validation results indicates that the developed media has met all feasibility criteria and is suitable for use in the learning process. In addition, the visual improvements made to the media were considered to enhance the quality of the presentation and support children's engagement during the use of the Augmented Reality (AR)-based learning media.

Implementation

At the implementation stage, the developed learning media that had been declared feasible was then tested with students through two phases, namely a small-group trial and a large-group trial. The use of the Augmented Reality (AR) media was carried out by preparing the device, opening the application, and scanning the marker until the three-dimensional (3D) object appeared. Next, children are guided to observe, name, and point to body parts according to the displayed visualization. This activity aims to help children understand the concept of body parts through more concrete and interactive learning experiences.

The large-group trial was conducted in a classroom setting involving 17 children through the use of Augmented Reality (AR) media using a laptop and a projector. At this

stage, the researcher operated the AR application by scanning the markers in the concept book, allowing three-dimensional (3D) body parts objects to appear and be displayed via the projector. The children observed the visualization together and were then given opportunities to respond, name, and point to body parts according to the displayed visualizations. The researcher acted as a facilitator guiding the learning process, while the classroom teacher served as a companion in managing and supporting the students during the activity. In addition, the researcher conducted observations of children's engagement and responses as initial evaluation data on the use of Augmented Reality (AR)-based learning media.

Data were collected through observation activities and assessment sheets used to determine children's responses during the learning process. The observation was conducted to examine the level of children's interest and engagement in the use of Augmented Reality (AR)-based learning media. The results of the children's response assessment in the large-group classical trial are presented in the following table:

Table 7. Children's Responses in the Class-Wide Trial

Category	Total
Total Score	275
Maximum score	340
Percentage	80,88%
Result	**Feasible**

The results of the children's response assessment in the large-group class-wide trial of the Augmented Reality (AR)-based body parts concept book showed that, from 17 children, a total score of 275 out of a maximum score of 340 was obtained, with a percentage of 80.88%, which falls into the "feasible" category. These results indicate that the developed learning media can be used in the learning process and is able to attract children's attention and enhance their engagement during the activity (Fathur Rojib & Ratnawati, 2024).

Next, the small-group trial was conducted involving 8 randomly selected children to obtain more specific data regarding children's responses to the use of Augmented Reality (AR)-based learning media. At this stage, the researcher prepared the required equipment, including the body parts concept book and a device installed with the AR application. The children were then guided to open the application, scan the markers on the concept book pages, and observe the three-dimensional (3D) visualizations of body parts displayed on the device screen.

In the small-group trial, children were given the opportunity to use the media independently with guidance from the researcher. They were also directed to name and point to body parts according to the displayed visualizations. The researcher observed children's ability to operate the media, understand the learning content, as well as their responses and engagement during the learning process. In addition, the researcher also asked oral questions at the end of the activity to obtain additional information regarding children's enthusiasm and learning experiences in using Augmented Reality (AR)-based learning media. The results of the children's response assessment in the small-group trial are presented in the following table:

Table 8. Children's Responses in the Limited (Random) Trial

Category	Total
Total Score	146
Maximum score	160
Percentage	91,25%
Result	Very Feasible

The results of the children's response assessment in the small-group trial showed a total score of 146 out of a maximum score of 160, with a percentage of 91.25%, which falls into the "very feasible" category. These results indicate that the developed Augmented Reality (AR)-based learning media is able to attract children's attention and enhance their engagement in the learning process (Cucu Atikah, Isti Rusdiyani, 2023). Based on the results of the large-group and small-group trials, there was a difference indicating an improvement in the quality of the learning media usage. In the large-group trial involving 17 children, a percentage of 80.88% was obtained, which falls into the "feasible" category, whereas in the small-group trial involving 8 children, a percentage of 91.25% was obtained, which falls into the "very feasible" category. The difference in the results indicates that the Augmented Reality (AR)-based body parts concept book is able to better support children's engagement and understanding, making it suitable for use in early childhood learning.

Evaluations

At the evaluation stage, the Augmented Reality (AR)-based body parts concept book was assessed based on expert validation results, trial outcomes, and user responses to the developed media. The evaluation results indicate that the media falls within the feasible to very feasible category for use in early childhood learning. In the large-group trial involving 17 children, a percentage of 80.88% was obtained, which falls into the "feasible" category, whereas in the small-group trial involving 8 children, a percentage of 91.25% was obtained, which falls into the "very feasible" category. These results indicate an improvement in the quality of media use when children interact more directly with the Augmented Reality (AR)-based learning media.

In addition, the observation results showed that the developed media was able to attract attention, increase engagement, and help children understand the concept of body parts in a more concrete and interactive way. These findings indicate that the use of Augmented Reality (AR)-based media can support a more engaging learning process that is in line with the learning characteristics of early childhood learners. However, several constraints were encountered during the learning implementation, such as network stability, the marker scanning process, and classroom management when using the projector. Therefore, these evaluation results served as a basis for improving the media to ensure more optimal use, particularly in terms of usage stability and ease of access in learning activities.

This research showed that the feasibility of AR-Based Body Parts Concept Book is very high. The high validation scores (100% from both experts) indicate that the developed media meets quality standards from content, visual, and technical perspectives. These results are consistent with previous studies on AR-based learning media for early childhood

(Ningrum & Nur (2023):Anggreani & Satrio (2021). However, the perfect score of 100% warrants critical examination. It may reflect not only the media's high quality but also the relatively lenient nature of the Guttman-scale instrument (yes/no options), which offers limited discrimination among indicators. Future studies should employ Likert-scale instruments with multiple response categories to capture more nuanced evaluations.

In the meantime, observational data revealed that children showed enthusiasm, asked questions, and voluntarily pointed to body parts displayed through AR visualizations. This finding supports the claim that AR media captures attention and promotes engagement. Nevertheless, the current study cannot conclusively determine whether this engagement translates into deep conceptual understanding or remains at the level of novelty-driven interest. As noted by Rondi & Amrullah (2026) the "wow effect" of AR technology may temporarily increase attention without guaranteeing long-term retention or comprehension. Therefore, while the media demonstrates potential, claims regarding its impact on learning outcomes require empirical verification through pretest-posttest designs.

The current study extends previous AR research in several ways. Unlike Ningrum & Nur, (2023) who focused on number recognition, or Anggreani & Satrio (2021) who developed flashcards for general vocabulary, the present study specifically addresses body parts introduction that is a foundational concept for self-awareness and personal safety. Additionally, the integration of 3D full-body visualizations combined with interactive audio represents a more immersive approach compared to prior studies that used static 3D objects without auditory support. However, unlike the study by (Cucu Atikah et al, 2023) which included a pretest-posttest design, the current research did not measure learning gains, limiting its ability to make comparative claims about effectiveness.

From Piaget's perspective, AR technology offers a form of "digital concrete experience" that bridges the gap between symbolic representation (two-dimensional images) and tangible experience (real objects). Children in the preoperational stage (ages 2–7) benefit from visual and auditory stimuli that make abstract concepts more accessible. The AR-based book provides repeated, consistent, and engaging exposure to body parts concepts without requiring physical manipulatives. Nevertheless, educators should view AR media as a supplement to, not a replacement for, direct hands-on experiences and social interaction.

Several technical constraints emerged during implementation. First, marker scanning required stable lighting conditions and optimal camera angles, which were not always achievable in classroom settings. Second, projector-based display in the large group trial reduced image clarity and delayed response time, potentially affecting child engagement. Third, internet connectivity issues occasionally interrupted the AR application's performance. These practical barriers suggest that AR media implementation requires adequate technical infrastructure and teacher training.

CONCLUSION

This study demonstrates that the development of an Augmented Reality (AR)-based body parts concept book is feasible for use in early childhood learning and supports concrete learning experiences through the integration of visual and audio elements that facilitate children's conceptual understanding. The findings reinforce Piaget's perspective that young

children learn more effectively through concrete and interactive experiences, with AR functioning as a form of digital hands-on learning. However, several limitations should be considered, including the limited sample size, the absence of a comparison group and pretest–posttest design, the potential for observer bias due to the researcher's dual role, and constraints in individual interaction during implementation. Therefore, future studies are recommended to employ more rigorous experimental designs, develop AR applications that can be accessed independently by children, and conduct broader trials across diverse educational settings to strengthen the evidence base and improve the generalizability of findings.

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