Englisia
Journal of Language, Education and Humanities
ISSN:
2089-6239 (Print)
2549-0648 (Online)

Developing augmented reality flashcards for English vocabulary instruction in Indonesian early childhood education: An ADDIE model feasibility study

ABSTRACT - This study was motivated by persistent challenges in early childhood English vocabulary acquisition, wherein conventional pedagogical tools remain widely used and frequently result in suboptimal learning outcomes. A preliminary problem analysis revealed that limited media diversity and minimal integration of digital technologies contribute to low learner engagement. A subsequent needs assessment further underscored the demand for visual, interactive learning media tailored to the developmental characteristics of early childhood learners. Market analysis indicated a notable scarcity of Augmented Reality (AR)-based flashcard media specifically designed for English vocabulary instruction at the early childhood education level. In response to these identified gaps, this research aimed to develop and evaluate the feasibility of AR-based flashcard learning media for early childhood English vocabulary acquisition. Employing a Research and Development (R&D) methodology structured around the ADDIE model, the study involved 16 children from Group TK B at a PAUD in Nagan Raya. Evaluation results demonstrated high feasibility, with validation scores from media experts (97.5%) and material experts (100%) exceeding the positive response rates from children, which ranged from 91.7% to 100%. All measured metrics fell within the "very feasible" category. Implementation challenges included unstable internet connectivity, prolonged AR scanning durations, and a shortage of supporting devices. Notwithstanding these limitations, the findings conclude that Augmented Reality-based flashcards constitute a highly viable and effective medium for introducing English vocabulary to young learners.

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Article History
Submitted: 14 January 2026
Accepted: 26 April 2026
Published: 31 May 2026

Keywords
Augmented reality; Flashcard; English vocabulary; Early childhood

Recommended APA Citation
Kosniawati., Fitriani, D., Aziz, U. B. A., Azizah., & Andriansyah. (2026). Developing augmented reality flashcards for English vocabulary instruction in Indonesian early childhood education: An ADDIE model feasibility study. *Englisia: Journal of Language, Education, and Humanities, 13*(2), 658-676. https://doi.org/10.22373/englisia.173

1. Introduction

Language serves a fundamental role in human life, functioning as an essential tool for thought, communication, and the expression of emotions and ideas (Ningrum et al., 2024). Within education, language extends beyond being a subject of study to become a vital instrument for developing students' social, emotional, and cognitive capacities (Mazidah et al., 2025). English occupies a particularly strategic position in this global context. As the predominant international language, it is extensively utilized in worldwide developments in science, technology, and communication (Lubis et al., 2024). Consequently, proficiency in English represents a critical competency that must be cultivated from an early age.

The introduction of English in early childhood is particularly appropriate, as this period represents an optimal stage for language development. Children aged 0 to 6 years are within the "golden age" a critical phase marked by the brain's rapid capacity for absorbing information (Angelica, 2023). During this window, children are naturally predisposed to acquire the sounds, vocabulary, and meanings of language through direct experience. Supported by language acquisition theory, learning occurs most effectively through interaction, repetition, and meaningful context rather than through rote memorization (Pransiska, 2020).

From a language acquisition theory perspective, the behaviorist approach emphasizes that children learn language through stimulus, response, and reinforcement, making repetition of vocabulary through media crucial. Meanwhile, the nativist theory, pioneered by Noam Chomsky, states that children possess an innate language acquisition device (LDA) that allows them to naturally understand language structures. Interactionist theory emphasizes that language acquisition occurs through social interaction and meaningful contexts. All three theories suggest that effective language learning must involve repetition, direct experience, and active interaction (Zhao, 2022).

In line with this theory, the use of Augmented Reality (AR) technology is able to integrate these three approaches, namely through the presentation of visual-audio stimuli (behaviourist), the provision of a language-rich learning environment (nativist), and direct interaction between children and learning objects (interactionist).

Introducing vocabulary to children helps them speak and communicate with each other (Chaniago et al., 2021). All aspects of language skills are interrelated and are very important for the ability to send and receive information during the communication process (Harianto, 2020). Children can learn and use language skills if they have mastered the language. When young children acquire good language skills, they will more easily understand the intentions and messages of others (Dini hari et al., 2021).

However, the effectiveness of English vocabulary learning in young children is heavily influenced by the media and teaching strategies employed. Young children learn through play, are easily bored, and respond well to engaging visuals (Losi & Ferusgel, 2021). Therefore, selecting appropriate learning media is crucial for creating effective learning experiences.

One widely used visual medium for teaching English vocabulary to young children is flashcards. Flashcards are picture cards that contain text, symbols, or illustrations, helping children remember and understand vocabulary through visual association (Warda & Kumalasari,

2023). However, conventional flashcards have limitations, particularly in creating interactive and immersive learning experiences. These limitations indicate a gap between the need for interactive language learning and the media used in the field. Therefore, the research problem in this study is the suboptimal use of innovative, technology-based media to improve English vocabulary mastery in early childhood (Yuniarto, et al,. 2025).

The evolution of learning media has been propelled by digital technology, including Augmented Reality (AR) (Dini et al., 2021). AR technology integrates two-dimensional or three-dimensional virtual objects into the real world in real time, allowing users to interact with these objects as if they were physically present (Ismayani, 2020). In the context of early childhood education, international research shows that AR can increase engagement, motivation, and conceptual understanding. Published studies have shown that AR is effective in improving learning outcomes through visual-interactive experiences (Oranç & Küntay 2019). Furthermore, research reported that AR holds significant potential for personalized, immersive, and inclusive education, provided its implementation is guided by pedagogically sound practices and ethical standards (Samuel., 2025). Another findings suggest that augmented reality applications can be a powerful tool for enhancing children's understanding of environmental concepts in early childhood education (Şimşek, 2024).

AR flashcards enable children to see objects in three-dimensional form and hear vocabulary pronunciation, allowing them to not only see but also hear and understand words in context (Padwika et al., 2023). This is in line with the multisensory learning theory, which states that the involvement of more than one sense (visual, auditory, kinesthetics) can increase the effectiveness of learning, especially in early childhood. Observations at a PAUD in Nagan Raya indicate that English vocabulary instruction still relies on conventional media such as whiteboards, posters, and simple songs. So, it is less interesting and makes children bored quickly.

Numerous previous studies have demonstrated that Augmented Reality-based learning media are effective, valid, and practical for early childhood education. Research by (Elvina et al., 2024) shows that AR-based thematic flashcards are valid and effective in enhancing the learning experience of children aged 5-6 years. Aisya and Wiranti (2024) also proved that using AR flashcards significantly improves student learning outcomes. Additionally, Utami et al. (2021) reported that AR-based flashcard media effectively increase attention and focus in early childhood learning. However, previous research has not specifically integrated language acquisition theory with the development of AR media for English vocabulary learning in early childhood, so this research has novelty in theoretical and practical aspects.

In line with these studies, this research also develops innovative AR flashcard media for learning. However, it differs in its focus on developing media specifically to introduce English vocabulary to young children using the ADDIE model. This study emphasizes feasibility testing by verifying the media with material experts, media experts, and teacher practitioners. Furthermore, the developed media includes three-dimensional audio and visual vocabulary pronunciations tailored to children's characteristics and learning experiences. Thus, this research

not only confirms the feasibility of AR media but also contributes to developing appropriate and suitable learning tools for early childhood.

Based on this background, it is essential to develop Augmented Reality-based flashcard learning media for teaching English vocabulary to young children. It is hoped that this media will not only help children learn English vocabulary in an enjoyable way but also assist educators in creating a learning environment that is innovative, interactive, and aligned with the demands of the digital era. This research aims to contribute to the development of English language learning theory and practice in early childhood education.

2. Literature review

English vocabulary learning in early childhood is a crucial part of language development, influenced by various factors, such as cognitive readiness, the learning environment, and the media used in the learning process. Early childhood learning is characterized by concrete, visual learning, and the need for direct experience. Therefore, learning must provide engaging and meaningful experiences to enhance comprehension and retention of new vocabulary (Bella, 2021).

In supporting this process, learning media plays a crucial role as a means of delivering material that can help children grasp concepts more easily. The right media not only functions as an aid but also can increase children's motivation, attention, and active engagement in learning activities. Along with technological advancements, the use of learning media has also undergone innovation, one example being the use of Augmented Reality (AR) technology, which can provide a more interactive and concrete learning experience through three-dimensional object visualizations and audio support (Oranç & Küntay 2019)

2.1. Theory of language acquisition in early childhood

Language acquisition in early childhood is a complex process involving the interaction of biological, cognitive, and environmental factors. Behaviourist theory emphasizes that language is learned through a process of stimulus, response, and reinforcement, making repetition and stimulus delivery crucial in vocabulary learning (Syifiyanti et al., 2025). In the context of English learning, this approach is relevant because early childhood tends to learn through imitation and reinforcement from the environment (Pransiska, 2020).

On the other hand, the nativist theory pioneered by Noam Chomsky states that children possess an innate language acquisition device (LAD) that allows them to naturally grasp language structures. However, this ability still requires adequate environmental stimulation to develop optimally (Asroriyah, et al 2026). Interactionist theory emphasizes that language acquisition occurs through social interaction and meaningful experiences. Children learn language through direct communication with their surrounding environment, both with teachers and peers (Suryadi, 2025).

These three theories demonstrate that effective language learning must involve engaging stimuli, hands-on experience, and active interaction. Therefore, the use of interactive and contextual learning media is essential to supporting early childhood language development.

2.2. Learning media in introducing English vocabulary

Learning media plays a crucial role in improving the quality of the learning process, especially for young children who are characterized by visual and kinesthetics learning styles. The right media can help increase children's attention, interest, and understanding of learning materials (Safitri, M., et al 2023). Flashcards are a common medium used in vocabulary learning because they effectively help children associate images with words. Furthermore, the use of visual media has been shown to improve children's retention of new vocabulary. Flashcards help children understand vocabulary through concrete visual representations. This medium is effective because it aligns with the characteristics of young children, who understand information more easily through images than through text (Nurkhakiki., et al., 2025).

2.3. Augmented reality in early childhood education

Augmented Reality (AR) is a technology capable of integrating virtual objects into the real world in real time, creating a more concrete and interactive learning experience. In an educational context, AR can increase student motivation and engagement in the learning process (Resti et al., 2024). The use of AR in early childhood learning has been proven to improve understanding of concepts through more interesting visual and audio experiences. In addition, AR also supports multisensory learning that involves more than one sense, so that the learning process becomes more effective. AR has the advantage of presenting learning objects in three dimensions and integrating visual and audio elements simultaneously (Rondi & Amrullah, 2025). This can significantly increase children's attention and learning motivation. In language learning, AR allows children to see objects directly in three dimensions and hear the pronunciation of words, thus helping children understand vocabulary in a more real context (Wulandari et al., 2025).

2.4. Research gap

Several studies have shown that the use of Augmented Reality-based media in early childhood education produces positive results. Previous research has shown that AR flashcards are effective in improving children's attention, motivation, and learning outcomes (Utami et al., 2021). In addition, AR media is also considered valid and practical for use in learning and is able to increase active student involvement. Although various studies have proven the effectiveness of AR media, most studies still focus on the development and learning outcomes aspects without deeply integrating language acquisition theory as the basis for media development (Nugroho et al., 2025). Based on this gap, this study developed AR flashcard media that not only focuses on the technological aspect, but also integrates language acquisition theory so that it is more appropriate to the learning characteristics of early childhood.

3. Method

This research uses development research, also known as Research and Development (R&D) with ADDIE Model.

Figure 1. ADDIE model

The ADDIE model used in this study consists of five main stages, namely Analysis, Design, Development, Implementation, and Evaluation, each of which is explained operationally so that the research can be replicated as follows (Waruwu, 2024):

a. Analysis stage

At this stage, a needs analysis was conducted through direct observation at a PAUD in Nagan Raya. Observations focused on: (a) the types of media used by teachers, (b) the level of child engagement, (c) children's difficulties in understanding English vocabulary, and (d) the availability of digital media. Additionally, an analysis of the curriculum and developmental characteristics of children aged 5–6 years was conducted (Sakinah & Maulana, 2026).

b. Design stage

The design stage includes: (a) determining the objectives of learning English vocabulary, (b) selecting materials (flower themes), (c) designing a flashcard storyboard, (d) designing the visual appearance, colour, and size of the cards, and (e) designing the flow of media use by teachers and children. The design also includes the integration of pronunciation audio and AR-based 3D objects (Putu et al., 2024).

c. Development stage

At this stage, product creation was carried out using the Canva application for visual design and Assemblr EDU for Augmented Reality integration. The resulting product was then validated by experts. The research instrument was developed through several stages: (1) compiling a grid based on the theory of learning media and early childhood development, (2) compiling statement items, (3) testing content validity by experts (content validity), and (4) revising the instrument (Ramdan et al., 2025).

d. Implementation stage

Media is implemented in learning activities with learning procedures including: (1) the teacher introduces vocabulary using flashcards, (2) the teacher demonstrates how to scan AR,

(3) children take turns using the media, (4) children mention and repeat vocabulary, and (5) the teacher provides reinforcement. Activities are guided directly by the class teacher (Novita et al., 2025).

e. Evaluation stage

Evaluation is conducted both formatively and summative. Formative evaluation is conducted at each stage of development through revisions based on expert input. Summative evaluation is conducted after implementation by analysing validation results, child responses, and obstacles to media use (Magdalena, et al., 2020).

This study involved 16 children from Kindergarten Group B at a PAUD in Nagan Raya as research subjects who participated in a media trial during the odd semester of the 2025/2026 academic year. The trial was conducted on a medium scale due to the number of students involved (Jailani, 2023).

The data collection techniques in this study used observation and feasibility testing. The instruments used to collect data were an observation sheet and a feasibility testing questionnaire. The observation sheet was used to analyse needs. Then, a questionnaire was used to evaluate the feasibility of the developed AR flashcard for teaching English vocabulary to early childhood. Product feasibility was assessed using a percentage score; a higher score indicates a more feasible product (Dewi, 2020). The usability of this AR flashcard learning media was evaluated through assessments from material and media experts, and the media's feasibility was also tested in the field by teachers. The material expert validator was a lecturer from the Early Childhood Islamic Education Study Program, the media expert validator was a lecturer from the Information Technology Education Study Program, and the media and material validator were a teacher practitioner at a PAUD in Nagan Raya to measure the feasibility of the AR flashcard learning media.

The data analysis technique used was product feasibility analysis. The steps for analyzing the product's feasibility criteria being developed included calculating the feasibility percentage using a Likert Scale (Sugiyono 2016, cited in Mahardika et al., 2022).

The formula used is as follows:

$$\boldsymbol{NP = \frac{R}{SM} X\ 100\%}$$

Sugiyono 2016, cited in Happynis et al. (2025)

Description:

NP : Percentage value sought

R : Score from the respondent's answer

SM : Maximum score from the test used

Table 1 presents a classification of learning media feasibility criteria based on the percentage of assessment scores. These criteria serve as a basis for assessing the feasibility of

the developed product, enabling evaluation results to be categorized systematically and quantitatively.

Table 1
Feasibility criteria.

Percentage	Criteria
82%-100%	Highly feasible
63%-81%	Feasible
44%-62%	Less feasible
25%-43%	Not feasible

Sugiyono 2017 cited in Utami et al. (2021)

Table 2 presents the assessment instruments used by media experts to evaluate the quality of AR-based flashcard media. The assessment covers aspects of visual appearance, material safety, size, colour compatibility, and ease of use in supporting early childhood learning.

Table 2
Media expert validation rubric.

Aspects assessed	Assessment Indicators
Cover	The Augmented Reality Flashcard display is appropriate and engaging for children
Material	The safety level of the materials used is appropriate and safe for children.
Size	The size of the Augmented Reality Flashcard is appropriate and safe for children
Colour	The colours on the Augmented Reality Flashcard are appropriate and engaging for children.
Use of Flashcard (AR) media	The use of Augmented Reality Flashcards in learning is appropriate for children

Fitriani et al. (2021)

Table 3 explains the assessment indicators used to assess the suitability of the material presented in the Augmented Reality flashcard media. The evaluation was conducted by considering the material's suitability to the learning objectives, the English vocabulary introduction theme, the developmental level of the early childhood, and the clarity of the presentation.

Table 3
Material experts validation rubric.

Assessment Indicators
The material presented in the Augmented Reality Flashcards is tailored to the desired learning objectives.

The material presented in the Augmented Reality Flashcards aligns with the learning theme, namely introducing English vocabulary for early childhood, and is presented in an engaging way.
The material in the Augmented Reality Flashcards is tailored to the child's developmental age.
The material presented is clear and aligns with the title of the Flashcard.

Fitriani et al. (2021)

Table 4 presents the indicators used to measure children's responses to AR-based flashcard media. These indicators include children's ability to understand vocabulary, remember information, and improve their listening and pronunciation skills in English.

Table 4
Rubric for children's response.

Assessment Indicators
Children are able to understand and recognize the vocabulary contained on the Flashcards
Children are able to remember and repeat the information on the flashcards well.
Children are able to improve their listening and pronouncing skills on the vocabulary contained in the Flashcards.

Fitria et al. (2024)

4. Findings and discussion

This research produces a product, which is a Flashcard learning media, converted into an Augmented Reality (AR) Flashcard, namely a flashcard that displays 3D images when scanned by a cell phone (Anggreani & Satrio, 2021). This media was developed to introduce English vocabulary to young learners at a PAUD in Nagan Raya. To measure the media's feasibility, validation tests were conducted by material experts, media experts, and ECE teacher practitioners, as well as trials with children aged from five to six years old of a PAUD in Nagan Raya.

In the analysis phase, researchers conducted a field needs analysis of the use of English vocabulary learning media at a PAUD in Nagan Raya. The analysis results showed that the learning process is still dominated by conventional media, such as whiteboards, songs, and posters. Based on initial observations, schools have not yet utilized digital-based learning media, so vocabulary learning tends to be less varied and has the potential to reduce children's interest in learning. This condition indicates a need for more innovative and engaging learning media for early childhood. Furthermore, market analysis results indicate that Augmented Reality (AR)-based Flashcard media for introducing English vocabulary to early childhood learners is not yet widely available. These findings indicate the need for innovative AR Flashcard media that is appropriate to the developmental characteristics of early childhood (Rifqy & Wahyudi, 2025).

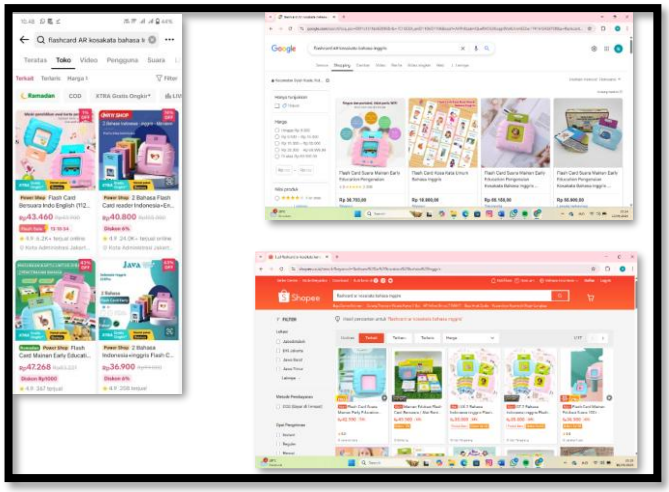

Figure 2. Market analysis (TikTok shop, google, and shopee)

In the design stage, researchers adapted the Augmented Reality (AR)-based Flashcard media to the learning needs and characteristics of early childhood. This included determining English vocabulary content, creating visual illustrations for the Flashcards, and planning the use of Augmented Reality technology to support learning. Furthermore, the media usage flow was designed in a way that was easy for both teachers and children to understand (Sukmawan et al., 2024). At this stage, a Flashcard media design plan based on Augmented Reality (AR) was developed, which became a reference for the next development stage.

In the development phase, the Flashcard media has been adapted to Augmented Reality (AR)-based development. Flashcard visuals were developed using the Canva app, and AR technology was integrated through the Assemblr EDU app. This media displays interactive visual objects and includes audio pronunciations of English vocabulary that correspond to those objects (Karina, 2025).

Before revision
Cover and box

After revision
Cover and box

Figure 3. Cover and box before and after revision

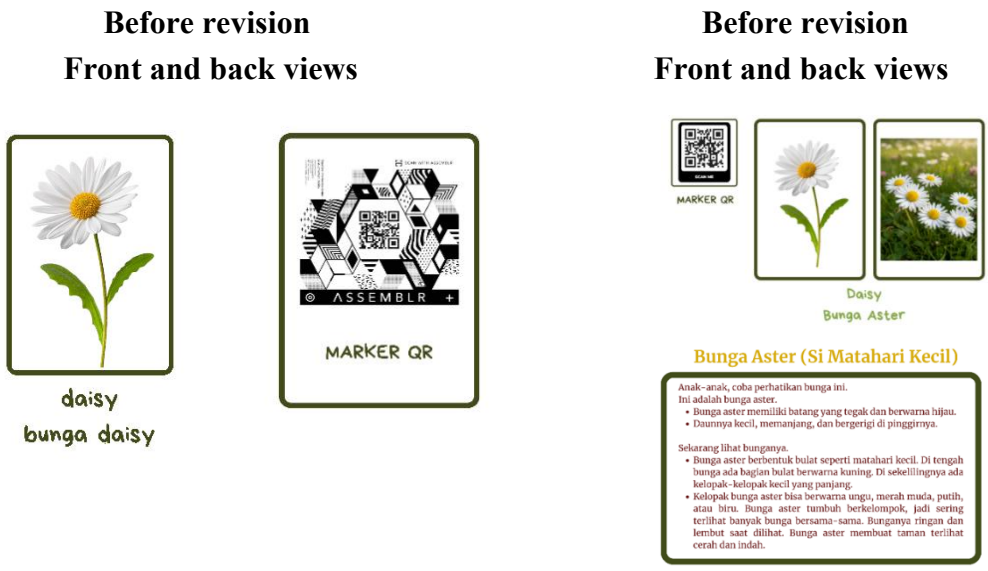

Figure 4. Front and back view before and after revision

The results of this development stage after revision are: 1) The cover was simplified by removing one tree element. 2) The animated image of a child on the box was removed. 3) The front of the flashcard features a flower illustration, a photo of a real flower, and an AR barcode. 4) The back contains a brief description of the flower. 5) The media is equipped with an audio pronunciation of the flower name.

Table 5
Media expert validator results.

Aspect	Category	Quantity
Lecturer Media	Total Score	20
	Maximum Score	20
Teacher Media	Total Score	19
	Maximum Score	20
	Percentage	97,5%
	Results	Highly feasible

Based on the validation results in Table 5, media expert lecturers gave the maximum score (20 out of 20), while teacher practitioners gave the maximum score of 19 out of 20, categorized as "Highly feasible " Further analysis based on indicators (appearance, material, size, colour, and media use) showed that the size indicator received a lower score in the teacher assessment.

This indicates that the media size still needs to be adjusted to the characteristics of early childhood and comfort in classroom use, as it can affect visibility, ease of handling, and effectiveness. Meanwhile, other indicators achieved maximum scores, indicating the media met the design, safety, and ease-of-use requirements.

Thus, even though the media is classified as "Highly feasible", there is still one aspect that needs to be improved, namely the size of the media to make it more optimal for learning.

Table 6
Material experts validator result.

Aspect	Category	Quantity
Lecturer Material	Total Score	16
	Maximum Score	16
Teacher Material	Total Score	16
	Maximum Score	16
	Percentage	100%
	Results	Highly feasible

Based on Table 6, the validation by subject matter experts showed a perfect score (16/16) from lecturers and teacher practitioners, with a percentage of 100%. Analysis per indicator (appropriateness of learning objectives, themes, child development, and clarity of presentation) showed that all indicators received maximum scores, so no aspects were rated lower.

This indicates that the material aligns with the learning objectives and characteristics of early childhood, and is presented clearly. However, the consistent scores also indicate that the assessment instrument is unable to capture subtle differences between indicators. Therefore, more detailed instruments are needed in future research to more specifically evaluate the quality of the material.

Based on the validation results from media and material experts presented in Tables 5 and 6, the Augmented Reality (AR)-based flashcard media achieved a very suitable percentage. These results indicate that the developed media meet the criteria for visual appearance, material suitability, and ease of use in learning activities. The interactive, engaging AR-based flashcard design can increase young children's attention and help them understand and master English vocabulary (Saputra et al., 2025). However, these results not only demonstrate the technical feasibility of the media but also need to be interpreted more critically, taking into account the context of use and student characteristics. A high percentage does not necessarily indicate absolute effectiveness without considering individual student factors.

In the implementation phase, Augmented Reality (AR)-based flashcards media was applied in English vocabulary learning activities at a PAUD in Nagan Raya. During the lesson, students demonstrated high enthusiasm and active engagement when the teacher introduced and explained how to use AR flashcards. The students appeared captivated by the three-dimensional visuals and animations that emerged from the flashcards, which focused their attention on the material being presented (Novita et al., 2024).

Furthermore, students followed the instructions well, such as observing the displayed AR objects and naming English vocabulary according to the images. This active engagement demonstrates that the AR flashcard media can create a fun, interactive learning atmosphere aligned with the developmental characteristics of early childhood. This supports the understanding of English vocabulary and increases students' motivation during learning. The implementation phase showed that the AR flashcard media can be used appropriately as a supporting medium for early childhood English learning.

Table 7
Percentage details of child trial results.

Respondents	P1-P3 Statements			Total Score	Maximum Total	Percentage
	P1	P2	P3			
CAJ	4	4	4	12	12	100%
ANO	4	4	4	12	12	100%
ENP	4	4	4	12	12	100%
NH	4	4	4	12	12	100%
KA	4	4	4	12	12	100%
AF	4	4	4	12	12	100%
AA	4	4	4	12	12	100%
AKM	4	4	4	12	12	100%
KH	4	3	4	11	12	91,7%
MG	4	4	4	12	12	100%
AR	4	4	4	12	12	100%
ASA	4	4	4	12	12	100%
ANR	4	4	3	11	12	91,7%
ANH	4	4	4	12	12	100%
NSR	4	4	4	12	12	100%
ER	4	4	3	11	12	91,7%

The test results showed that not all children achieved the maximum score. Some children scored 91.7%, while others achieved 100%. This difference indicates individual variation in the learning process. Children who scored lower were likely influenced by factors such as different levels of attention, limited prior experience with English vocabulary, and differences in cognitive and language abilities. Furthermore, situational factors such as limited media usage time and distractions in the learning environment could also influence these results.

With a relatively small sample size (n=16), a change in one respondent can affect the percentage by 6.25%. Therefore, the difference between 91.7% and 100% should not be interpreted as significant, but rather as a small variation that is common in a small-scale study. Thus, this variation in results cannot be interpreted as a weakness of the media, but rather as a natural characteristic of early childhood learning which is heterogeneous and contextual.

The evaluation phase examined the use of Augmented Reality (AR) Flashcard media during learning activities, including technical constraints and student responses. Based on the observation results, several obstacles were identified during media implementation, including an unstable internet connection, which caused the AR barcode-scanning process to experience a relatively long loading time. In addition, when children waited for their turn to scan, some appeared a little noisy and less orderly. There were also instances in which children gathered to watch the scanning process simultaneously, which disrupted the lighting and affected the appearance of the AR object on the cell phone screen. Nevertheless, when the scanning process succeeded and the Augmented Reality object appeared, the children showed great enthusiasm.

This was shown through expressions of amazement and spontaneous comments such as "Miss, how come it can appear on the cell phone but not on the card," "Miss has a voice," and "Great, Miss, it can appear like that, cool."

These responses show that AR Flashcard media is able to attract attention, arouse curiosity, and provide meaningful learning experiences for early childhood (Dhea Meichika, 2025). Despite technical constraints during implementation, Augmented Reality-based Flashcard media is still considered feasible and effective in creating interactive and enjoyable English vocabulary learning (Saputra, et. al., 2025). Thus, children's responses and behaviour during the use of AR Flashcard media reflect the important roles of the learning environment and concrete stimuli, and it is relevant to analyze them based on theories of language acquisition and children's cognitive development.

From the perspective of behaviourist theory pioneered by B.F. Skinner, children's success in recognizing vocabulary can be explained through stimulus-response and reinforcement processes. AR media acts as a powerful stimulus through a combination of visuals and audio, thereby strengthening children's vocabulary memory. However, the variation in results indicates that not all children receive reinforcement with the same intensity, thus affecting their learning outcomes (Warmadewi, et al., 2021). From a cognitive perspective, according to Jean Piaget, early childhood is in the preoperational stage, requiring concrete objects to understand concepts. AR media, which displays 3D objects, facilitates the assimilation and accommodation processes. However, differences in the pace of cognitive development among children lead to inconsistent learning outcomes (Khotimah & Agustini, 2023).

Meanwhile, Noam Chomsky's nativist theory explains that every child has an innate ability to acquire language, but the development of this ability is heavily influenced by environmental stimuli. AR media provides a stimulus-rich environment, but its effectiveness still depends on the individual child's readiness to process language (Dash, 2023). The integration of these three theories shows that learning using AR is not only feasible because of the technology, but also because of its ability to provide stimuli, concrete experiences, and a learning environment that supports children's holistic language development.

The results of the development process in this study indicate that Augmented Reality (AR)-based Flashcard media is highly suitable for teaching English vocabulary to young children. By integrating three-dimensional visuals and audio vocabulary pronunciation, this media has the ability to produce a concrete, interactive, and engaging learning experience. These findings indicate that AR Flashcards not only support young children's learning but also align with language acquisition theories that emphasize the roles of the environment, multisensory stimuli, and concrete objects in helping children better understand and remember English vocabulary.

6. Conclusion

This study concludes that the development of Augmented Reality (AR)-based flashcard learning media, structured around the ADDIE model, produces a highly feasible and effective product for introducing English vocabulary to early childhood learners. Validation by material

and media experts demonstrated a very high level of feasibility, while trials with children yielded strongly positive responses. The media has been shown to increase children's engagement, attention, and ability to comprehend and pronounce English vocabulary through an interactive and enjoyable learning experience. Theoretically, these findings strengthen and extend the understanding of AR technology integration in early childhood learning, particularly in the domain of language acquisition. AR media not only supports the behaviorist approach through stimulus-response mechanisms but also aligns with nativist and interactionist theories by providing a learning environment rich in multisensory experiences and meaningful interactions. Thus, this research contributes to bridging the gap between language acquisition theory and the implementation of digital technology, specifically within the context of early childhood English vocabulary learning.

The practical implications of this research suggest that teachers can utilize AR media as an innovative alternative to create more engaging and effective learning experiences. For curriculum developers, the findings serve as a basis for integrating digital technology into early childhood learning designs. For educational technology designers, this study underscores the importance of developing media that is child-friendly, user-friendly, and capable of accommodating multisensory learning needs. Successful implementation of this media also requires teacher readiness in using technology and adequate infrastructural support. Several limitations of this study must be acknowledged, including a small sample size, conduct at a single location, the absence of a control group, and technical constraints such as internet connectivity and device limitations. These factors affect the generalizability of the findings. Accordingly, future research is recommended to employ experimental designs comparing AR flashcards with conventional flashcards, explore the most optimal AR design features for early childhood, conduct studies across more diverse contexts, and undertake longitudinal research to examine long-term vocabulary retention. Moving forward, the integration of technologies such as AR in early childhood education holds significant potential to support pedagogical transformation that is more adaptive, interactive, and aligned with the demands of the digital era.

Declaration on the use of AI

The authors acknowledge the use of generative AI tools, which were employed exclusively for language refinement and to facilitate comprehension of complex conceptual material. The original manuscript draft and all data analysis procedures were conducted independently by the authors, who assume full responsibility for the content and integrity of the work.

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