



## **Development of an Augmented Reality Learning Application to Introduce Animal Concepts for Early Childhood Education**

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### **Abstract**

**Keywords:**

Augmented Reality;  
Animal World;  
Learning Media.

This research aims to describe the process of developing Augmented Reality (AR) applications as an interactive and effective learning medium for materials on the animal world. The research method used is a research and development (R&D) model with a qualitative and quantitative approach. The development process includes analyzing user needs, designing and implementing the application, and evaluating its effectiveness in the classroom. The study's results show that AR applications can provide a more realistic and engaging learning experience for students. Key features such as 3D displays of animals, sound effects, and interactive information effectively improve student engagement and understanding of the material. Analysis of students' responses showed that the majority felt more motivated and found the concepts of the animal world easier to understand through this medium. The implications of this study indicate that AR technology has great potential to enhance learning effectiveness, especially for materials that require high levels of visualization. Further development and integration with the curriculum can expand its benefits in the world of education.

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### Abstrak

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**Kata Kunci:** *Penelitian ini bertujuan untuk menggambarkan proses pengembangan aplikasi Augmented Reality (AR) sebagai media pembelajaran interaktif dan efektif untuk materi tentang dunia hewan. Metode penelitian yang digunakan adalah model penelitian dan pengembangan (R&D) dengan pendekatan kualitatif dan kuantitatif. Proses pengembangan meliputi analisis kebutuhan pengguna, desain dan implementasi aplikasi, serta evaluasi efektivitasnya di kelas. Hasil penelitian menunjukkan bahwa aplikasi AR dapat memberikan pengalaman belajar yang lebih realistis dan menarik bagi siswa. Fitur-fitur utama seperti tampilan 3D hewan, efek suara, dan informasi interaktif secara efektif meningkatkan keterlibatan dan pemahaman siswa terhadap materi. Analisis tanggapan siswa menunjukkan bahwa mayoritas merasa lebih termotivasi dan menemukan konsep-konsep dunia hewan lebih mudah dipahami melalui media ini. Implikasi penelitian ini menunjukkan bahwa teknologi AR memiliki potensi besar untuk meningkatkan efektivitas pembelajaran, terutama untuk materi yang memerlukan tingkat visualisasi yang tinggi. Pengembangan lebih lanjut dan integrasi dengan kurikulum dapat memperluas manfaatnya di dunia pendidikan.*

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## 1. Introduction

Ideal learning in early childhood education should stimulate imagination, provide concrete experiences, and encourage active interaction with learning objects (Asmara et al., 2023). This principle aligns with Piaget's cognitive development theory, which emphasizes direct environmental exploration as the foundation for concept formation, including understanding animal concepts (Adawiyah, 2022). However, science learning in early childhood particularly animal topics remains dominated by lectures, static images, and passive videos (Tanfiziyah et al., 2021). Such practices show a gap between experiential learning theory and classroom reality. Children often struggle to understand animal characteristics, habitats, and classifications in depth. Limited access to zoos or natural environments further restricts authentic learning experiences. Therefore, interactive and accessible learning media are needed (Sumatraputra et al., 2023).

Augmented Reality (AR) offers potential to bridge this gap by integrating real environments with virtual objects (Ocha et al., 2024). Previous studies report that AR increases children's interest and recognition of animal forms and colors (Atikah et al., 2023) and enhances engagement through immersive visual interaction (Fauziyah et al., 2024; Uno, 2024). Despite these findings, existing research presents several limitations. First, many studies emphasize

effectiveness outcomes while neglecting systematic development models (Hermawan & Hadi, 2024). Second, methodological designs often lack comprehensive validation stages from needs analysis to implementation trials (Saputra, 2024). Third, AR applications are frequently adapted from general educational contexts without considering pedagogical alignment with early childhood developmental characteristics. These weaknesses indicate the need for research that integrates technological innovation with child-centered instructional design.

The present study addresses these gaps through three key contributions. Theoretically, it strengthens experiential learning and cognitive development frameworks by contextualizing AR within early childhood science learning. Methodologically, it applies a structured development process that encompasses needs analysis, media design, prototyping, and limited feasibility testing, ensuring alignment between technological features and developmental appropriateness (Wahyuni & Haryanti, 2024). In practice, it produces an AR application with simplified navigation, child-friendly audiovisual elements, interactive animal sounds and movements, and mini-quiz activities designed to stimulate curiosity and early scientific literacy. The design explicitly considers motor ability, cognitive readiness, and classroom implementation constraints.

This study aims to describe and evaluate the development process of an augmented reality-based application for introducing animal concepts in early childhood education. The research focuses on user needs analysis (teachers and children), content and interaction design, prototype development, and limited implementation testing to examine feasibility and pedagogical relevance.

This research is based on the argument that contextually designed AR media can support meaningful learning by providing simulated concrete experiences when direct environmental access is limited. Previous evidence indicates that AR increases participation and strengthens visual memory (Nurdiani, 2024). However, its educational value depends on alignment with development and the quality of instructional design. Therefore, this study investigates whether an appropriately developed AR application can function not merely as a technological enrichment, but as a pedagogically grounded medium that supports cognitive stimulation and active learning in early childhood science education.

## 2. Methods

This study employed a development research design with qualitative evaluation, rather than a purely qualitative case study. The primary objective was to develop an Augmented Reality (AR) application for introducing animal concepts in early childhood education and to evaluate its feasibility and pedagogical relevance through qualitative inquiry. The development process focused on designing, refining, and testing the application, while qualitative data were used to examine user needs, contextual suitability, and implementation dynamics.

The research was conducted at An Nur Malang Kindergarten, an institution that has initiated the integration of digital technology into classroom learning. The site was selected purposively for its openness to educational innovation and for the availability of teachers willing to collaborate during the development and trial stages. The institutional context represents an urban early childhood education setting with sufficient technological infrastructure to support AR implementation.

Participants consisted of 1 school principal and 5 kindergarten teachers who were directly involved in curriculum planning and classroom instruction. Participants were selected using purposive sampling, with the criteria that they (1) actively teach early childhood classes, (2) have experience using learning media, and (3) are willing to participate in the development and evaluation process. The principal contributed insights on institutional policy and infrastructure readiness, while teachers provided empirical data on children's developmental characteristics, classroom learning challenges, and media needs.

Data were collected through multiple techniques to ensure methodological rigor. These included: 1) literature and document review of the PAUD curriculum and scholarly sources on AR in education; 2) classroom observations to identify current learning practices related to animal topics; 3) structured and semi-structured interviews with principals and teachers; 4) open-ended questionnaires to gather additional feedback; and 5) Focus Group Discussions (FGDs) to refine application design and features.

Data triangulation was applied by comparing findings across sources and methods to strengthen credibility. Data analysis followed three stages: data condensation, data display, and conclusion drawing/verification. Content analysis was used to examine curriculum documents and textual materials. Interview and FGD transcripts were analyzed using interpretive analysis to identify themes related to pedagogical suitability, usability, and development challenges. This approach enabled a comprehensive understanding of both the technical development process and its alignment with early childhood learning principles.

This study adhered to research ethics standards. Participants provided informed consent prior to data collection. Their identities and institutional information were kept confidential, and all data were used solely for academic purposes. Participation was voluntary, and participants had the right to withdraw at any stage of the research process.

### **3. Result and Discussion**

#### **Result**

#### **User Needs Analysis in AR-Based Animal World Learning**

The analysis of user needs in learning the animal world based on Augmented Reality (AR) in this study is interpreted as the process of identifying the expectations, difficulties, and preferences of education actors, in this case, early childhood teachers and school principals, towards learning media that support early childhood understanding of the animal world. This definition emphasizes that effective learning

media must align with children's developmental characteristics, be relevant to the curriculum, and actively engage children's interest in learning. In the field, this needs analysis not only covers the type of visual content and expected interactions, but also includes the technical constraints that may be encountered when using AR media in the classroom. Therefore, these sub-findings are an important basis for designing AR applications that are appropriate, functional, and adaptive to the needs of end users, namely, early childhood teachers and students.

The results of interviews with school principals show that currently, there is no interactive learning media that can introduce children to the world of real animals without taking them outside the school.

*"We want to have a medium that can make children like dealing directly with animals, but still be safe and easy for teachers to use."* (KS\_01)

Meanwhile, one of the class teachers said that children often have difficulty distinguishing animals solely from their habitat or physical characteristics in static images.

*"Children are often confused about which is the water animal and which is the land animal. They need something that can be seen, heard, and even touched virtually."* (GK1\_01)

These two informants emphasized the importance of visual, interactive, and simple media. They also hope that the developed AR technology can be used independently by teachers without the need for complex technical training.

Observations in the classroom show that conventional learning methods, such as picture books or animal posters, are less effective at stimulating children's interest. When the teacher shows the animal pictures on the posters, most of the children just glance at them, then lose focus and start talking to themselves. However, when the teacher plays a short video about animals moving and making sounds, the child's attention increases dramatically, and they begin to imitate the animals' sounds or ask questions. Nonetheless, children's interactions remain passive because they are only spectators. There is no media that allows children to explore further independently or interactively. This shows that early childhood needs media that is not only visual but also interactive and responsive to their actions.

Based on these interviews and observations, it can be seen that both teachers and students have a strong need for technology-based learning media that can provide a real, safe, and engaging learning experience. Teachers need learning aids that are practical, flexible, and don't require complex technical training, while children need media they can actively explore, see, hear, and even experience animals virtually. Both want a more lively learning process and want to avoid being limited by the classroom. Therefore, the development of AR applications is expected to address the need for 3D animal visualization, original animal sounds, and easy-to-use interactive features.

From all the data obtained, a pattern of needs emerges that can be classified into three main aspects: (1) the need for real visualization, namely the need for realistic representations of animals in 3D form and motion animations; (2) the need for interactivity, namely the ability of children to interact directly with learning objects such as choosing, playing, or hearing animal sounds; and (3) the need for technical convenience, namely the hope that the application will be easily accessible and used by teachers without the need for special skills. These three aspects show that the development of AR media must consider pedagogical, technological, and psychological factors in a balanced manner to function as an effective learning medium in the context of early childhood education, especially for materials on the animal world.

### **Design and Development of Augmented Reality Applications for Animal World Materials**

The design and development of Augmented Reality (AR) applications for animal world materials in the context of this research is understood as the process of designing learning media based on interactive visual technology, aiming to help early childhood understand animal characteristics in a fun and immersive way. In the field, this design includes selecting 3D visual content, sounds, educational narratives, easy-to-understand navigation, and simple interactivity that can stimulate children's cognitive and affective development. The development of this application also considers early childhood learning principles, such as play-based learning, thematic approaches, and multisensory engagement. Thus, the main focus of this sub-finding is not only on the technical aspects of digital media, but also on their pedagogical and psychological suitability for early childhood development. This application was developed as a tool for teachers in conveying material about the animal world through visual and auditory recognition of animal types, habitats, and sounds that resemble real experiences.

The two main informants in this study, namely the principal and the classroom teacher, provide a consistent view on the importance of adaptive and attractive learning media design.

The Principal stated:

*"So far, children only know animals from pictures of books or ordinary videos, even though they need direct interaction. If there's a medium like AR that can show animals moving and making sounds, it really helps them imagine."* (KS\_02)

Meanwhile, the classroom teacher revealed:

*"What is important for children is the ease of access and understanding. If the application is complicated, they are confused. But if they can be touched, animals move, and there is sound, they respond quickly."* (GK\_02)

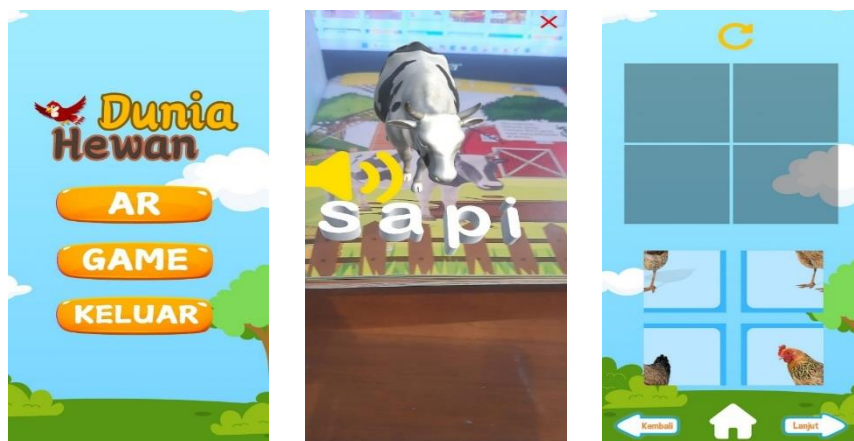
These two opinions emphasize the importance of child-friendly interface design and visual-auditory content that can bring the concept of the animal world closer to children in a concrete way.

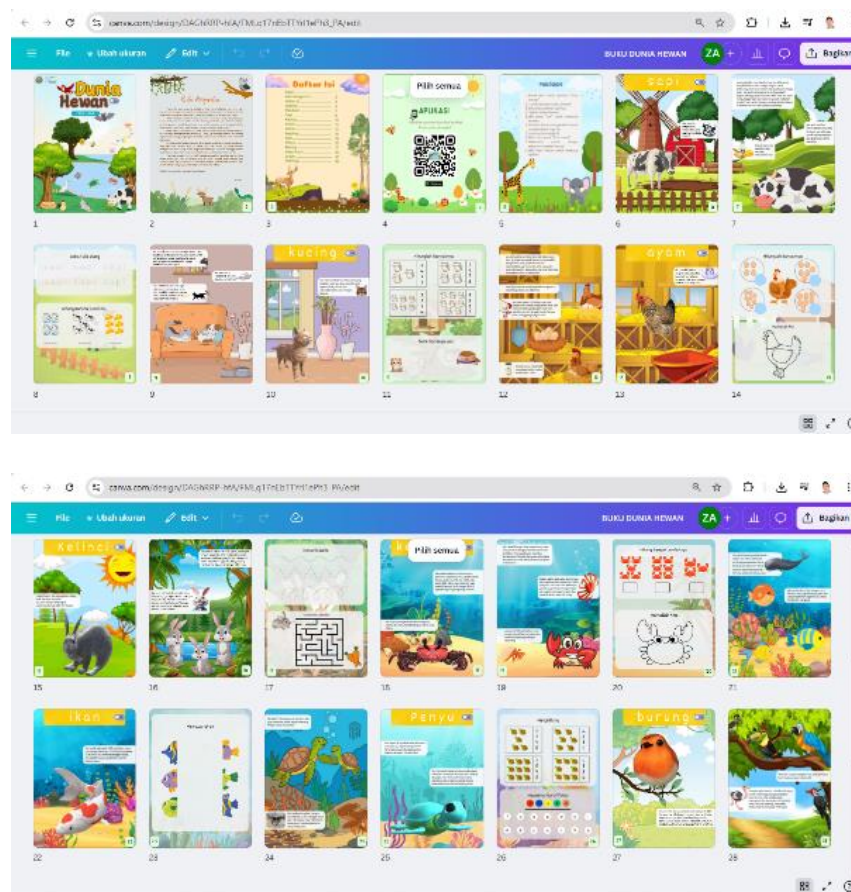
The observations were conducted during a limited trial of AR applications in the classroom. Children show high enthusiasm when

they see animals appear in 3D on the device's screen. They react with expressions of admiration and cheer, and actively point to the screen as they name the animals that appear. Children also try to touch the virtual animals on the screen and imitate their sounds. The teacher is seen accompanying by giving directions, and some children can operate the application independently after being given a one-time example. However, some children experience confusion when navigation icons are unclear or too small. From the teacher's perspective, they said this application is very helpful for explaining the differences between land, sea, and air animals, because AR visualization makes learning more concrete than just using posters or printed images.

Based on data from interviews and observations, the researcher concluded that the design and development of AR applications for learning about the animal world rely heavily on three main factors: display simplicity, visual-auditory strength, and ease of navigation. The positive response from teachers and principals shows that the need for interactive, context-specific media has long been recognized, but there are few truly child-friendly solutions. Meanwhile, the reactions of children who appeared enthusiastic and active, and who quickly adapted during app use, showed that an app design that takes into account early childhood developmental characteristics can increase material absorption. Thus, application development must strike a balance between technological sophistication and pedagogical simplicity.

From the overall data, a pattern emerges: AR-based learning media that are visually attractive, responsive, and simple are more effective at facilitating learning about the animal world in early childhood. This pattern is supported by the consistency of data from interviews and observations, which show that children's direct interaction with digital objects that resemble real-life experiences can increase their interest, focus, and understanding of the material. Another pattern is the importance of teachers' role in directing the use of this digital media, as well as the need to simplify the user interface to suit children's motor and cognitive abilities. In general, the developed application serves not only as a visual aid but also as a medium that offers new, fun, and meaningful learning experiences for early childhood.





**Fig1. AR Applications and Animal World Guidebooks**

### **Analysis of Student Responses to the Use of Augmented Reality in Learning**

The student response in this study is operationally defined as the attitudes and behaviors of early childhood students toward the use of Augmented Reality (AR) media in learning about the animal world. This response was observed from three main aspects: (1) interest and motivation to learn, characterized by the child's enthusiasm and attention during the learning process; (2) active participation, which is reflected in the child's involvement in exploring AR content such as pointing the camera at a marker image, touching the screen, or asking about an animal that appears; and (3) initial understanding, namely the child's ability to say animal names, habitats, and sounds after using the application. Student responses were observed through direct classroom interactions, reinforced by interviews with teachers and principals. The use of this definition allows researchers to quantitatively measure how AR applications qualitatively and contextually impact the early childhood learning experience.

Interviews with two main informants, namely the classroom teacher and the principal, showed that students responded positively to the use of the AR application.

*"The children are very enthusiastic when they see animals appear on the screen. They shouted with delight, even scrambling to try.*

*Usually they get bored quickly, but with AR they feel at home sitting and following instructions." (GK\_03)*

*"We see children who are usually passive so they ask questions, curious about the names of animals and their sounds. It's very different than when they just look at the pictures in the book." (KS\_03)*

Both informants agreed that the use of AR not only increases interest in learning but also encourages social interaction between students as they show each other their findings in the app. This shows that AR technology has the potential to create a collaborative, fun learning environment in early childhood.

Based on observations during three learning sessions, the researcher noted that the majority of students showed high interest when the AR application was first used. Children can be seen focusing on pointing the camera at the animal image and on the animations that appear. Most children smile, point to the screen, and excitedly say the names of animals. In the second session, more than half of the students were able to name the animal's habitat and mimic the sounds the app displayed. In addition, teachers noted that children tend to ask more questions during AR sessions than during conventional learning sessions. There is no bored or restless behavior that usually arises in static visual learning. Classroom activities become more lively, interactive, and fun. This observation reinforces the interview's findings that AR media has a direct impact on student attention, participation, and learning interaction.

Based on interviews and field observations, researchers concluded that the use of Augmented Reality applications in learning about the animal world had a significant impact on the responses of early childhood students. Students' interest increases noticeably, as shown in their facial expressions, enthusiasm, and behavior during the learning process. In addition, AR generates active reactions through participation in answering teacher questions, using application features, and engaging in social interactions with friends. With immersive visual and auditory experiences, students find it easier to understand the concepts of animals and their habitats. This technology bridges the limitations of conventional media to provide a concrete, fun, and meaningful learning experience for early childhood.

From the overall data obtained, a consistent pattern of student responses emerged. First, the initial interest arises spontaneously when the app is first introduced, characterized by high curiosity. Second, continuous active response, in which the child continues to engage in exploration and voluntarily repeat the use of the application. Third, there is an increase in conceptual understanding, as evidenced by children's ability to name, identify sounds, and identify the places of residence of animals after using AR applications. Finally, there are positive social dynamics between students, such as working together and sharing experiences while using the application. This pattern shows that AR technology is not only an effective cognitive medium but also has a positive impact on children's affective and social aspects during the learning process. Thus, AR applications act as learning tools that encourage holistic engagement of early childhood students.

## **Discussion**

The findings indicate that teachers and school leaders require interactive, accessible, and developmentally appropriate media to support the learning of animal concepts in early childhood. This need reflects a pedagogical rather than merely technical demand. Conventional media remain limited in providing concrete and exploratory experiences. These results align with Hidayatullah & Wardani (2022) and Atikah et al. (2023), who argue that educational technology for young children must encourage active participation. Similarly, Munafiah et al. (2024) emphasize that digital media should correspond to children's developmental stages and contextual learning needs.

The study confirms that AR-based media can address limitations of print materials and restricted access to natural environments. However, its effectiveness depends on the quality of the instructional design. The key finding is that AR functions optimally when user needs, curriculum alignment, and developmental psychology principles are integrated within the design structure.

Previous studies primarily examined the effectiveness of AR in increasing interest and engagement (Atikah et al., 2023; Nurmaliah et al., 2024; Zumroh, 2024). This study supports those findings but extends them by emphasizing the development process and contextual alignment. While earlier research highlighted engagement outcomes, the present study demonstrates that intuitive navigation, simple interaction, and pedagogically structured features are critical determinants of usability (Sayidil Waro et al., 2024).

Consistent with Setiawan et al. (2021), AR serves as a bridge between abstract concepts and quasi-concrete experiences. The increase in attention and motivation observed in this study reinforces Khilma et al.'s (2022) argument that realistic visualization and interactivity strengthen cognitive and affective engagement. However, unlike Untari et al. (2022), who focused mainly on technological adaptation, this study prioritizes developmental suitability and instructional coherence.

The findings strengthen constructivist learning theory by demonstrating that interactive AR environments support experiential knowledge construction. AR provides simulated exploration that approximates real-world interaction when direct access to nature is limited. This supports the view that meaningful early childhood learning occurs through sensory-rich engagement and active interaction.

The study contributes theoretically by integrating experiential learning principles with digital media development frameworks in early childhood science learning. It positions AR not as technological enrichment, but as a structured medium grounded in cognitive development theory.

In practice, this research provides a design reference for developing AR applications suitable for early childhood contexts. Simplicity of interface, limited menu complexity, audio-visual clarity, and guided interaction are essential design principles. Schools can

integrate AR without requiring advanced technical facilitators if applications are developmentally appropriate and easy to operate.

However, implementation requires attention to several practical constraints. Device availability remains uneven across schools. Not all institutions have adequate smartphones or tablets to consistently support AR. Teacher digital literacy gaps also affect the quality of implementation. Some educators require additional training to confidently integrate AR into classroom routines. Screen exposure concerns must also be considered, as prolonged digital interaction may raise developmental and health considerations for young children. Therefore, AR should complement, not replace, hands-on learning activities.

This study has several limitations. First, it was conducted within a specific institutional context, which may limit generalizability. Second, the qualitative evaluation focused on feasibility and user perceptions rather than long-term, measurable learning gains. Third, technological dependency introduces sustainability challenges, especially in settings with limited infrastructure. Future research should incorporate broader participant samples and mixed-method evaluations to examine long-term cognitive outcomes.

The added value of this research lies in three aspects. First, it provides a development-oriented perspective that integrates pedagogical theory with the design of AR applications. Second, it offers empirically grounded design principles tailored to the characteristics of early childhood. Third, it critically highlights implementation constraints often overlooked in technology integration studies, such as digital literacy readiness and screen-time balance.

Overall, this research demonstrates that AR-based media can enhance early childhood science learning when grounded in developmental theory, supported by thoughtful instructional design, and implemented with awareness of contextual limitations. Technology becomes meaningful not because of its novelty, but because of its pedagogical alignment and practical feasibility.

#### **4. Conclusion**

This study demonstrates that an Augmented Reality (AR) based learning application can support early childhood understanding of animal concepts by increasing attention, engagement, and initial conceptual comprehension. The findings indicate that children respond positively to interactive 3D visualization, audio features, and simple navigation. The effectiveness of the application depends on its alignment with developmental characteristics, curriculum content, and teacher facilitation. AR functions most effectively as a complementary medium that simulates concrete experiences when direct environmental exposure is limited.

This research provides three main contributions. First, it strengthens the theoretical integration of constructivist and experiential learning perspectives with digital media development in early childhood science education. Second, it offers a development-oriented methodological framework that combines needs analysis, pedagogical design, and qualitative feasibility evaluation. Third, it contributes practically by identifying essential design principles for

early childhood AR applications, including usability simplicity, contextual content, and curriculum alignment. These findings provide guidance for educators and developers seeking to meaningfully integrate AR into early childhood classrooms.

This study was conducted in a single early childhood institution, limiting generalizability across contexts. The evaluation relied primarily on qualitative data, without quantitatively measuring long-term learning outcomes. In addition, implementation depends on device availability and teacher digital readiness, which may vary across institutions.

Future research should involve broader institutional contexts and apply mixed-method or experimental designs to measure learning outcomes more comprehensively. Studies should also examine long-term cognitive impacts and screen-time balance in early childhood settings. At the policy level, technology integration initiatives should be accompanied by teacher digital literacy training and infrastructure support to ensure sustainable implementation.

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Hopefully this research can provide great benefits, both for the development of early childhood education and for the education community in general. Thank you for all the contributions that have been given.

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