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Augmented reality (AR)-based experimental learning: A solution to overcome boredom with worksheet usage in generation alpha (Gen-A) early childhood

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Abstract

Generation Alpha (Gen-A), who have grown up in the digital era, are more interested in interactive and visual learning. Conventional learning medias such as worksheets are considered monotonous, reducing children motivation and engagement in learning. RA Nurul Ulum, a type of kindergarten in Indonesia, has applied Augmented Reality (AR)-based experimental learning for children. However, how was AR-based experimental learning implemented in Early Childhood Education (ECE), particularly in Indonesia is underexplored. Therefore, this study aims to explore the implementation of Augmented Reality (AR)-based experimental learning in overcoming the boredom of Gen-A children with conventional worksheets in ECE. This research used a descriptive qualitative method with observation, interviews, and document analysis at RA Nurul Ulum. The finding showed that AR-based experiential learning is adaptive learning innovation to the characteristics of Gen-A, creating a more engaging and effective learning environment. It suggests the AR-based experimental learning as one of learning media variation and combination with hands-on activities for children in ECE.

Keywords: augmented reality; early childhood education; experimental learning.

INTRODUCTION

Early Childhood Education (ECE) is the most important foundation in shaping children's character and learning abilities. However, in the era of Generation Alpha (Gen-A)—children born after 2010—conventional learning methods such as worksheets are often considered monotonous and less engaging, leading to a decline in children's motivation and learning involvement. The main reason for this boredom lies not only in the static nature of conventional methods but also in their misalignment with the unique characteristics and learning needs of Gen-A. Gen-A has several prominent traits. They tend to prefer instant results, show a strong interest in freedom, and possess high self-confidence. These children are highly responsive to recognition or appreciation but are less interested in printed literature like physical books, as they are more accustomed to digital content. On the other hand, they have developed skills in technology-based environments from an early age, making them a generation naturally fluent in using digital devices (Yusuf et al., 2024). This indicates

that Gen-A children, growing up in a digital environment, are more attracted to interactive, visual, and technology-based learning. Easy access to devices like tablets, smartphones, and digital educational apps makes them a generation often regarded as more intelligent than previous generations (Purnama, 2018). Unfortunately, the use of modern technologies such as Augmented Reality (AR) in the context of ECE remains very limited, especially in Indonesia.

This research is based on experiential learning theory, which emphasizes the importance of direct and interactive learning experiences. AR, as a technology capable of presenting three-dimensional (3D) visuals and direct interaction, is believed to enhance children's conceptual understanding and learning interest. Additionally, educational technology theory supports the use of AR as an innovative learning medium that aligns with the characteristics of V. This study refers to Permendikbud No. 137 of 2014 on ECE Standards, which highlights the importance of developing creative and enjoyable learning methods. Government policies on educational digitalization also encourage the integration of technology into the learning process, including at the ECE level. However, the implementation of AR in ECE has not been widely adopted, necessitating further research to explore its potential.

School activities play a crucial role in supporting early childhood development, as this period is the golden age of their growth and development. During this time, appropriate stimulation is essential to optimize various aspects of child development, such as physical, cognitive, language, social-emotional, and creativity. This is because early childhood learning is fundamentally centered around play activities. This aligns with the characteristics of young children, who tend to be active and enjoy exploring their surroundings. Play is not only a means of entertainment but also an integral part of the learning process. Through play, children can develop and refine various potentials, such as language skills, social-emotional skills, physical-motor skills, and cognitive abilities. Thus, learning is directed to support the holistic growth of children in a natural and enjoyable way (Laksana et al., 2021). Therefore, learning activities in schools must be designed to be fun, varied, and aligned with the developmental needs of children. Young children learn through direct experiences and interactions with their environment. If school activities are monotonous or uninteresting, children may lose interest in learning, which ultimately hinders their developmental stimulation. To keep children engaged and prevent boredom, teachers need to design creative and interactive learning activities. For example, by incorporating educational games, art, nature exploration, and project-based activities that actively involve children.

Many studies have discussed the most suitable learning models for Generation Alpha

children. The results indicate that learning activities using experimental methods are more aligned with their characteristics, as these activities involve exploration, creativity, and interaction that match the interests and learning styles of Gen-A children. For instance, Susi Susanti's research shows that learning using experimental methods can optimize the creativity of early childhood. Through experiments, children are encouraged to be brave and confident in expressing their ideas, which ultimately helps them understand learning materials more easily. Especially for Gen-A, who are known for their digital literacy, experimental-based learning approaches become more appealing compared to traditional methods like worksheets (Susi, 2023).

A study showed that experimental methods encourage children to learn actively through direct experiences, such as observing changes in simple science experiments, classifying objects based on color or shape, measuring materials during play activities, and explaining their observations. These activities not only help them understand concepts better but also enhance their curiosity, creativity, and critical thinking skills from an early age (Samatowa, 2018). Other scholar also demonstrated that experimental methods allow children to gain direct experiences by involving all their senses in the process of acquiring information. Through this method, students can actively observe, carry out, and prove the activities they have chosen, making learning more interactive and meaningful (Putri & Bayuni, 2019).

Several studies reported that experimental methods are highly important for early children (Ma'viyah, 2021; Susi, 2023). Moreover, by combining it with Augmented Reality (AR), it supports Gen-A learning motivation due to the visual graphic provided (Nuhoğlu, 2024). These studies highlight that AR could support enjoyable learning experiences, thereby enhancing children's creativity, curiosity, and critical thinking skills. Therefore, learning approaches that utilize digitalization, such as AR, become more engaging for children.

Raudhatul Athfal (RA) Nurul Ulum Tugu Semarang — a type of kindergarten in Indonesia — has implemented AR-based experimental learning methods in daily activities. Based on previous preliminary study, RA Nurul Ulum recognizes the importance of aligning teaching methods with the needs and characteristics of Gen-A. By using AR, children at RA Nurul Ulum not only become more interested and motivated to learn but can also develop their potential optimally, including cognitive, socio-emotional, physical-motor, and language skills. Through this learning process, educators can not only reduce children's boredom in learning but also more easily monitor and understand their learning progress. However, how this approach was implemented in ECE as an innovation in learning is underexplored.

Therefore, this study aims to fill this gap by exploring the implementation of AR-based experimental learning in RA Nurul Ulum Tugu Semarang context for some aspects, such as the integration of technology and hands-on experiences and how it can enhance children's interest and attention in the learning process.

METHOD

The research method used in this study is descriptive qualitative research. Qualitative research is a method used to investigate natural conditions of an object, where the researcher acts as the key instrument. A descriptive approach was employed to deeply understand the implementation of AR-based experimental learning in enhancing the motivation, engagement, and understanding of Gen-A children in early childhood education (ECE). This method was chosen because it can capture subjective nuances, social contexts, and the holistic experiences of students, educators, and the learning environment. This research involved children aged 4 – 6 years old from Group A and Group B at RA Nurul Ulum Tugu as participants, because AR-based experimental learning is applied in those groups. RA Nurul Ulum was chosen as the research location for several reasons: 1. Strategic Location: RA Nurul Ulum is located in a remote area of Semarang, where access to educational technology is still limited, making AR-based learning innovations highly unique. 2. Good Reputation: RA Nurul Ulum stands out among other RAs in the area, with high-quality teaching and management. 3. Parental Support: Parents of students at RA Nurul Ulum strongly support the implementation of AR-based learning and have no objections to the method. They are also actively involved in providing learning materials and supporting their children's daily learning activities. Parents and teachers agreed to participate and allowed their children to be participants in this study.

Data collection was carried out through interviews, open observation, and document analysis. Interviews were conducted with the school principal, classroom teachers, and assistant teachers. Participatoryn observation was conducted at RA Nurul Ulum Tugu, Group A and Group B, Ngaliyan District, Semarang City. The researcher directly observed the learning process in the classroom without intervention, capturing the interactions and responses of children to AR. Document analysis involved supporting documents such as lesson plans (RPP) and teachers' daily notes. During the research process, the researcher encountered challenges, including data subjectivity. Since qualitative research relies on the researcher's interpretation, there is a risk of bias in data analysis. To minimize bias, the researcher used data triangulation (combining interviews, observation, and document analysis) and involved cross-checking by relevant parties (member check). Data credibility check in this

study used triangulation (a combination of methods) with inductive data analysis, so the research results emphasize meaning rather than generalization (Marwiyati & Kinasih, 2022).

With this approach, the research aims to provide an in-depth understanding of teaching practices at RA Nurul Ulum. The researcher strives not only to observe the learning process superficially but also to explore the meaning behind each activity, interaction, and response during learning. Participatory observation (observation) was conducted to see how teachers plan, implement, and evaluate learning, as well as how children respond to the applied learning methods. Additionally, the researcher interviewed teachers, parents, and relevant parties to understand their perceptions, expectations, and challenges in implementing AR-based Experimental Learning.

RESULTS AND DISCUSSION

Research data was collected through interviews, observations, and document studies at RA Nurul Ulum, yielding several key findings. First, children became more actively engaged in the learning process when using AR-based experimental learning methods compared to conventional methods. Second, educators stated that this method makes it easier for children to understand concepts through direct experiences. During the 2023-2025 academic year, educators at RA Nurul Ulum observed significant changes in students' learning patterns, particularly regarding their declining enthusiasm for conventional worksheet-based learning. In response, the educators innovated by integrating digital technology-supported experimental learning methods. Before conducting experiments, children were introduced to learning concepts through interactive tutorial videos and AR technology displayed on classroom televisions via the YouTube platform. This approach proved more effective in maintaining children's interest and engagement during the learning process.

This research is detailed by linking it to the learning themes based on the Merdeka Curriculum. The study shows that AR-based experimental learning methods not only increase children's engagement and interest but also support their understanding of various learning concepts. These findings indicate that dynamic and technology-based learning approaches are highly suitable for the learning characteristics of Gen-A, who have grown up in the digital era and prefer interactive and experiential learning.

The implementation of Augmented Reality (AR)-based Experimental Learning at RA Nurul Ulum has shown positive impacts in increasing children's engagement and understanding of learning materials. Based on interviews with educators, several interesting

cases can be explained thematically in line with the Merdeka Curriculum.

Environmental Awareness

Bu Herlina, an educator in Learning Group A, explained that children were invited to experiment with planting trees as part of learning about the environment. Before the activity, the children watched an interactive animated video showing the tree-planting process, accompanied by an engaging song. After watching the video, the children were taken to the schoolyard to practice planting trees directly using polybags and seeds they brought from home. This approach not only increased the children's enthusiasm but also helped them understand the importance of planting and caring for trees as part of their environmental responsibility.

Basic Science (Floating Concept)

Bu Murni, an educator in Group B, invited the children to experiment with making simple sailboats using materials such as styrofoam, toothpicks, folded paper, and straws. This activity aimed to introduce the concept of floating and the movement of boats powered by wind. The children worked in groups, blowing on the boats floating in a tray of water, and observed how the boats moved. This experiment not only helped the children understand basic science concepts but also trained their social-emotional skills through group collaboration.

Solar System Exploration

Bu Ani, an educator in Group B, combined conventional worksheets with creative experiments in a solar system-themed lesson. The children were invited to color pictures of planets, cut them out, and paste them to create solar system crowns. Before the activity, the children watched a video about the solar system displayed on the classroom television. Although it started with a traditional activity (coloring), the learning process evolved into an interactive and creative experimental experience. The children not only learned about the planets but also developed fine motor skills and creativity.

Social-Emotional Learning and Creativity

Bu Ulya, an educator in Group A, emphasized the importance of following a learning model that aligns with the characteristics of Gen-A. She stated that AR-based experimental learning methods increase children's curiosity, making them more focused and less prone to boredom. This approach also supports the development of social-emotional aspects, such as cooperation and communication, as well as creativity through activities like making sailboats

and solar system crowns.

Bu Ulya's statement aligns with the approach implemented at RA Nurul Ulum, where learning not only focuses on cognitive and creative development but also emphasizes the formation of environmental awareness from an early age. Through active collaboration with parents, educators optimize available resources, such as utilizing recycled materials from home for learning purposes. This not only supports environmental sustainability but also creates engaging and relevant learning media for children.

Table 1 below describes the comparison of children learning engagement before and after AR-based experimental learning implementation in five aspects, such as child engagement, conceptual understanding, creativity, collaboration and socialization, learning motivation. There were a remarkable changes in five aspects of children learning involving children more interest in learning process, children's conceptual understanding were increased, children's creativity and exploration of new idea were improved, social-emotional skill and collaboration were also enhance, and there were also significantly boosted children motivation and enthusiasm of learning.

Table 1.

Comparison of engagement levels before and after the implementation of AR-based experimental learning

Aspect	Before Implementation of Augmented Reality (AR)	After Implementation of AR	Change
Child Engagement	Children tend to be passive, less enthusiastic, and easily bored with conventional worksheet-based learning.	Children are more active, enthusiastic, and directly engaged in the learning process through interaction with Augmented Reality (AR).	A significant increase in children's engagement and interest in learning.
Conceptual Understanding	Children struggle to understand abstract concepts due to a lack of visualization and direct interaction.	Children find it easier to understand concepts through 3D visualization and interactive experiences based on Augmented Reality (AR).	A noticeable and profound improvement in conceptual understanding.
Creativity	Children's creativity is limited because of monotonous and less interactive learning methods.	Children become more creative through hands-on experiments and interaction with Augmented Reality (AR).	An increase in creativity and exploration of new ideas.
Collaboration and Socialization	Children are less involved in collaboration as the	Children collaborate more frequently in groups to complete	An enhancement in social-emotional skills and collaboration.

	learning process is more individual.	tasks.	
Learning Motivation	Learning motivation is low due to boring teaching methods.	Learning motivation increases because the learning process is more engaging and enjoyable.	A significant boost in motivation and enthusiasm for learning.

Generation Alpha is in their golden age, a crucial period where their development occurs very rapidly and will not be repeated in subsequent phases of life. During this time, development in cognitive, language, moral and religious, physical-motor, and social-emotional aspects will form the foundation that influences their growth in adolescence and adulthood. Because this golden age is so critical, it is essential for parents and the environment to provide positive and supportive stimulation so that children can grow and develop optimally (Novianti et al., 2019). Early childhood education also serves as an important foundation in a child's development, so daily learning activities need to be designed in an engaging and enjoyable way to maintain children's enthusiasm for learning. All learning activities should be designed holistically to support the development of various aspects, such as cognitive, physical, social-emotional, and language skills, enabling children to grow and develop optimally according to their age stage. However, it is important to note that Gen-A children prefer dynamic, interactive, and hands-on learning experiences. They require learning approaches that can spark curiosity, creativity, and active engagement. Therefore, technology-based learning methods, such as AR-based experimental learning, become an effective solution to sustain their interest and motivation in learning. Augmented Reality (AR) offers entertainment elements that naturally attract students' interest. Through interactive three-dimensional (3D) visual representations, AR allows students to engage directly in the learning process. As a result, abstract concepts can be visualized and made easier to understand, as students not only see but also interact with the learning content in an immersive AR environment (Makapedua et al., 2021). This approach not only aligns with their digitally literate learning style but also helps them better understand learning concepts through visualization and hands-on practice.

The AR-based Experimental Learning method has been implemented at RA Nurul Ulum in response to the declining enthusiasm of Gen-A children toward conventional learning methods, such as worksheets. Augmented Reality (AR) enables students to interact directly with learning materials, making learning more engaging and easier to understand. This technology also supports collaborative learning and can be adapted to the needs of students

at various levels, from kindergarten, elementary school, middle school, to university (Wiliyanti et al., 2024). Additionally, AR is highly effective in providing a deep initial understanding before students proceed to the Experimental Learning stage. In addressing the characteristics of Gen-A, educators at RA Nurul Ulum require varied teaching methods to help children stay focused and avoid boredom during learning. This implementation aligns with the Merdeka Belajar Curriculum, which emphasizes hands-on learning and the holistic development of children's potential. The learning topics derived from this curriculum include basic science, solar system exploration, environmental awareness, motor skills development, arts and creativity, and socio-emotional learning.

In the research, approach taken by the educators at RA Nurul Ulum, not only were available resources optimized, but environmental awareness was also instilled in students from an early age. Active collaboration with parents became very important in the learning process, where parents were involved in providing learning materials based on recycled items from home. The more engaging the media used, the greater the children's motivation, allowing the teaching and learning process to achieve the desired results (Kartini & Kurniawaty, 2023). This practice reflects the implementation of a tri-center educational approach involving schools, families, and the community in the learning process. This was done because the educators at RA Nurul Ulum deeply understand the importance of experimental learning as a solution to overcome children's boredom with worksheet-based learning. Through this approach, students not only gain meaningful learning experiences but also develop an understanding of sustainability values and the responsible use of resources.

The A-Gen brings a new perspective for educators in designing learning methods to be implemented in the classroom. The learning process is the key to children's success in education. However, there are still issues in society, particularly regarding the perception that early childhood education (PAUD) is often seen as separate from play activities. One of the most prominent issues is the tendency of teachers to still use conventional methods. In this approach, teachers act as lecturers in front of the class, while children only listen and complete worksheets such as coloring or drawing based on the teacher's instructions. This method tends to make children feel burdened by the material presented and reduces their freedom to learn according to their interests. As a result, children's potential to explore ideas and creativity independently is hindered (Latif & Sirait, 2022). In contrast, Rahmawati and Rachmah, through their research, argue that using worksheets is quite effective and can help children in carrying out learning activities. This is because worksheets contain attractive

images for children. These images also capture children's attention to complete the tasks assigned by educators and make it easier for educators to explain the learning material (Rahmawati & Rachmah, 2022).

In previous research conducted by Yuyun Ningsih and her colleagues, it was found that the task assignment method can increase children's independence. Children become more responsible in completing their tasks without needing help from parents or teachers and are able to tidy up their learning tools on their own. Additionally, the use of worksheets as part of this method can also assist children in learning. Worksheets provide structured and clear guidance, making it easier for children to understand the tasks assigned while training systematic and independent thinking skills (Yana, 2024). The Gen-A is clearly different from previous generations. Advanced technology that was once considered "impossible" by previous generations is now a tangible part of their lives. This technological development marks a significant shift, as Alpha children grow up with digital devices as everyday companions. This influences their behavior, thinking, and skill development, making them a generation deeply connected to technology (Assingkily et al., 2020). Therefore, innovation in early childhood education is a necessity in line with the dynamics of the times. This becomes increasingly relevant in the context of the Gen-A, who are growing up amidst rapid digitalization. The unique characteristics of this generation demand learning approaches that are not only adaptive to technological advancements but also capable of optimally facilitating the development of children's creativity and potential.

One of the technologies used at RA Nurul Ulum as a learning medium for early childhood is Augmented Reality (AR). With the advancement of time, AR can now be utilized as a learning medium that not only conveys information clearly but also provides an interactive experience in the learning process (Wenthe et al., 2021). According to Parian Madanipour and Caroline Cohrssen, the use of AR technology, as part of digital innovation, is increasingly integrated into various applications due to its ability to combine interactions between real and virtual objects (Madanipour & Cohrssen, 2020). Unlike virtual reality, AR does not replace the real world with a virtual one but retains the real world as seen by the user, complementing it with virtual information overlaid in various formats such as 3D, video, text, or images (Redondo et al., 2020). However, the use of AR can sometimes have negative impacts on the learning process for children and educators. Research findings indicate that while AR-based learning in the form of videos demonstrates some effective teaching practices, particularly in the use of concrete materials and relevant themes, there are still aspects that need improvement. Some of these include a lack of motivational interaction

between teachers and children during the planning stage, insufficient dialogue on the social and emotional aspects of the roles played, and weak scenario development (Fitri & Yusuf, 2023).

The unique characteristics of the Gen-A show that they can learn more effectively when multiple senses are engaged (multisensory learning), not limited to visual and fine motor stimulation as commonly applied in conventional worksheets. Responding to this phenomenon, educators at RA Nurul Ulum consistently implement experimental learning combined with AR technology before conducting experiments. According to Ma'viyah in her research, the experimental method is capable of creating a learning environment that supports the maximum development of thinking and creativity (Ma'viyah, 2021). According to Pura and Wulandari, this experimental learning method has proven to be more effective in developing critical thinking, creativity, and problem-solving skills, while maintaining children's concentration and providing a deeper and more meaningful learning experience in facing the challenges of the digital era. The negative impacts experienced by individuals who have difficulty concentrating include low interest in the subjects being studied, an unconducive learning environment, suboptimal physical health, and boredom during the learning process. This issue of lack of concentration needs to be addressed promptly as it can cause students to fail to absorb learning material effectively (Pura & Wulandari, 2020). In the implementation of experimental learning, the application of theory in practical contexts is often involved, similar to project-based learning, which requires students to apply their knowledge in real-world situations. Another research showed that project-based learning is an approach that involves teachers in organizing the learning process so that children can solve problems with full interest and enthusiasm during project-based learning activities (Ichlas et al., 2023).

By introducing simple experiments in learning, children can be given the opportunity to try, develop their understanding optimally, and gain positive impacts that benefit their development (Soleha et al., 2024). According to a study, it is important to extend the duration of experiments and explore various types of learning tasks to enhance the effectiveness of experimental learning. This aligns with efforts to address the boredom of using worksheets among Alpha children, where task variation and experimental approaches can serve as alternative solutions that are more engaging and have a positive impact on children's learning engagement (Wang et al., 2024). This research has provided valuable insights for educators in developing learning innovations for early childhood in the classroom, but further research specifically exploring experimental learning to address children's boredom in classroom

learning is needed.

CONCLUSION

This research explores the implementation of experimental learning as an alternative solution to address the boredom of Gen-A children with the use of conventional worksheets at RA Nurul Ulum. The findings indicate that a hands-on learning approach combined with AR technology can enhance children's active participation, focus, and conceptual understanding. Children become more enthusiastic and engaged in the learning process when given the opportunity to experiment directly, such as planting trees, creating sailboats, or exploring solar system concepts through creative activities. These findings align with the characteristics of Generation Alpha, who are digitally literate and prefer interactive and experiential learning.

Based on the research findings, several important results can be outlined. First, the use of AR and interactive animated videos successfully captured the children's attention and increased their engagement in learning. Second, experimental methods, such as creating sailboats from simple materials (styrofoam, toothpicks, and colored paper), helped children understand the concept of buoyancy while honing their fine motor skills and teamwork in group settings. Third, a blended learning approach, such as combining conventional worksheets with creative experiments (e.g., making solar system crowns), demonstrated that children can remain interested and focused even when starting with traditional activities. These findings suggest that AR-based experimental learning not only addresses boredom but also supports the achievement of broader learning objectives.

However, this research has several limitations. First, the scope of the study is limited to RA Nurul Ulum, so the findings may not be generalizable to all ECE contexts. Second, the study focuses more on short-term outcomes, such as increased enthusiasm and engagement among children, necessitating further research to measure long-term impacts. Third, the involvement of parents and the home environment in supporting AR-based learning has not been deeply explored, making it a potential area for future research. Thus, this study recommends that ECE educators adopt more innovative learning methods, such as experimental learning and Augmented Reality, to create more engaging and meaningful learning experiences. However, the implementation of these methods requires infrastructure support, teacher training, and collaboration with relevant stakeholders to ensure their widespread success.

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