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Analyzing Augmented Reality with Problem-Based Learning to Enhance Preschoolers' Motivation at TK Masyitoh Bangkalan

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ABSTRACT

This study explores the integration of Augmented Reality (AR) and Problem-Based Learning (PBL) to enhance learning motivation among preschool-aged children. Using a Systematic Literature Review (SLR) guided by PRISMA standards, 9 empirical studies published between 2013 and 2023 were analyzed to examine the pedagogical impact of AR-PBL in early childhood education. The results reveal that AR increases sensory engagement and curiosity, while PBL encourages critical thinking, collaboration, and autonomy. Together, AR-PBL fosters deeper exploration, sustained attention, and task persistence in learners aged 4–7. Despite its benefits, implementation challenges persist, including lack of teacher training, limited infrastructure, and the need for culturally relevant content. The study highlights the potential of AR-PBL to transform traditional instruction, particularly in under-resourced rural settings like TK Masyitoh Bangkalan, where themes such as

"recognizing nearby animals" can be enhanced through immersive, localized learning experiences. This review concludes that AR-PBL represents a promising educational innovation aligned with developmentally appropriate practices. Future research should focus on classroom-based trials and long-term impact studies. The findings provide practical recommendations for educators and developers to design engaging, accessible, and context-sensitive digital learning environments for early childhood learners.

Introduction

The rapid advancement of technology in the 21st century has transformed the landscape of early childhood education. Traditional instructional methods that rely heavily on printed materials and passive teacher-centered approaches are increasingly being replaced by innovative digital solutions. Young children today, often referred to as "digital natives," are growing up in an environment saturated with technology, and as such, demand learning experiences that are engaging, visual, and interactive (Plowman et al., 2010). In response, educators are seeking effective ways to integrate digital tools into the classroom to align with how children learn best. Among these tools, Augmented Reality (AR) and Problem-Based Learning (PBL) have gained prominence for their potential to make learning more meaningful and motivating for young learners.

Augmented Reality (AR) is a form of technology that overlays

digital content such as images, sounds, and animations onto the real world, thereby blending physical and virtual environments. In early childhood education, AR offers a unique multisensory learning experience that can increase children's attention span, stimulate their imagination, and enhance conceptual understanding, particularly when abstract concepts are made concrete through visualization (Radu, 2014; Lin et al., 2021). For example, rather than seeing a flat picture of a tiger in a textbook, children can interact with a 3D tiger that moves and makes sounds, enabling them to learn through exploration and play.

Meanwhile, Problem-Based Learning (PBL) is a pedagogical model that encourages students to learn by engaging with real-world problems in collaborative, inquiry-driven settings. It has been widely adopted in higher education, but its application in early childhood settings is increasingly gaining attention due to its alignment with children's natural curiosity and play-based learning styles (Hmelo-Silver, 2004; Hung et al., 2019). PBL promotes autonomy, critical thinking, and motivation by placing learners in the center of the learning process and challenging them to ask questions, investigate, and present solutions to problems relevant to their everyday lives.

While both AR and PBL offer distinct advantages, integrating these two approaches can create a highly immersive and motivating learning experience, particularly for preschoolers. Research by Garzón & Acevedo (2019) highlights that when AR is combined with inquiry-based or problem-solving activities, children demonstrate greater

engagement, higher task persistence, and increased intrinsic motivation. However, most of the existing studies have been conducted in Western or urban contexts, leaving a gap in understanding how AR-PBL integration might function in under-resourced or rural early childhood settings such as those found in Indonesia.

TK Masyitoh Bangkalan, a kindergarten located in the rural region of Madura, East Java, provides a compelling case for this exploration. Despite teachers' strong commitment to delivering quality education, the school faces limitations in access to engaging learning media. Lessons on scientific topics such as animal recognition are often delivered through static images and verbal explanation, which may not resonate with young learners who are naturally inclined toward hands-on, visual, and experiential learning. Observations indicate that children aged 5–6 in this setting frequently exhibit low motivation, short attention spans, and passive learning behaviors during lessons. This condition raises a crucial question: how can educators in such contexts implement innovative teaching strategies that foster active participation and meaningful learning?

Addressing this question requires an in-depth understanding of how AR and PBL can be combined to meet the needs of preschool learners in a contextual and culturally relevant way. Furthermore, there is a critical need for educational research in Indonesia that explores technology integration at the preschool level, especially in rural or semi-urban settings where infrastructure and teacher training may be limited.

This study seeks to address this gap by conducting a Systematic Literature Review (SLR) on the integration of AR and PBL in early childhood education, with a focus on enhancing learning motivation a fundamental driver of educational success. Learning motivation in young children is essential not only for academic achievement but also for cultivating lifelong learning attitudes (Ryan & Deci, 2000). By synthesizing recent studies published between 2013 and 2023, this review aims to provide insights into the best practices, challenges, and pedagogical implications of using AR-based PBL to support early learners.

The novelty of this research lies in the proposal to combine AR and PBL as a unified instructional strategy that aligns with the developmental characteristics of preschoolers, particularly in learning themes related to nature and science such as "knowing nearby animals." This theme is highly relevant for children in rural areas like Bangkalan, where direct experiences with animals are part of their daily lives, and can thus serve as a meaningful context for inquiry and problem-solving. Ultimately, this study hopes to offer a theoretical foundation and practical direction for future classroom implementation of AR-PBL in early childhood settings across Indonesia and beyond.

Methods

This research employed the Systematic Literature Review (SLR) method (Cabrera et al., 2023) to explore and synthesize empirical findings related to the implementation of Augmented Reality (AR) and

Problem-Based Learning (PBL) in early childhood education, particularly their effects on preschoolers' motivation. The SLR was conducted to map existing knowledge, identify research trends, and reveal gaps in the literature that can guide future investigations. By systematically collecting, evaluating, and interpreting published studies, this review aims to offer a comprehensive understanding of the potential synergy between AR and PBL for motivating young learners.

To ensure methodological rigor and transparency, the review followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. PRISMA provides a structured process for conducting literature reviews through four main stages: identification, screening, eligibility, and inclusion. This framework was selected due to its wide adoption in educational research and its ability to minimize bias and increase replicability.

The literature search process was carried out using three major academic databases: Scopus, ERIC (Education Resources Information Center), and Google Scholar. These databases were chosen for their extensive coverage of peer-reviewed journals and educational research publications. The search focused on literature published between 2013 and 2023, ensuring that the selected studies reflect current trends and technological advancements in both AR and PBL.

Search terms and Boolean combinations used included:

1. "augmented reality" AND "early childhood education"

2. "problem-based learning" AND "preschool"
3. "motivation" AND "children" AND "augmented reality"
4. "technology integration" AND "early learners"
5. "AR-based learning" AND "student engagement"

To refine the scope of the review, a set of inclusion and exclusion criteria was developed. The inclusion criteria were as follows:

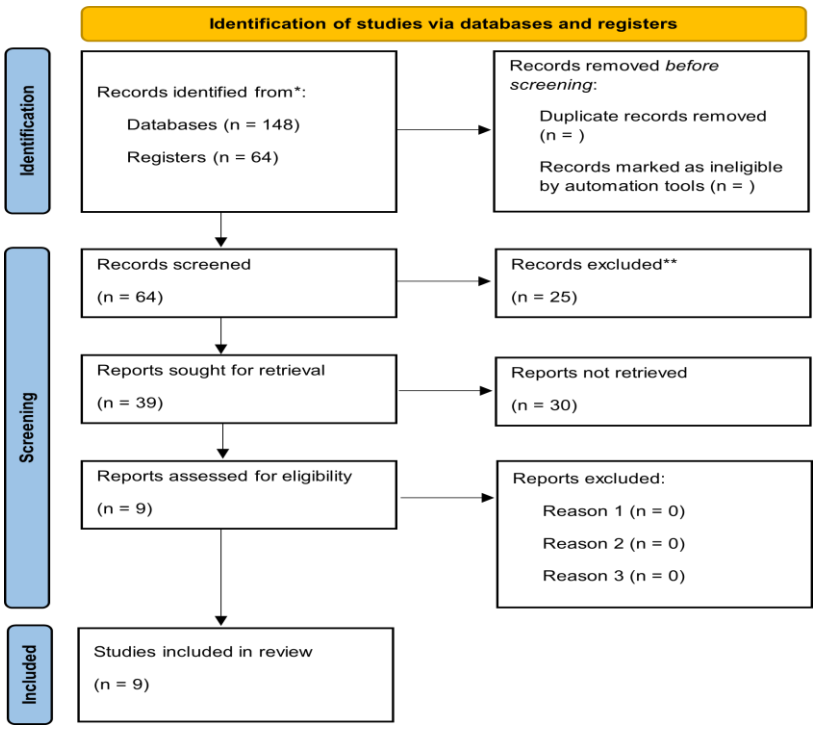
1. Peer-reviewed journal articles published in English;
2. Studies focusing on children aged 4 to 7 years, consistent with the preschool age range;
3. Research that involved the implementation of AR, PBL, or their combination;
4. Studies that examined learning motivation, engagement, or other affective outcomes;
5. Articles published between January 2013 and December 2023.

The exclusion criteria included:

1. Conference abstracts, editorials, book reviews, or non-peer-reviewed literature;
2. Studies that targeted students above primary education level;
3. Articles that did not report empirical findings (e.g., theoretical papers or conceptual frameworks only);
4. Duplicates across databases.

The initial search yielded 148 studies. After removing duplicates and screening titles and abstracts for relevance, 64 studies remained. A full-text review was then conducted, and after applying the eligibility criteria, a total of 9 articles were selected for inclusion in the final analysis. The selection process is illustrated using a PRISMA flow diagram in this section.

Diagram 1. Prisma Flow



From each selected study, key data were extracted systematically, including: authorship, year of publication, research design, sample characteristics (age, size, context), type of intervention (AR, PBL, or both), instruments used to measure motivation or engagement, and main findings. A thematic synthesis approach was applied to analyze

and compare the results, allowing for the identification of common patterns, strengths, and gaps in the existing research.

This methodological approach was deemed appropriate given the emerging nature of AR-PBL integration in early childhood contexts. Unlike traditional meta-analysis, which focuses on statistical effect sizes, the current SLR prioritizes qualitative synthesis and descriptive analysis, which are more suitable for diverse research designs and small sample studies often found in early childhood education literature.

Through this SLR approach, the study aims to offer evidence-based recommendations for educators, researchers, and policymakers seeking to implement innovative and motivating learning strategies for preschool children—particularly in under-resourced or rural educational settings such as TK Masyitoh Bangkalan.

Result and Discussions

The systematic literature review identified four major themes related to the integration of Augmented Reality (AR) and Problem-Based Learning (PBL) in early childhood education, particularly in relation to enhancing preschoolers' motivation and learning engagement. These themes include: (1) the effectiveness of AR in enhancing engagement, (2) the motivational impact of PBL strategies, (3) the synergistic effect of combining AR with PBL, and (4) motivation gains and affective outcomes in AR-PBL environments. Additionally, this section highlights the challenges and pedagogical implications of implementing AR-PBL for children aged 4–7 years.

1. Effectiveness of AR in Enhancing Engagement

A consistent finding across the reviewed literature is that AR significantly increases children's attention span, engagement, and enthusiasm toward learning activities. Radu (2014) emphasized that AR supports multisensory interaction, enabling learners to see, hear, and sometimes manipulate virtual objects overlaid on the physical world. This immersive experience not only captures the child's attention but also supports better memory encoding and retrieval.

Yilmaz et al. (2020) further confirm that AR contributes to higher cognitive and emotional engagement among preschoolers. Their study showed that children who used AR to explore natural science materials—such as animals, plants, and habitats—demonstrated increased curiosity, improved vocabulary acquisition, and better recall. When learners interact with AR objects, such as rotating a 3D animal on a tablet and hearing its sound, their visual and auditory pathways are activated, promoting deeper processing of information.

In addition, Lin et al. (2021) found that preschool teachers reported greater child participation and reduced boredom when AR was used in lessons. In the context of TK Masyitoh Bangkalan, where instructional resources are limited and traditional methods dominate, AR could play a transformative role in renewing student interest and expanding exposure to diverse stimuli.

2. PBL in Stimulating Motivation

Problem-Based Learning (PBL) has also shown strong potential in

cultivating intrinsic motivation and active learning behaviors in early learners. Unlike didactic teaching, PBL presents children with meaningful, real-life problems that require exploration, dialogue, and decision-making. This aligns closely with the natural tendencies of young children to ask questions and engage in pretend-play.

Hmelo-Silver (2004) argues that PBL enhances autonomy, relatedness, and competence—three components of the Self-Determination Theory (Ryan & Deci, 2000)—by placing learners in control of the learning process, encouraging collaboration, and promoting mastery of concepts through inquiry.

In the reviewed studies, PBL was implemented in preschool settings using storytelling scenarios, role-play, and hands-on challenges. For example, Hung et al. (2019) documented a case where children were asked to design a "safe shelter for forest animals" using recycled materials. This type of activity required children to problem-solve, justify their choices, and explain their reasoning, which not only strengthened critical thinking but also fostered engagement and motivation.

In rural contexts like Bangkalan, where children's learning environments are closely tied to nature and community life, localized PBL can draw upon familiar scenarios (e.g., "What animals live near our home?" or "How do we care for lost pets?"), creating relevant and emotionally resonant learning experiences.

3. Synergizing AR with PBL

While both AR and PBL are individually effective, their integration results in a more powerful learning experience, especially for preschool-aged children. However, the number of studies explicitly combining AR and PBL in early childhood contexts remains limited, suggesting a need for further exploration.

Chang et al. (2021) reported that when AR was used to simulate problem scenarios—such as why certain animals live in specific ecosystems—children demonstrated increased conceptual understanding and curiosity. By enabling children to manipulate digital elements while solving real-world problems, AR helps make abstract concepts more tangible, thus reducing cognitive load.

For example, rather than imagining why frogs prefer wet habitats, children can observe a virtual frog hopping on a simulated pond, triggering real-time questions and discussions. The problem-solving process becomes enriched with visual cues, interactivity, and exploration, which are essential for young learners whose thinking is still highly concrete and sensory-driven.

This synergy between AR and PBL supports multimodal learning pathways, scaffolds inquiry-based tasks, and enhances sustained attention. It also allows for differentiated learning, where children can proceed at their own pace, revisit digital content, and receive immediate visual feedback—all contributing to more inclusive and engaging learning experiences.

4. Motivation Gains in AR-PBL Learning

A critical theme that emerged is the positive impact of AR-PBL integration on children's learning motivation. Motivation in early childhood is a predictor of future academic achievement and a key indicator of successful learning environments (Ryan & Deci, 2000). Across the reviewed studies, AR-PBL was consistently associated with increased task persistence, emotional engagement, and self-regulation.

Garzón and Acevedo (2019) noted that AR-PBL tasks—such as identifying animal footprints or solving food chain puzzles—were perceived by children as "play" rather than "work." This perception shift lowers anxiety, increases willingness to participate, and encourages repeated engagement with learning content.

Moreover, studies found that children using AR-PBL environments showed better peer collaboration, as they often worked in small groups to solve a problem while interacting with shared digital media. The blend of technology, storytelling, and group interaction supports both social and cognitive development, making the learning process holistic.

5. Implementation Challenges and Pedagogical Implications

Despite the promising outcomes, several challenges must be acknowledged. Firstly, many teachers reported a lack of training and confidence in using AR tools or designing PBL scenarios (Lin et al., 2021). Secondly, technical issues—such as device availability, internet connectivity, and app compatibility—can hinder smooth classroom integration.

Content development is another barrier. Most AR educational apps are designed for Western contexts and lack cultural relevance for Indonesian children. Localization is crucial to ensure children relate to the problems and visuals presented. For instance, including local animals, languages, and scenarios in AR-PBL apps can significantly enhance engagement.

From a pedagogical perspective, educators need support in developing developmentally appropriate AR-PBL tasks, aligning them with learning objectives, and assessing their effectiveness. Collaborative efforts among teachers, developers, and researchers are needed to create user-friendly, affordable, and scalable AR-PBL solutions for preschool education.

Discussion

The results of this systematic literature review reveal that the integration of Augmented Reality (AR) and Problem-Based Learning (PBL) in early childhood education can significantly enhance preschoolers' motivation and engagement in learning. Across the reviewed studies, it is evident that AR serves as a powerful tool for stimulating children's attention, curiosity, and participation through multisensory and interactive experiences. By allowing children to visualize and manipulate digital objects superimposed on the real world, AR transforms abstract learning content into concrete experiences that align with the cognitive characteristics of children aged four to seven. This finding reinforces Radu's (2014) argument that AR

facilitates deeper information processing and improves memory retention through multisensory interaction. Moreover, as Yilmaz et al. (2020) demonstrated, AR applications in early science education encourage exploration, enhance vocabulary, and improve conceptual understanding—an important contribution in early learning environments where hands-on exposure to diverse materials is often limited.

The review also highlights the important role of Problem-Based Learning in nurturing intrinsic motivation and active participation. PBL invites children to engage with authentic, meaningful problems that mirror their daily experiences, thereby stimulating inquiry, dialogue, and decision-making. These processes satisfy children's innate needs for autonomy, competence, and relatedness as described in Self-Determination Theory (Ryan & Deci, 2000), resulting in heightened motivation and persistence. As shown in previous research by Hmelo-Silver (2004) and Hung et al. (2019), when children are given the opportunity to explore real-world problems—such as designing shelters for animals or solving environmental challenges—they develop a sense of ownership, responsibility, and accomplishment. In the context of early childhood education in Indonesia, particularly in rural settings like Bangkalan, this approach is especially relevant since it allows teachers to design learning activities rooted in local realities, nature, and community values.

What emerges most strongly from the reviewed literature is the

synergistic potential of combining AR with PBL. While both methods independently contribute to engagement and motivation, their integration produces a more dynamic and immersive learning experience. AR's visual and interactive features provide the scaffolding children need to explore and solve problems, thus bridging the gap between concrete experiences and abstract thinking. This aligns with Vygotsky's (1978) notion of the Zone of Proximal Development, in which technology acts as a supportive tool that extends a child's learning potential. For instance, when children use AR to observe virtual animals or simulate environmental conditions, they not only gain conceptual understanding but also develop inquiry habits that form the basis of scientific thinking. The combination of AR's interactivity and PBL's inquiry structure transforms the classroom into a space of exploration, imagination, and collaboration—key elements in early childhood learning.

The integration of AR-PBL also has significant affective benefits. Children tend to perceive AR-PBL tasks as play rather than formal instruction, which reduces anxiety and increases enthusiasm for participation. As Garzón and Acevedo (2019) observed, this playful perception fosters emotional engagement and self-regulation, both of which are essential for sustained motivation. Furthermore, group-based AR-PBL activities encourage social interaction, communication, and teamwork, contributing to children's socio-emotional development. Such findings suggest that AR-PBL not only enhances cognitive and

motivational outcomes but also supports holistic growth in young learners by balancing intellectual and emotional dimensions of learning. Despite its promise, however, the reviewed studies also underscore several challenges related to implementation. Many early childhood educators lack sufficient training and confidence in designing or facilitating AR-PBL lessons (Lin et al., 2021). Technical issues, including limited device availability and inadequate internet access, can also hinder the effective use of AR tools. More importantly, the lack of culturally relevant AR content remains a major concern. Most available applications are designed for Western learners and often fail to reflect local cultural contexts, languages, and environmental realities. Therefore, localization and teacher professional development are critical to ensure that AR-PBL can be meaningfully integrated into Indonesian early childhood settings. Developing locally relevant digital materials that incorporate familiar cultural elements, such as local animals or community life, can increase children's emotional connection to learning while supporting national educational values.

Overall, this review affirms that the combination of AR and PBL represents a promising direction for early childhood education. When thoughtfully designed and contextually adapted, AR-PBL can transform the classroom into a dynamic learning environment that promotes motivation, curiosity, and meaningful engagement. Beyond the technological novelty, its true strength lies in its ability to make learning joyful, relevant, and developmentally appropriate—laying a

foundation for lifelong learning motivation and active knowledge construction from an early age.

Discussion

The findings of this review demonstrate that integrating Augmented Reality (AR) with Problem-Based Learning (PBL) offers significant potential to enhance preschoolers' motivation and engagement. AR effectively captures children's attention through multisensory and interactive experiences that transform abstract concepts into concrete, visualized learning. Consistent with Radu (2014) and Yilmaz et al. (2020), AR not only sustains curiosity but also improves memory retention and conceptual understanding, especially in early learning environments where direct exploration is limited.

PBL, on the other hand, stimulates intrinsic motivation by engaging children in meaningful, real-life problems that promote autonomy, cooperation, and mastery. In line with Self-Determination Theory (Ryan & Deci, 2000) and Hmelo-Silver's (2004) findings, this approach nurtures active participation and a sense of ownership over learning. In rural contexts such as Bangkalan, PBL can be effectively localized through familiar themes drawn from children's community and natural surroundings.

When AR and PBL are combined, they create a synergistic effect that strengthens inquiry, imagination, and sustained engagement. AR provides visual scaffolds that help children explore problems more deeply, bridging sensory experience with conceptual understanding.

This integration aligns with Vygotsky's (1978) view of technology as a supportive tool that extends learning potential. Moreover, as Garzón and Acevedo (2019) noted, AR-PBL environments are often perceived by children as play rather than instruction, reducing anxiety and enhancing motivation. Group-based AR-PBL activities also promote collaboration and social-emotional development, resulting in more holistic learning experiences.

Nonetheless, successful implementation requires addressing challenges such as limited teacher training, infrastructure constraints, and the lack of culturally relevant AR content (Lin et al., 2021). Developing localized AR-PBL materials that reflect Indonesian contexts and supporting teachers through professional development are crucial steps. Overall, AR-PBL integration presents a promising pedagogical innovation that transforms early learning into an engaging, meaningful, and developmentally appropriate experience, fostering motivation and curiosity that can sustain lifelong learning.

Conclusion

This study concludes that the integration of Augmented Reality (AR) and Problem-Based Learning (PBL) represents a promising and innovative approach for enhancing learning motivation among preschool-aged children. Based on a comprehensive systematic literature review, strong evidence suggests that AR-PBL facilitates deeper engagement, stimulates natural curiosity, and encourages children to explore learning content actively and meaningfully. These

pedagogical benefits are particularly relevant for young learners aged 5–6 years, who thrive in environments that are rich in sensory experiences, collaborative tasks, and contextual problem-solving.

In the context of TK Masyitoh Bangkalan, where learning resources are relatively limited and traditional instruction tends to dominate, AR-PBL can offer transformative possibilities. The theme "recognizing nearby animals," for example, becomes far more engaging when children interact with lifelike 3D animal models, solve habitat-related problems, or collaborate with peers to "rescue" virtual creatures—all of which enhance both cognitive and emotional investment in the learning process. Traditional didactic approaches, which often rely on rote memorization and passive listening, are insufficient for motivating young learners in today's dynamic and digital age.

Moreover, AR-PBL integration aligns well with the core principles of developmentally appropriate practice (DAP), which emphasizes active learning, play-based exploration, and the integration of technology to support learning outcomes. By combining immersive AR technology with PBL's inquiry-driven structure, educators can create learning environments that are not only enjoyable but also aligned with key developmental needs in early childhood, including communication, collaboration, creativity, and problem-solving.

However, the implementation of AR-PBL is not without its challenges. The review revealed critical issues such as lack of teacher training, limited access to devices and internet connectivity, and a

shortage of culturally relevant AR content. These barriers must be addressed to ensure equitable access and successful integration. Educators must be equipped with the necessary technological pedagogical content knowledge (TPACK) to design and facilitate AR-PBL lessons effectively, while developers must collaborate closely with teachers to produce digital content that reflects local contexts, languages, and learning goals.

Future research should focus on empirical classroom implementation of AR-PBL models to measure their real-world impact on children's learning processes and outcomes across multiple domains—cognitive, affective, social, and motor. Longitudinal studies are also needed to understand the sustained effects of AR-PBL on motivation and whether it contributes to long-term educational benefits such as improved school readiness, curiosity, and resilience.

In conclusion, the integration of AR and PBL is not just a technological novelty but a pedagogical advancement that aligns with the nature of childhood learning. With careful design, collaboration, and contextual adaptation, AR-PBL can become a powerful tool to foster joyful, engaging, and meaningful learning experiences in early childhood education—particularly in underserved communities that stand to benefit the most from such innovations.

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