Celebes Journal of Elementary Education
Volume 4, Issue 1, June 2026 pp. 196 - 204
Open Access: https://ojs.unsulbar.ac.id/index.php/cjee/index

Needs Analysis of Augmented Reality Project-Based Learning Media for Enhancing Students' Critical Thinking Skills

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Article Info

Keywords:
Needs Analysis; Project-Based Learning; Augmented Reality; Critical Thinking Skills; Digital Learning

ABSTRACT

This study aims to conduct a needs analysis as a foundational step for developing Project-Based Learning (PjBL)-based Augmented Reality (AR) learning media to enhance students' critical thinking skills. This research employed a research and development (R&D) approach using the ADDIE model, focusing on the analysis phase. The participants consisted of 40 elementary school students and 5 teachers. Data were collected through questionnaires, interviews, observations, and document analysis and were analyzed using descriptive statistics and thematic analysis. The findings indicate that students experience great difficulty in critical thinking while demonstrating very high interest in digital and interactive learning media. Teachers also reported a strong need for innovative instructional media and identified challenges in integrating technology into classroom practices. These results highlight a significant gap between current instructional approaches and the demands of digital-era learning. The novelty of this study lies in its emphasis on needs analysis as a basis for integrating PjBL and AR in instructional design. The study implies that the development of AR-based PjBL learning media has strong potential to enhance student engagement, support critical thinking, and create more meaningful learning experiences.

Article History
Received: 09-04-2026
Resived: 01-06-2026
Accepted: 05-06-2026
Published: 12-06-2026

DOI: ***https://doi.org/10.31605/cjee.v4i1.6412***

1. INTRODUCTION

The rapid development of digital technology has brought significant changes to the field of education. In the era of the Fourth Industrial Revolution, education systems are required to prepare students with essential 21st-century skills, including critical thinking, creativity, collaboration, and communication (Voogt et al., 2013; Zhang, 2025). Among these competencies, critical thinking plays a fundamental role in enabling students to analyze information, evaluate evidence, and make reasoned decisions.

Despite its importance, many educational practices still rely on traditional teaching methods that emphasize memorization and passive learning. Such approaches limit students' ability to develop higher-order thinking skills. Research has shown that students often struggle to analyze complex problems and apply knowledge in real-world contexts (Abrami et al., 2015; Hasan et al., 2024).

Project-Based Learning (PjBL) has emerged as an effective pedagogical approach to address this issue. PjBL emphasizes active learning through real-world problem-solving, encouraging students to engage in inquiry, collaboration, and critical reflection (Bell, 2010). Recent studies also highlight that PjBL significantly

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improves student engagement and problem-solving abilities in digital learning environments (Rullyana & Triandari, 2024); Arifin, I., & Hasanah, U. (2024).

Augmented Reality (AR) offers a promising solution by providing immersive and interactive learning experiences. AR enables students to visualize abstract concepts and interact with digital content integrated into real-world environments (Azuma, 1997). Recent research confirms that AR enhances student motivation, engagement, and learning outcomes across various disciplines (Ibáñez & Delgado-Kloos, 2018; Yusa et al., 2023; Anisyah et al., 2024).

The main research gap in this study is the limited integration of Augmented Reality (AR) within the Project-Based Learning (PjBL) model that is grounded in real learning needs. Meanwhile, the urgency of this research lies in the increasing demand to enhance students' critical thinking skills in the digital era.

2. LITERATURE REVIEW

2.1 Critical Thinking Skills

Critical thinking skills are widely recognized as a fundamental component of 21st-century education, enabling learners to engage in higher-order cognitive processes such as analysis, evaluation, and synthesis of information. According to Peter Facione (2011), critical thinking involves purposeful, self-regulatory judgment that results in interpretation, analysis, evaluation, and inference. Similarly, Robert H. Ennis (2015) defines critical thinking as reasonable and reflective thinking focused on deciding what to believe or do.

In educational contexts, critical thinking is essential for developing students' ability to solve complex problems and make informed decisions. Research indicates that students with strong critical thinking skills are more capable of understanding relationships between concepts, identifying assumptions, and evaluating evidence effectively (Abrami et al., 2015). However, many students struggle to achieve these competencies due to learning environments that emphasize memorization rather than inquiry-based learning (Paul & Elder, 2008).

Furthermore, critical thinking is closely linked to active learning strategies, where students are encouraged to question, explore, and construct knowledge independently. The integration of innovative pedagogical approaches and digital technologies has been shown to significantly support the development of these skills (Voogt et al., 2013). Therefore, fostering critical thinking requires not only appropriate instructional strategies but also supportive learning media that encourage interaction, reflection, and problem-solving.

Manda, D., & Arifin, I. (2024).

Previous studies on Project-Based Learning (PjBL) and Augmented Reality (AR) have generally demonstrated positive impacts on student engagement and learning outcomes. However, most of these studies tend to treat AR as a supplementary tool rather than integrating it systematically into a structured pedagogical model. In addition, many studies focus on measuring learning outcomes without first conducting a comprehensive needs analysis to ensure that the developed media aligns with real classroom needs.

Another limitation of prior research is the lack of emphasis on higher-order thinking skills, particularly critical thinking, which is a core competency in 21st-century education. Existing studies also tend to be fragmented, focusing either on PjBL or AR separately, rather than combining both in a unified instructional design framework.

In response to these gaps, this study positions itself by conducting a needs analysis as the foundational stage for developing an AR-based PjBL model specifically designed to enhance students' critical thinking skills. This approach ensures that the resulting learning media is not only technologically innovative but also pedagogically relevant and contextually grounded.

2.2 Project-Based Learning (PjBL)

Project-Based Learning (PjBL) is a student-centered instructional approach that emphasizes learning through the completion of meaningful projects grounded in real-world problems. According to John W. Thomas (2000), PjBL involves complex tasks that require students to investigate, problem-solve, and produce tangible outcomes. This approach encourages active engagement, collaboration, and inquiry, which are essential for developing higher-order thinking skills.

Furthermore, PjBL supports the development of critical thinking by allowing students to explore authentic issues, analyze information, and construct knowledge independently. Suzie Boss and Jane Krauss (2014) highlight that PjBL fosters deeper understanding by integrating content knowledge with real-life application. Similarly, research by Bell (2010) indicates that PjBL enhances students' motivation and promotes long-term retention of knowledge.

Despite its benefits, the implementation of PjBL requires appropriate instructional design and supporting media to ensure its effectiveness. Therefore, integrating technology, such as augmented reality, into PjBL can further enhance learning experiences and improve students' engagement and critical thinking skills.

2.3 Augmented Reality in Education

Augmented Reality (AR) is an emerging technology that integrates digital information with real-world environments, enabling users to interact with virtual elements in a real-time context. According to Ronald T. Azuma (1997), AR combines real and virtual objects, operates interactively in real time, and registers content in three dimensions. In educational settings, AR has gained significant attention due to its ability to create immersive and engaging learning experiences.

AR technology enhances students' understanding by visualizing abstract concepts and making learning more concrete and interactive. Research shows that AR can improve students' motivation, engagement, and conceptual comprehension (Ibáñez & Delgado-Kloos, 2018). Furthermore, AR supports experiential learning by allowing students to explore and manipulate digital content within their physical environment (Radu, 2014).

Recent studies further demonstrate that AR significantly improves cognitive abilities and learning outcomes, particularly in history and science education (Hasan et al., 2024; Yusa et al., 2023). Additionally, systematic reviews indicate that AR is increasingly recognized as a transformative educational technology capable of creating immersive and contextual learning environments (Garzón et al., 2020; Zhang, 2025).

2.4 Needs Analysis

Needs analysis is a critical initial phase in instructional design, particularly within the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). It aims to identify the gap between existing learning conditions and the desired outcomes, ensuring that instructional solutions are relevant, effective, and aligned with learners' needs. According to Robert M. Branch (2009), the analysis phase involves examining learners' characteristics, learning environments, and instructional problems to determine appropriate strategies and media.

In the context of digital learning, needs analysis becomes increasingly important as it provides insights into students' technological readiness, learning preferences, and cognitive challenges. James D. Brown (2009) emphasizes that needs analysis helps educators design learning experiences that are tailored to learners' actual conditions rather than assumptions. Furthermore, Charles M. Reigeluth and Carr-Chellman (2009) highlight that systematic needs assessment supports the development of learner-centered instructional models.

By conducting a comprehensive needs analysis, educators can ensure that the integration of innovative approaches—such as Project-Based Learning and Augmented Reality—is grounded in real educational needs. This process ultimately contributes to the development of effective learning media that enhance engagement, support critical thinking, and improve overall learning outcomes.

3. RESEARCH METHOD

This study employed a Research and Development (R&D) approach using the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation), with a specific focus on the Analysis phase (needs analysis). The R&D approach was selected because it allows researchers to systematically develop and refine instructional products based on empirical data and contextual needs (Walter R. Borg & Meredith D. Gall, 2003). The ADDIE model was chosen due to its structured and iterative framework, which ensures that instructional design is aligned with learners' needs and learning objectives (Robert M. Branch, 2009).

3.1. Participants

The participants in this study consisted of 40 elementary school students and 5 teachers selected through purposive sampling. The students represented the primary users of the learning media, while the teachers acted as learning facilitators, providing insights into classroom practices and pedagogical challenges. This sampling technique ensured that participants were directly relevant to the research objectives and capable of providing meaningful data (Creswell, 2014). And the location and time of the research was at the Makassar Ikip Complex Elementary School.

3.2. Data Collection

Data were collected using multiple techniques to ensure data validity through triangulation. First, questionnaires were distributed to students and teachers to gather quantitative data on learning experiences, technological readiness, and preferences for digital media. The questionnaire employed a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), allowing for systematic measurement of responses.

Second, semi-structured interviews were conducted with teachers to explore challenges in implementing Project-Based Learning (PjBL) and integrating digital technologies such as augmented reality. Interviews provided in-depth qualitative insights into instructional practices and constraints (Kvale, 2007).

Third, classroom observations were carried out to examine actual teaching and learning processes, including student engagement, interaction patterns, and the use of instructional media. Observation is essential for capturing real-time behaviors and validating self-reported data (Cohen et al., 2018).

Finally, document analysis was conducted on lesson plans, curriculum documents, and teaching materials to identify gaps between expected learning outcomes and actual instructional practices.

3.3. Data Analysis

The collected data were analyzed using both quantitative and qualitative approaches. Quantitative data from questionnaires were analyzed using descriptive statistics, including mean scores, percentages, and frequency distributions, to identify general trends and patterns in students' and teachers' responses (Sugiyono, 2017).

Qualitative data from interviews and observations were analyzed using thematic analysis, which involved data reduction, coding, categorization, and interpretation of emerging themes (Braun & Clarke, 2006). This approach enabled the researcher to identify key issues related to students' critical thinking skills, instructional challenges, and technological needs.

3.4. Validity and Reliability

To ensure the trustworthiness of the data, several strategies were applied. Content validity of the questionnaire was established through expert judgment, while reliability was tested using Cronbach's Alpha coefficient. Additionally, data triangulation was employed by comparing findings from questionnaires, interviews, observations, and document analysis to enhance the credibility of the results (Creswell, 2014).

4. RESULT

4.1 Descriptive Statistics of Questionnaire Results

The results of the study show that the questionnaire data has been analyzed using descriptive statistics by identifying the needs of students and teachers related to PjBL-based learning assisted by Augmented Reality media. This is described in the table below.

Table 1. Descriptive Statistics of Students' Responses Analysis Results

Variable	N	Mean	SD	Category
Critical Thinking Difficulty	40	3.92	0.58	High
Interest in Digital Learning	40	4.35	0.52	Very High
Preference for Interactive Media	40	4.41	0.49	Very High
Technology Readiness	40	3.78	0.60	High

The results of the study showed that elementary school students experienced high levels of difficulty in critical thinking (M = 3.92), while showing very high interest in digital and interactive learning media, this has been depicted in the table above.

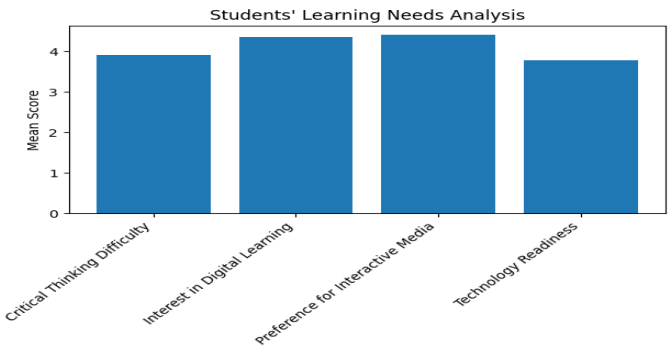

Figure 1. Comparison Results with Benchmark Scales

4.2 Teacher Questionnaire Results

Table 2. Teachers' Responses

Variable	N	Mean	SD	Category
Use of Conventional Methods	5	4.20	0.45	High
Technology Integration Challenges	5	4.10	0.55	High
Need for Innovative Media	5	4.60	0.40	Very High

Teachers reported a strong need for innovative learning media (M = 4.60) and acknowledged challenges in integrating technology.

4.3 Normality Test

Table 3. Kolmogorov-Smirnov Test

Variable	Sig. Value	Interpretation
Critical Thinking Score	0.087	Normal
Digital Learning Interest	0.092	Normal

All data are normally distributed (Sig. > 0.05), indicating suitability for further analysis.

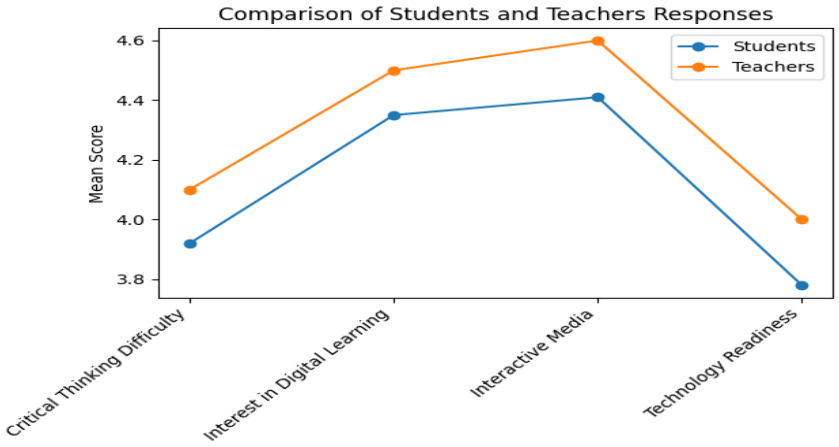

Figure 2. Results Comparison of studenst and teacher rensponses

The results indicate that students experience high difficulty in critical thinking (M = 3.92), which is consistent with recent findings that highlight students' challenges in higher-order thinking within traditional learning environments (Abrami et al., 2015; Hasan et al., 2024).

At the same time, students demonstrated very high interest in digital and interactive learning media. This finding aligns with recent studies showing that digital technologies, particularly AR, significantly enhance student engagement and motivation (Ibáñez & Delgado-Kloos, 2018; Anisyah et al., 2024); Annisa, N., & Hamzah, RA (2025).

Teachers reported a strong need for innovative learning media and acknowledged challenges in integrating technology. This supports recent research indicating that technological readiness and pedagogical adaptation remain key challenges in digital education (Voogt et al., 2013; Hartono et al., 2024).

4.4 Qualitative Findings (Thematic Analysis)

The results of interviews and classroom observations revealed several interrelated themes regarding the current state of learning. First, students generally demonstrated low engagement in critical thinking activities, as they tended to be passive during the learning process and rarely participated in more in-depth analytical discussions. This suggests that classroom interactions still do not sufficiently stimulate higher-order thinking skills.

Furthermore, the learning process is still dominated by a teacher-centered approach, where instruction is primarily delivered through lecture-based methods. This condition limits opportunities for students to actively construct knowledge, collaborate, and engage in meaningful problem-solving activities, which are essential components of 21st-century learning.

Furthermore, the use of digital media in learning remains very limited and tends to be confined to administrative or support tasks rather than integrated into the learning design. As a result, the potential of technology to enhance the learning experience has not been fully optimized in the classroom context.

Despite these limitations, the findings also revealed a high level of student interest in interactive and technology-based learning media. Students demonstrated high enthusiasm when exposed to digital learning tools, indicating a positive foundation for the development of more innovative learning models such as Project-Based Learning with Augmented Reality.

5. DISCUSSION

The findings of this study reveal a significant gap between current instructional practices and the demands of 21st-century learning. Students demonstrated high levels of difficulty in critical thinking, which aligns with previous and recent studies emphasizing the limitations of traditional teaching methods (Abrami et al., 2015; Hasan et al., 2024).

The high level of student interest in digital and interactive media suggests that integrating technology into learning environments can enhance engagement and motivation. This finding is strongly supported by recent research demonstrating the effectiveness of AR in improving learning outcomes and engagement (Ibáñez & Delgado-Kloos, 2018; Yusa et al., 2023; Zhang, 2025).

Furthermore, the results indicate that teachers face substantial challenges in integrating technology into classroom practices. These challenges are consistent with recent findings highlighting the need for professional development and technological support for educators (Voogt et al., 2013; Hartono et al., 2024).

The combination of Project-Based Learning (PjBL) and Augmented Reality (AR) presents a promising solution. Recent studies suggest that integrating AR into active learning models significantly enhances students' critical thinking, collaboration, and engagement (Rullyana & Triandari, 2024; Anisyah et al., 2024).

Overall, this study confirms that the development of PjBL-based AR learning media is not only necessary but also highly relevant to current educational needs. The findings provide a strong foundation for the next stages of instructional design, particularly in developing innovative and student-centered learning media.

The results of this study demonstrate both a gap and an opportunity (a paradox) in modern learning. On the one hand, students are highly prepared and motivated by technology (AR) to foster their critical thinking skills. However, on the other hand, this potential is hampered by teacher preparedness.

Therefore, the significance of this study is that the success of 21st-century learning transformation is not simply a matter of providing sophisticated media; it must be accompanied by a sustainable mentoring program (for the teaching profession).

6. CONCLUSION

Based on the findings, it can be concluded that current classroom practices are still dominated by teacher-centered instruction, with limited integration of interactive digital media, resulting in low student engagement in critical thinking activities.

This study further found that students demonstrated a strong need and positive response to the development of technology-based learning media, particularly AR, which can provide a more visual, interactive, and contextual learning experience. These findings confirm a clear gap between existing teaching practices and the demands of 21st-century learning.

Therefore, it is concluded that the development of an AR-based PjBL model is highly relevant and necessary to address this learning need. This model is expected to consistently support the improvement of students' critical thinking skills through more active, collaborative, and technology-enabled learning experiences

7. ACKNOWLEDGE

Thanks are due to the Faculty of Social Sciences and Law, Makassar State University, for providing PNBP funding for the research and other contributions to this research.

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