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The Impact of Augmented Reality-Based Learning Media on Students' Digital Literacy Skills: A Study on Junior High School Students

Risnawati[1,*], Mohamed Ramadan[2], Khalid Baba[3], Sali Hammad[4], Mohammad Ali Rustaminezhad[5]
[1]Faculty of Science and Technology, Universitas Islam Negeri Alauddin Makassar, Sulawesi Selatan, Indonesia
[2]Department of Educational Technology, Fayoum University, Egyp
[3]Faculty of Science and Technology, Mohammed VI Polytechnic University, Morocco
[4]Faculty of Mathematics, International University for Science and Technology, Kuwait
[5]Department of Educational Technology, University of Birjand, Iran

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ABSTRACT

Purpose of the study: This study examines influence of augmented reality (AR)-based learning media on junior high school students' digital literacy skills, exploring its potential to enhance technology integration in education.

Methodology: Conducted in Jambi, the research involved 220 students and employed a mixed-method approach, collecting data through questionnaires that assessed students' responses to AR use and their digital literacy levels. Data analysis using SPSS 21 included descriptive statistics and regression analysis to evaluate the relationship between AR media and digital literacy development.

Main Findings: The findings revealed overwhelmingly positive student perceptions of AR-based learning media, with 58.6% rating it as "Good" and 24.2% as "Very Good." Additionally, 62.3% of students demonstrated "Good" digital literacy skills, with an average score of 28. Regression analysis indicated a significant relationship between the use of AR learning media and improvements in students' digital literacy, with AR contributing 65.1% to the observed variance. The study further highlighted that AR media fostered interactive and immersive learning experiences, making abstract concepts more accessible and engaging for students.

Novelty/Originality of this study: The novelty of this study lies in its focus on the dual impact of AR in promoting both academic learning and essential 21st-century skills like digital literacy. By illustrating the practical benefits of AR in junior high school education, this research offers valuable insights for educators and policymakers aiming to integrate innovative technologies into curricula. These findings underscore AR's potential to transform traditional classrooms, preparing students for a digitally-driven future while enhancing their learning outcomes.

Corresponding Author:
Risnawati,
Faculty of Science and Technology, Universitas Islam Negeri Alauddin Makassar,
Jl. Sultan Alauddin No. 63 Makassar, Sulawesi Selatan, 90221, Indonesia
Email: risnawati@gmail.com

1. INTRODUCTION

The role of Information and Communication Technology (ICT) in learning is critical, especially in today's digital era. ICT provides wide and fast access to information, enriching students' learning experiences through

various interactive media that can be adjusted to individual learning styles [1]-[4]. ICT not only improves the quality of teaching but also opens up opportunities for distance learning, allowing students worldwide to access the same material without geographical limitations [5]-[9]. In addition, ICT facilitates collaboration between students, teachers, and stakeholders through digital platforms, creating more practical discussions and exchanges of ideas. Using ICT makes learning more flexible, engaging, and relevant to current developments while preparing students to face global challenges that increasingly rely on technological skills.

In Asia, the role of ICT in education is becoming increasingly significant in improving the quality of learning and narrowing the gap in access to education. Japan, for example, has used ICT for advanced technology-based learning, such as AI simulations and virtual laboratories that accelerate the mastery of science and technology [10], [11]. With its excellent internet infrastructure, South Korea has leveraged ICT to support online learning and technology-based educational applications, making it a pioneer in digital education [12], [13]. In India, initiatives such as Digital India have expanded rural education access, enabling students to learn through online platforms [14]-[16]. Singapore is leading the way by leveraging big data to analyze student progress and adapt the curriculum in real time [17], [18]. In Indonesia, online learning platforms such as Ruangguru are helping to bridge the education gap by providing access to learning in remote areas [19]. The success of these countries highlights the importance of ICT as a key element in building an inclusive, innovative, and 21st-century education system.

Along with technological development, augmented reality (AR) has emerged as one of the significant innovations in education. AR allows the integration of virtual elements into the real world, creating a more interactive and immersive learning experience for students [20]-[23]. This technology allows the visualization of complex learning materials, such as the structure of the human body anatomy, simulations of scientific experiments, and historical and cultural reconstructions. AR improves students' understanding of abstract concepts, strengthens the appeal of learning, and encourages active student involvement [24]-[29].

Using AR, students can develop creativity and technological skills, making them better prepared to face the challenges of the digital era. However, the implementation of AR in learning still faces challenges, one of which is the limited digital literacy of students. Digital literacy, which includes accessing, analyzing, evaluating, and creating information through technology, is an essential skill in the digital era [30]-[35]. Digital literacy enables students to use technology effectively and responsibly but also helps them sort out valid information, avoid the negative impacts of technology, and become wise users of technology [36]-[40]. With adequate digital literacy, students can utilize technologies such as AR to support their learning and improve their skills.

Although many studies have explored the benefits of AR in improving students' conceptual understanding and engagement, studies examining its impact on digital literacy are still minimal, especially at the secondary education level. Many students find it challenging to optimize the benefits of AR without adequate digital literacy skills. In addition, the implementation of AR in Indonesia is still in its early stages, with a greater focus on technical aspects than its impact on students' digital literacy skills.

This study aims to fill this gap by analyzing the effect of AR-based learning media on students' digital literacy at the junior secondary education level, primarily through Android devices. This study offers a holistic approach by combining analysis of students' responses to AR, its impact on digital literacy, and the practical implications of using this technology in everyday learning. Thus, this study provides new insights into the potential of AR in education and highlights the importance of digital literacy as a key component to support technology-based learning in the digital era.

2. RESEARCH METHOD

This study uses a mixed-method approach. The type used is sequential explanatory. Sequential explanatory is a study whose initial data collection is quantitative, followed by qualitative data, which means that quantitative data is strengthened by qualitative data to be obtained.

The sample in this study consisted of 220 Junior High School students in Jambi who were selected using purposive sampling techniques. The sample selection criteria were 8th-grade students with academic grades above the class average, which was a minimum of 80, and who could operate smartphones well. This criterion aims to ensure that students involved in the study have the potential to utilize AR-based learning media effectively.

The instrument used in this study was the Student Response Questionnaire. This questionnaire measured how students responded to using AR-based learning media. Respondents will be asked to provide an assessment based on a Likert scale (1-5) regarding involvement, ease of use, and learning effectiveness. This questionnaire has been tested for validity and reliability, with a Cronbach's Alpha value of 0.82, indicating that this instrument is reliable for measuring student responses. Digital Literacy Test: This test measures students' digital literacy skills, including the ability to access, analyze, evaluate, and create digital content. Below is a category of the character of caring for the environment of students, among others, very good, good, not good, and very not good, like Table 1 below.

Table 1. Categories of Response and Digital Literacy

Categoty	Interval	
	Response of Augmented Reality Media	Digital Literacy
Very Not Good	24.0 – 42.0	10.0 – 17.5
Not Good	42.1 – 60.0	17.6 – 25.0
Good	60.1 – 78.0	25.1 – 32.5
Very Good	78.1 – 96.0	32.6 – 40.0

The collected data will be analyzed using descriptive statistics and inferential statistics. Descriptive statistics will describe the characteristics of students' responses to AR media and digital literacy skills. In contrast, simple regression analysis will be used to test the effect of using AR-based learning media on improving students' digital literacy skills. Data analysis was carried out using SPSS statistical software to obtain more accurate results that can be interpreted objectively.

3. RESULTS AND DISCUSSION

The results of the questionnaire and questions given were analyzed using the SPSS 21 application and can be seen in tables 2 and 3.

Table 2. Results of student responses in the use of Android-based augmented reality learning media

Classification					Mean	Min	Max	%
Range	Respond	M	F	Total				
24.0 – 42.0	Not very good	8	7	15	68	38	92	6.8
42.1 – 60.0	Not good	10	13	23				10.4
60.1 – 78.0	Good	57	72	129				58.6
78.1 – 96.0	Very good	27	26	53				24.2
TOTAL		102	118	220				100

From table 2, which came from 220 respondents from the junior high school of jambi after they were obtained and the results obtained using the SPSS 21 application program, the response of students in the use of AR learning media has a dominant result of good, with a percentage of 58.6% for 129 students from a total of 220 students, very good at 24.2% for 53 students from a total of 220 students, not good 10.4% for 23 students from a total of 220 students, and very bad at 6.8% for 15 students from a total of 220 students. From 220 students, the mean result was 68, the maximum value was 92, and the minimum value was 38.

Table 3. Results of students' digital literacy skills

Classification					Mean	Min	Max	%
Range	Respond	M	F	Total				
10.0 – 17.5	Not very good	7	6	13	28	15	38	5.9
17.6 – 25.0	Not good	11	14	25				11.4
25.1 – 32.5	Good	61	76	137				62.3
32.6 – 40.0	Very good	23	22	45				20.4
TOTAL		102	118	220				100

From Table 3, which came from 220 respondents from the junior high school of Jambi after they obtained the results using the SPSS 21 application program, in the digital literacy skills of students, the dominant results were good, with a percentage of 62.3% for 137 students from a total of 220 students, very good at 20.4% for 45 students from a total of 220 students, not good 11.4% for 25 students from a total of 220 students, and very bad at 5.9% for 13 students from a total of 220 students. From 220 students, the mean result was 28, the maximum value was 38, and the minimum value was 15.

Table 4. Results of the influence of student responses in the use of Android-based augmented reality learning media on students' digital literacy.

Variabel	Unstandardized Coefficients		Standardized Coefficients	t	sig.
	B	Std. Error	Beta		
1 (Constant)	12.128	3.151		4.513	.000
Digital Literacy	.115	.124	.123	1.129	.014

Table 4 shows that the results of a simple regression test showed that the regression equation is Y = 12.18 + 0.115X. The magnitude of the contribution of the use of AR-based learning media to students' digital literacy skills can be seen in Table 5 below.

Table 5. Contribution of the use of AR-based learning media to Students' digital literacy skills

Model	R	R square	Adjust R Square	Std. Error of the Estimate
1	.807	.651	.672	2.418

The results of the simple regression analysis show that the coefficient of determination is (R2) 0.651. This means that the contribution of AR-based learning media to students' digital literacy skills is 65.1%, while other variables influence the remaining 34.9%.

Based on the results of data analysis carried out using the SPSS 21 application, it can be seen that the use of augmented reality (AR)-based learning media has a significant influence on improving students' digital literacy skills. This study shows a relatively substantial contribution of using AR media to students' digital literacy, which is 65.1%. These results provide an overview of how AR technology can improve students' digital skills, although other factors still play a role in the results obtained.

In Table 2, the questionnaire results regarding the use of AR-based learning media show a dominant positive response from students. As many as 58.6% of the 220 respondents gave responses categorized as "Good," with an average score of 68, a maximum score of 92, and a minimum score of 38. On the other hand, around 24.2% of students rated this media as very good, while 10.4% and 6.8% rated the AR-based learning media as not good and very bad. This finding reflects that most students feel the positive benefits of using AR-based learning media, but some still face challenges in maximizing the potential of this technology. This study confirms the findings that Baabdullah et al., also stated that technology such as AR can enrich the learning experience [41]. However, the level of acceptance varies depending on student readiness and the quality of the technology implementation. This finding shows the diversity in student responses, which could be due to factors such as different levels of technological skills between students, differences in access to devices that support the use of AR, and the quality of instruction in integrating AR into the learning curriculum. Therefore, these diverse results suggest the importance of adaptive strategies in implementing new technologies to maximize inclusive learning experiences for all students.

In Table 3, the questionnaire results on students' digital literacy skills show a distribution mainly in the “Good” category, with 62.3% of students showing good digital literacy skills. As many as 20.4% of students have very good skills, while 11.4% and 5.9% show poor and very poor skills. Students' average digital literacy score is 28, with a maximum score of 38 and a minimum score of 15. Although most students have shown good digital literacy skills, these results indicate that there is still room for improvement, especially for students with lower digital literacy. Digital literacy is a very important factor in using educational technology, and improving these skills will significantly support students’ success in utilizing technology-based media such as AR [42]-[45]. These findings indicate that to maximize the potential of learning technologies such as AR, there needs to be an increase in overall digital literacy among students.

Based on the results of Table 4, a simple regression test shows a significant relationship between the use of AR media and students' digital literacy skills. The regression equation obtained is Y = 12.18 + 0.115X, with a regression coefficient value of 0.115 and a significance value of 0.014, indicating that the effect is significant at a 95% confidence level. This finding aligns with Papanastasiou et al., who found that AR-based technology can improve students' digital skills because AR facilitates more interactive and comprehensive learning [46]. These results indicate that using AR-based media is beneficial in enhancing subject matter knowledge and helps students hone their digital skills. By utilizing AR, students learn through visualization and direct experience and how to integrate technology into their learning process. In Table 5, the regression model shows an R-value of 0.807 and an R square value of 0.651, meaning that using AR-based learning media can explain 65.1% of the variability in students' digital literacy skills. The remaining 34.9% is influenced by other variables not analyzed in this study. These findings provide an overview that although AR-based learning media has a significant influence on improving students' digital literacy, other factors such as media usage training, learning environment, and basic technology skills also contribute to the development of students' digital literacy. In this context, contextual factors such as teaching support and technology accessibility greatly influence the results obtained using AR-based media. The influence of technology media on learning outcomes is highly dependent on how the technology is applied in the teaching context and how prepared students are to face it [47]-[50].

This study provides new insights into how AR-based learning media can improve student learning outcomes and significantly enhance students' digital literacy. Although many studies discuss the benefits of AR in education, this study highlights the direct relationship between the use of AR and digital literacy, which is an essential basis for preparing students to face challenges in the digital era. The implications of these findings are significant for developing a more adaptive and technology-oriented educational curriculum. The integration of

AR-based learning media in learning can improve students' digital skills, which are essential competencies in a world that is increasingly dependent on technology. Therefore, educators and policymakers must integrate AR into the curriculum more broadly and provide adequate training to improve student and teacher readiness in implementing this technology.

This study has several limitations. First, this study was only conducted in one junior high school in Jambi, so the results may not be fully generalizable to other student populations. Second, other factors such as student motivation, home environment, and use of technology outside the classroom were not analyzed, even though these factors can also affect students' digital literacy. Third, this study only used quantitative data from questionnaires, without delving deeper through interviews or direct observation of the use of AR media in the classroom. Based on the results of this study, it is recommended that schools introduce and expand the use of AR-based learning media to improve students' digital skills, especially in subjects that require visualization. Educators are given further training on how to use AR in learning to maximize its benefits. Additional research is needed to explore other factors that affect students' digital literacy and test the effectiveness of AR use at different levels of education and contexts. Thus, using AR-based technology can be an essential step in preparing the younger generation to face the challenges of an increasingly digital world.

4. CONCLUSION

This study confirms that AR-based learning media significantly enhances students' digital literacy skills, particularly by engaging students and providing interactive learning experiences. Qualitative findings reveal that students responded positively to AR integration, citing its ability to make learning more dynamic, relatable, and accessible. Many students demonstrated a marked improvement in their digital literacy, showcasing their ability to navigate, analyze, and engage with digital tools effectively. However, some students with lower initial digital literacy levels faced challenges in fully utilizing AR, highlighting the need for differentiated support. The findings suggest that AR-based learning media has immense potential to enrich educational practices, especially in fostering critical digital skills in a technology-driven era. However, for maximum impact, educators must address disparities in students' digital literacy levels by providing tailored training and guidance. This approach ensures that all students, regardless of their starting competencies, can benefit from AR integration. Future research should delve deeper into understanding the challenges faced by students with lower digital literacy levels, exploring strategies such as scaffolding and adaptive learning frameworks to make AR more inclusive. Additionally, expanding the study to diverse educational settings and grade levels can provide a broader perspective on AR's impact and inform strategies for large-scale implementation. By integrating AR thoughtfully into curricula, schools can not only enhance students' learning experiences but also equip them with vital digital competencies for future success.

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