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Usability Analysis of Augmented Reality-Based Flipbooks as Learning Media for Elementary School Students

Aditia Ayu Rahma Nabila[1]✉, Ahmad Rusdi[2], Zuleriwati AS[3], Velano Esbi Parsaoran Gultom[4]

[(1,2)]Department of Industrial Engineering, Faculty of Engineering and Maritime Technology, Raja Ali Haji Maritime University

[(3)]Department of Urban and Regional Planning , Faculty of Engineering and Maritime Technology, Raja Ali Haji Maritime University

[(4)]Department of Informatics Engineering, Faculty of Engineering and Maritime Technology, Raja Ali Haji Maritime University

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✉ Corresponding author:
[aditianabila@umrah.ac.id]

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Abstract

Digital transformation in education has driven the adoption of technologies to enhance student engagement and understanding. Augmented Reality (AR) is one such rapidly growing technology, offering immersive and visual learning experiences through 3D objects. When combined with digital flipbooks, AR creates flexiblity, particularly suitable for elementary students. AR flipbooks are seen as promising tools, blending interactive visuals with the familiar digital book. However, their effectiveness must be evaluated from the user's perspective, especially students as end-users. This study aims to assess the usability of AR flipbooks using the USE instrument (Usefulness, Ease of Use, Ease of Learning, Satisfaction). A descriptive quantitative method was applied to 13 students from SDN 10 Tanjungpinang Kota. The results revealed that usefulness and ease of learning significantly influenced student satisfaction. These findings suggest that the more beneficial and easy-to-understand the media is perceived by students, the higher their satisfaction in using AR flipbook learning tools.

1. INTRODUCTION

The advent of digital technology has significantly transformed various sectors, and education is no exception. In recent years, the integration of digital tools in classrooms has shifted the landscape from traditional, teacher-centered instruction toward a more student-centered, interactive, and adaptive learning environment (Salsabila, et al. 2023; Wardoyo et al. 2021). This transformation has altered not only the way knowledge is delivered but also how students engage with content, teachers, and peers. The shift aligns with the broader movement toward Education 4.0, which emphasizes technological competence, personalized learning, and lifelong

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learning paradigms (González-pérez and Ramírez-montoya 2022; Matsumoto-Royo, Ramírez-Montoya, and Conget 2021; Rane 2024).

Central to this transformation is the development and utilization of diverse digital learning materials. These materials, when designed effectively, support active learning by incorporating multimedia elements such as text, images, audio, and video, thus catering to multiple learning styles (Afif 1970; Al-Gerafi et al. 2024). Digital content allows for self-paced learning and fosters greater autonomy among students. This flexibility is essential in promoting meaningful learning experiences and improving overall academic achievement (Ade Sofyan and Amin Hidayat 2023; Setiyadi 2023).

Digital learning materials are not only relevant in secondary or higher education but are increasingly crucial in primary education as well. Children today are considered "digital natives"—students who grow up in technology-rich environments and are naturally inclined toward digital interaction (Shariman, et al. 2012). Consequently, traditional textbooks and printed worksheets often fail to capture their interest. To bridge this engagement gap, educators are increasingly turning to more interactive and visually rich media. Among the various digital innovations, flipbooks have emerged as a promising learning medium. A flipbook is a digital book that simulates the page-turning experience of a physical book while incorporating dynamic content such as animations, videos, hyperlinks, and sound effects. It offers the familiarity of traditional learning tools while integrating modern technological features that enhance student interest and motivation (Millati and Setyasto 2023). Flipbooks also promote cognitive development by structuring content in a sequential and logical format, allowing learners to follow the material at their own pace (Ramdani et al. 2023). In this way, flipbooks support both the constructivist learning theory—where learners actively construct knowledge based on experience—and the cognitive load theory, by reducing extraneous load through multimedia integration (Roemintoyo and Budiarto 2021). Furthermore, flipbooks are portable and can be accessed on various devices, including smartphones and tablets, thus supporting both classroom and remote learning. Another advantage of flipbooks is their adaptability. Teachers can customize flipbook content to suit the learning objectives, student age, and subject matter. For younger learners, particularly in primary schools, this adaptability allows educators to design visually stimulating and age-appropriate content that maintains student attention and supports literacy development (Ekasafitri, et al. 2024).

Despite the inherent advantages of flipbooks, further enhancement is possible through the integration of Augmented Reality (AR). AR is a technology that overlays digital content—typically 3D models, animations, or informational tags—onto the physical world via smartphone or tablet screens (Hutahaean, et al. 2022). AR provides real-time interaction with virtual objects, enabling a highly immersive and contextualized learning experience. In the context of education, AR has shown great promise across various domains including science, mathematics, and language learning. It supports kinesthetic and experiential learning by enabling students to manipulate and interact with virtual models (Al-Ansi et al. 2023). For example, a biology lesson that allows students to explore the anatomy of the human body in 3D through AR is likely to be more engaging and memorable than static textbook images. Moreover, AR simplifies the learning of abstract or complex concepts. In physics, chemistry, or geography, concepts that are difficult to visualize can be represented spatially in AR, improving comprehension and retention (Indahsari and Sumirat 2023). This capability makes AR particularly beneficial in primary education, where abstract reasoning is still developing. In this context, AR becomes more than a tool for engagement—it becomes a scaffold for deeper understanding.

Studies have also highlighted the cost-effectiveness of AR in education. Contrary to assumptions that such technology requires sophisticated devices, many AR applications are compatible with standard mobile devices and can be developed using free or low-cost platforms (Hidayat, et al. 2022). Therefore, schools with limited budgets can still adopt AR without incurring excessive costs. Integrating AR into flipbooks—resulting in Flipbook AR—combines the strengths of both mediums: the systematic content delivery of flipbooks and the interactivity of AR. This hybrid medium creates a more engaging, multimodal learning experience that can appeal to a wide range of learning preferences.

Flipbook AR serves as a platform for multi-sensory learning. Visual learners benefit from animations and interactive 3D models, auditory learners from narration and sound effects, and kinesthetic learners from engaging with touch-based content. In turn, this multimodal approach aligns with the Universal Design for Learning (UDL) framework, which advocates for providing multiple means of representation, engagement, and expression in education (Atut, 2023). Furthermore, Flipbook AR supports 21st-century skills such as critical thinking, creativity, and digital literacy. By presenting content in ways that encourage exploration and self-guided discovery, it promotes inquiry-based learning and problem-solving. This innovation is particularly aligned with the demands

of the Indonesian curriculum, which emphasizes holistic and student-centered approaches. Despite the pedagogical potential of Flipbook AR, its successful implementation depends on usability—the degree to which the medium is effective, efficient, and satisfying for its users. Usability is a key aspect of User Experience (UX), which encompasses all aspects of a person's interaction with a digital product (Hamidli, 2023). In educational contexts, usability determines whether learners can navigate and benefit from digital materials independently and enjoyably. A well-designed AR learning tool should not only function correctly but also be intuitive, accessible, and enjoyable for its intended users—primary school students in this case. Unfortunately, many educational innovations prioritize technological novelty over usability, leading to limited classroom adoption (Ramdani et al. 2023).A product that is difficult to use or understand will hinder rather than support learning.

The importance of conducting structured usability evaluations is well-recognized in the field of educational technology design. Without such assessments, developers risk creating products that do not meet user needs or expectations. In the case of AR media in primary schools, usability research remains limited, with most existing studies focusing solely on learning outcomes (Atut, 2023). This leaves a gap in understanding how students perceive and interact with the technology.

A number of studies have explored AR in education with promising results. For instance, (Ramdani et al. 2023) reported increased student engagement when AR was used in science instruction. Similarly, (Atut, 2023) observed improvements in conceptual understanding when AR was integrated into flipbooks. However, these studies did not utilize standardized instruments to assess usability or systematically explore student perceptions.

Moreover, most existing evaluations are exploratory or qualitative, lacking the quantitative rigor required for generalization. There is also a scarcity of research focused on the primary school level, where developmental characteristics and cognitive load considerations differ significantly from those of older students. This study responds to these gaps by employing a structured and validated instrument for usability evaluation: the USE questionnaire developed by Lund (2001) . The USE instrument assesses four key dimensions of usability: (1) Usefulness – How the system helps users achieve their goals effectively; (2) Ease of Use – How simple and effortless the system is to use; (3) Ease of Learning – How quickly and easily users can learn to operate the system; and (4) Satisfaction – The level of contentment users feel when using the system. The USE questionnaire has been widely used and validated in numerous technology usability studies across educational, commercial, and software development domains. It offers a comprehensive, yet concise method for evaluating user perceptions and experiences quantitatively (Gesilanda, et al. 2023). Applying this instrument in the context of AR-based flipbooks provides actionable insights into what aspects of the media work well and what needs improvement.

So this study was conducted at SDN 10 Tanjungpinang Kota, a school that has adopted Flipbook AR in its instructional process but lacks systematic evaluation of its usability. The objective of the research is to assess the usability level of Flipbook AR as perceived by primary school students, using the USE instrument.

2. METHODS

The method employed in this study consists of four stages, namely Define, Design, Development, and Evaluation. In the Define stage, the research problem and objectives were identified to establish a clear direction for the study. The Design stage involved the creation of appropriate research instruments to measure usability effectively. During the Development stage, the AR-based flipbook learning media was created based on the defined objectives and designed instruments. Finally, in the Evaluation stage, the developed media was tested and analyzed to assess its usability and effectiveness in supporting the learning process.

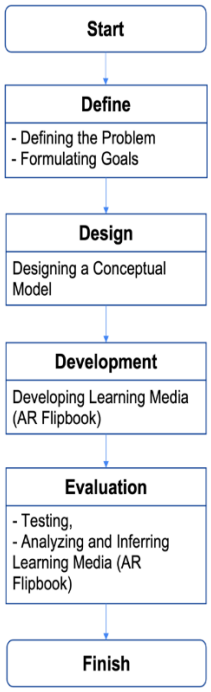

Fig. 1. Research Stages

Define

In the initial stage, the problem was identified, and the research objectives were formulated through classroom observations during teaching and learning activities. These observations focused on identifying students' learning styles and their engagement during lessons. The results revealed that the learning process and media predominantly relied on lecture methods, textbooks, and PowerPoint presentations. As a result, the classroom environment appeared monotonous and lacked active student involvement. Therefore, it became evident that more engaging learning media were needed to foster better understanding and promote interactive learning experiences. After identifying the core problem, the next step was to formulate the research objectives. The objective of this study is to develop and evaluate an AR-based flipbook learning medium. To enhance the learning atmosphere, AR markers designed to display 3D objects were integrated into the digital book (flipbook).

Design

At this stage, a conceptual model was designed to facilitate the measurement of the effectiveness of using AR-based flipbooks as a learning medium. The conceptual model employed in this research is based on the USE instrument model, which includes four variables: Usefulness, Ease of Use, Ease of Learning, and Satisfaction.Should you need sub-headings, use this style as the level-1 sub-heading. The paragraphs following the sub-heading level-1 should be formatted in this way.

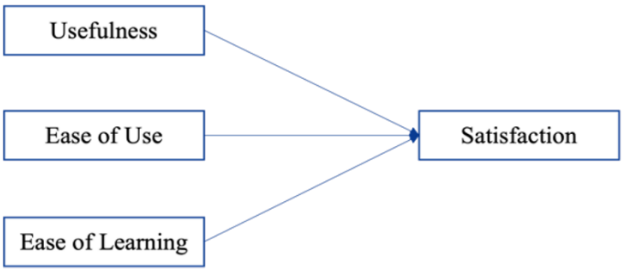

Fig. 2. Conceptual Research Model

Development (Developing the Media)

This stage involved the development of the AR-based flipbook learning media. Key activities included designing the initial layout of the flipbook, integrating AR prototypes, and demonstrating the media to students. Additionally, data were collected through surveys to evaluate the usability of the AR flipbook.

Evaluation (Testing and Analyzing)

The final stage of the research was evaluation, aimed at testing and analyzing the effectiveness of the developed AR-based flipbook learning media. The instrument used for evaluation was a questionnaire adapted from the USE Questionnaire.

Respondents and Questionnaire

The respondents in this study were fifth-grade students at SD Negeri 10 Tanjungpinang Kota. A total of 13 students participated, comprising 38.5% (5 students) female and 61.5% (8 students) male. The students' ages were distributed as follows: 38.5% were 10 years old, 53.8% were 11 years old, and 7.7% were 14 years old. Data collection was conducted using a questionnaire adapted from the USE Questionnaire, which consisted of 16 statements translated into Indonesian, as shown in Table 1.

Table 1. Results of Validity and Reliability Analysis

No	Questionnaire Statement Indicators	Code
	Usefulness (UFN)	
1	This flipbook helped me understand the lesson better.	UFN1
2	This flipbook makes the learning process more effective.	UFN2
3	I feel that this flipbook is useful to support my learning.	UFN3
4	This flipbook helps me complete tasks faster.	UFN4
	Ease of Use (EOU)	
5	This flipbook is easy to use.	EOU1
6	I had no trouble using it.	EOU2
7	The appearance of this flipbook is easy to understand.	EOU3
8	I feel comfortable when using this flipbook.	EOU4
	Ease of Learning (EOL)	
9	I was able to quickly understand how to use this flipbook.	EOL1
10	I don't need anyone else's help to learn how to use it.	EOL2
11	The instructions for using this flipbook are quite clear.	EOL3
12	I was able to use this flipbook correctly from the first try.	EOL4
	Satisfiction (STF)	
13	I feel satisfied using this flipbook.	STF1
14	This flipbook makes me enjoy learning.	STF2
15	I want to use flipbooks like this for other lessons.	STF3
16	I would recommend this flipbook to others.	STF4

3. RESULT AND DISCUSSION

The learning media developed in this study is an AR-based flipbook focused on the topic of energy sources, specifically wind energy in the maritime sector. The application system within the flipbook includes an AR feature that detects markers by having the user point a smartphone camera at a barcode. Once detected, a 3D virtual object is displayed in real time on the smartphone screen. The 3D virtual object presented in the AR flipbook is a wind turbine.

Fig. 3. Flipbook.

Fig. 3 shows the interface of the flipbook, which consists of several digital slides or pages. A QR code is embedded within the flipbook, which, when scanned using a smartphone or tablet camera, directs students to a

video explaining the learning material. The video provides a brief explanation of the concept being discussed, specifically how a wind turbine works and its benefits as an alternative energy source. This feature enables students to learn through audio-visual content.

In addition to the video, there is also a specially designed AR barcode intended to display a 3D model of a wind turbine. When this barcode is scanned through an AR application on a mobile device, the wind turbine appears in a three-dimensional (3D) format on the screen. Students can rotate, zoom in, and observe the structure of the wind turbine from multiple angles, as if viewing it in real life, as illustrated in Fig 4.

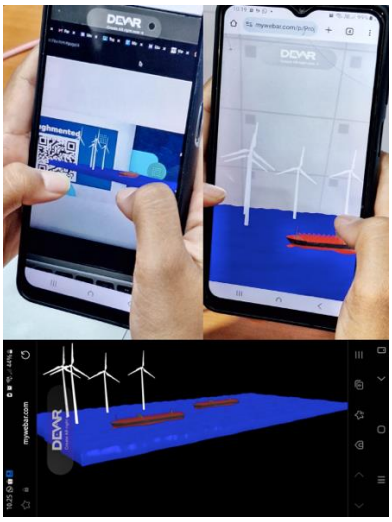

Fig. 4. AR Display in the Flipbook.

Data Collection

After the AR-based flipbook learning media was demonstrated to the students, the next stage involved testing its effectiveness. This evaluation focused on the students' perspective as the primary users, aiming to obtain an objective understanding of their experience using the media. A survey was conducted involving 13 fifth-grade students from SD Negeri 10 Tanjungpinang Kota. The instrument used in the survey was the USE Questionnaire (Usefulness, Satisfaction, and Ease of Use), which was designed to assess the perceived usefulness, ease of use, and user satisfaction with the AR flipbook learning media.

Validity and Reliability Testing of the Questionnaire

Validity and reliability testing of the questionnaire was conducted to ensure the assessment instrument was accurate, stable, and consistent. Validity was tested using Pearson correlation through the SPSS software. In the first round of testing, two indicators were found not to meet the validity criteria and were thus removed from the instrument. A second round of analysis showed that all remaining indicators were valid, with correlation values exceeding the critical value of 0.553. Reliability was tested using Cronbach's Alpha, with a minimum threshold of 0.70 (Hair, 2017). The results indicated that all indicators were reliable. The outcomes of the validity and reliability analyses are presented in Table 2.

Table 2. Results of Validity and Reliability Analysis

No	Assessment Instrument	Validity	Reliability
1	UFN2	0,786	0,945
2	UFN3	0,694	0,948
3	UFN4	0,734	0,946
4	EOU1	0,833	0,944
5	EOU2	0,613	0,951
6	EOU3	0,718	0,947
7	EOU4	0,832	0,944
8	EOL1	0,792	0,945
9	EOL2	0,832	0,944
10	EOL3	0,828	0,944
11	EOL4	0,829	0,944

No	Assessment Instrument	Validity	Reliability
12	STF1	0,880	0,942
13	STF2	0,787	0,945
14	STF3	0,778	0,945

Partial t-test Analysis

Partial t-test was conducted to examine the influence of Usefulness (UFN), Ease of Learning (EOL), and Ease of Use (EOU) on Satisfaction (STF) in the use of AR-based flipbook learning media. The test was performed using a significance level of 0.05, with a critical t-value of 2.262. The results of the partial t-test analysis are presented in Table 3.

Table 3. Results of Partial t-Test Analysis.

	Unstandardized Coefficients		Standardized Coefficients		
Model	**B**	**Std.Er**	**Beta**	**t**	**Sig.**
(Constant)	.388	1.317		0.295	.775
UFN	.365	.153	.393	2.388	.041
EOU	-.202	.158	-.270	-1.277	.234
EOL	.674	.126	.887	5.354	.000

The analysis results in Table 3 indicate that the variables UFN and EOL have significance values of 0.041 and 0.000, respectively (< 0.05), and t-values of 2.388 and 5.354 (> t-table), indicating that both variables have a significant effect on satisfaction. Meanwhile, the EOU variable has a significance value of 0.234 (> 0.05) and a t-value of -1.277 (< t-table), indicating that it does not have a significant effect. Therefore, it can be concluded that student satisfaction with the use of the AR flipbook is significantly influenced by its usefulness and the ease of learning the media.

Results of the F-Test Analysis

The F-test was conducted to determine whether the independent variables simultaneously influence the dependent variable. The test was performed using a significance level of 0.05, with the known F-table value of 3.71. The results of the F-test analysis are presented in Table 4.

Table 3. Results of Partial t-Test Analysis.

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	61.823	3	20.608	34.299	0.000
Residual	5.407	9	.601		
Total	67.231	12			

The analysis results in Table 4 show that the calculated f-value (34.299) is greater than the F-table value (3.71). This indicates that the independent variables (Usefulness, Ease of Use, and Ease of Learning) simultaneously have a significant effect on the dependent variable (Satisfaction).

4. CONCLUSION

Based on the analysis and discussion, it can be concluded that the Augmented Reality (AR)-based flipbook learning media developed in this study is effective as a learning aid at the elementary school level. This media has been proven to facilitate students' understanding of the learning material in a more interactive and engaging manner. The evaluation results through the t-test and F-test show that the variables of usefulness and ease of learning have a significant effect on students' satisfaction with the use of the AR flipbook media. This indicates that the more useful and easier the media is to understand, the higher the level of student satisfaction in using it.

These findings are consistent with previous studies, such as Sibarani et al. (2024), who stated that flipbook media is highly suitable and effective for learning activities among third-grade elementary students. Additionally, Gesilanda (2023) also found that the use of AR puzzle book media helps students better understand the presented learning material.

Therefore, the AR flipbook learning media can be recommended as an innovative and effective teaching aid for elementary school students, particularly in providing a more enjoyable, interactive, and meaningful learning experience.

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