Migration Letters

Volume: 21, No: 5, pp. 195-209

ISSN: 1741-8984 (Print) ISSN: 1741-8992 (Online)
www.migrationletters.com

The Development of AR Books for Thematic Contents of Science and Social Studies in Elementary School to Foster Literacy and Numeracy Skills

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Abstract

The present study aimed to develop an AR book that focuses on fostering literacy and numeracy skills for elementary school students. We employed the ADDIE (Analysis, Design, Develop, Implement, and Evaluate) framework as a research design to develop an AR book. To examine several stages in ADDIE, we involved several groups of participants, all of whom were chosen using the purposive sampling technique, as their appropriateness aligned with our research goals: two professional fifth-grade elementary school teachers, three experts in educational technologies, and 20 sixth-grade elementary students. All of them contributed to the examination of AR books. Several analyses, including bibliometric analysis, portability tests, content validity index (CVI), and the System Usability Scale (SUS), were used to ensure that the AR book fulfills the requirements of the literacy and numeracy skills context in the Indonesian curriculum for elementary schools. Based on our measurements and data analysis, we revealed that the developed AR book had an appropriate framework, achieved a successful installation rate on several Android OS platforms, and was categorized "good" based on the System Usability Scale. This demonstrates that the AR book is ready to be applied in the classroom and has the potential to benefit the training of literacy and numeracy skills in elementary schools.

Keywords: *AR book; literacy skills; numeracy skills.*

1. Introduction

Textbooks have played important roles in fostering and shaping essential aspects of learning. Some research in educational fields has focused on aspects of scientific literacy, genders Gumilar, et.al, 2022), nature of science (Chiappetta and Fillman, 2007), and language (Yun & Park, 2018). This shows that research in the context of textbooks is still growing over time. Not only has the research come from the science education field (Gumilar and Ismail, 2023), but it has also been investigated in the social studies field. Indeed, there are some reasons why research in textbooks has become popular. Firstly, textbooks have been positioned as the main resources for students to learn specific content knowledge. Secondly, textbooks are closely related to other aspects such as literacy and numeracy skills, which have been objects of educational research. Lastly, textbooks serve as essential agents for instilling several values in students (Knain, 2001), such as gender equality.

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In spite of the increasing focus on textbook research, the integration of technological advancements, particularly computers, into textbooks continues to gain attention. Some researchers have specifically concentrated on the development of augmented reality (AR) books. These textbooks utilize AR technology to offer visualizations of various phenomena. According (Azuma, 1997), (Kaufmann, 2003) defined the implementation of AR based on its characteristics, as a combination of real-world and virtual elements that are interactive in real-time and registered in 3D. Other researchers have defined AR systems as a combination of real and computer-generated information in a real environment, interactive in real-time, which aligns with both virtual and physical objects (Höllerer and Feiner, 2004). Presently, research on AR books has been undertaken in numerous subjects within the educational domain. For instance, scholars from Spain have delved into the development of AR books to enhance the comprehension of certain concepts in biology, particularly anatomy. The research findings demonstrated that the utilization of AR books could boost motivation, autonomous work, and comprehension of three-dimensional tasks (Torregrosa, et.al. 2015). Similarly, other researchers created AR books and examined the interaction between children and parents who shared the experience of reading AR books. The results revealed that the use of AR picture books also fostered motivation and led to a comprehensive understanding (Cheng & Tsai, 2016). Furthermore, in a different context, researchers disclosed that the implementation of AR books in the learning process could enhance children's motivation to read (Roumba and Nicolaidou, 2022). All these studies confirm that the use of AR books has indeed facilitated students' motivation in the learning process.

This research is based on the foundation that sub-microscopic phenomena, such as electron movement, cannot be effectively represented in practical physical works (Ismail, et.al. 2019). In a different context of physics education, AR technologies have been integrated into physics learning as part of the implementation of problem-based learning (Fidan and Tuncel, 2019). The findings have indicated that learning achievement and attitudes toward learning physics increased significantly. In the field of biology, the use of AR in the learning process has also been found to enhance students' motivation, although there has been no significant improvement in students' achievements in the biology course (Erbas and Demirer, 2019). In the context of social studies, AR technologies have been utilized to offer students new experiences or revitalize old ones at museums, heritage sites, and other areas of historical value (Challenor and Ma, 2019), (Raghaw, et.al. 2018), (Lim and Lim, 2020), (Ibharim, et.al, 2021). For instance, Gopalan et al. has investigated how the role of science textbooks integrating AR technology could enhance students' motivation (Gopalan, et.al. 2019). The result showed that motivation of lower students in secondary school toward science learning increase. Other researchers also investigated potential benefits of AR book when used by children to read story books, and it showed that the children were driven to actively interact to real world phenomena provided (Dünser and Hornecker, 2007). AR books can visualize abstract historical object into more concrete objects (Tetep, 2019). These examples of the research in AR book have shown that it had positive impacts on both motivation and students' interaction during reading activities.

2. Methodology

2.1 Research Design

We employed the ADDIE (Analysis, Design, Develop, Implement, and Evaluate) framework (Rossi, 2021), (Mayfield, 2011). as a research design to develop an Augmented Reality (AR) book. The "analysis" phase was dedicated to the needs analysis, which was necessary to investigate both theoretical and practical evidence. For the theoretical aspect, we used a Publish and Perish software to analyze a number of articles. Then, the Vos-viewer software was employed to visualize the keywords based on these

articles. The publishing and research software allowed us to review ten out of a hundred articles related to AR books, which represented the highest number of citations. Simultaneously, we explored practical evidence, particularly the perceptions of teachers regarding the use of AR books in the learning process. This study involved sixth-grade students in an elementary school, two senior elementary teachers, and engaged three experts in educational technologies. Moving on to the next stage, the design of the AR books. Our objective was to establish a well-suited design for AR books that effectively support literacy and numeracy skill development. In this stage, we also developed frameworks or structures for the content of AR books based on literacy and numeracy skills. The third stage involved development, aiming to generate and validate AR books. In this stage, we included experts in AR technology and literacy-numeracy experts to validate both the content and product of AR books. The following stage was the implementation, where the AR books developed were tested on a limited number of participants, consisting of 20 sixth-grade students from elementary schools. This implementation aimed to examine whether the AR book could run on various devices, such as mobile phones, and significant issues arose during this process. Finally, the last stage involved evaluation of our work on AR books from the analysis to the implementation stage.

2.2 Sample and Data Collection

We involved several groups of participants, all of whom were chosen using the purposive sampling technique, as their appropriateness aligned with our research goals. The first category of participants consisted of two senior elementary teachers who taught students in public elementary schools. They were 42 and 43 years old, with more than 15 years of experience. The second category of participants encompasses three experts in educational technologies. Their average ages were 43.3 years old, two out of them hold doctoral degree in technological education and an expert hold doctoral degree in informatics and computer science. They were also lecturers in department of technological education in one private university in Indonesia and have had experiences in this field for almost 15 years. The third category of participants comprised sixth-grade students from a public elementary school in Indonesia. Their participation in this study was permitted by their teachers and parents through an ethical agreement. They were between 10 and 11 years old and were also familiar with using mobile or smart phones.

2.3 Analyzing of Data

We developed and utilized several instruments throughout each stage of the ADDIE process. An analysis of the data obtained was adjusted to ensure their reliability with the instruments and data. Table 1 displays the types of instruments, data, and data analysis used in the present study.

Table 1. Instruments, types of data, and data analysis

ADDIE stages	Instruments	Data sorts	Data analysis
Analysis	• Publish and perish software (Jacso, 2009); Vos-Viewer software (Wang, 2023)	• Article and Visual representation	• Citation and visual analysis
	• Seven questions of semi-structure interviews	• Transcription of the interview responds	• Descriptive analysis (Traphagan, 1997)
Design	Judgement worksheet (two optional choices:	Score agreement of three experts	Content validity index analysis (Shrotryia and

ADDIE stages	Instruments	Data sorts	Data analysis
	(1) shows acceptance and (0) shows a rejection		Dhanda, 2009)
Develop	The researchers explain some procedures to develop AR book from creation of story board to creation of user interface.		
Implement	• Portability test	• Observation of application trials in several devices	• Descriptive analysis
	• Usability test (Questionnaire: System Usability Scale) [34]	• Quantitative rating scale given by users	• Simple proportion of rating scale
Evaluate	Researchers evaluated four previous stages to ensure that AR book developed fulfilled need analysis, design, and explained some issues emerging in the development and implementation if were.		

3. Results and Discussion

3.1 Need analysis

To gain insight into the context of the present study, we utilized publishing and research software to gather articles related to the development of AR books for both natural science and social studies content, as well as Vos-viewer representation. Additionally, we conducted semi-structured interviews. Initially, we employed publishing and research software to investigate articles related to the use of AR technologies. Using two key words, "augmented reality" and "AR book," we identified 10 articles out of 100 that dominated in terms of the number of citations. These ten articles were the top ten most cited in relation to the keywords "augmented reality" and "AR books." Details of these articles are provided in Table 2. It became evident that not all research in AR technologies focused on augmented reality books. From the ten articles with the highest number of citations, we inferred that the use of AR technologies and AR books in the educational field needed further advancement. This highlighted the rarity of the development of AR books for content in natural and social science.

Table 2. Some publications of AR technologies by using a publish and perish software

No	Citations	Title of the articles	Year	Author(s)
1	46	A Review of Telepresence, Virtual Reality, and Augmented Reality Applied to Clinical Care	2020	Hilty., et al (Hilty et al., 2020)
2	39	Enhancing Students' Biology Learning by Using Augmented Reality as a Learning Supplement	2020	Weng., et al (Weng, et.al. 2020)
3	30	Co-designing with children a collaborative augmented reality book based on a primary school textbook	2018	Alhumaidan., et al (Alhumaidan, et.al. 2018)
4	22	Mixed Reality in Science Education as a Learning Support: A Revitalized Science Book	2019	Weng., et al. (Weng, et.zl. 2019)

No	Citations	Title of the articles	Year	Author(s)
5	18	Interactive learning media innovation: Utilization of augmented reality and pop-up book to improve user's learning autonomy	2019	Elmunsyah (Elmunsyah, et.al. 2019)
6	17	Augmented reality social story for autism spectrum disorder	2018	Syahputra., et al (Syahputra., et al. 2018)
7	16	The development of an electricity book based on augmented reality technologies	2019	Permana., et al (Permana., et al, 2019)
8	13	Interactive multimedia-based educational system for children using interactive book with augmented reality	2019	Abu-Arqoub., et al (Abu-Arqoub., et al. 2019)
9	12	The effect of augmented reality on spatial visualization ability of elementary school student	2019	Phon., et al. (Phon., et al. 2019)
10	10	Promoting the quality of life of elderly during the COVID-19 pandemic	2021	Lee., et al (Lee., et al. 2021)

Secondly, after obtaining 10 articles with the highest percentage of citations, we utilized the Vos-viewer software to create visualizations. These visualizations established connections between various key words extracted from the articles. Some of the key words included "AR app," "AR book," "marker," "video," "implementation," "medium," "real world," "user," "concept," "consumer," "experiences," "tourism," "role," "journal," "mixed reality," "literature," "systematic review," "virtual reality," "field," "work," "child," "display," "mathematics," "image," "way," "effectiveness," "interest," "training," "evaluation," and "covid" (see Figure 1). The size of each round shape corresponds to the extent of investigation, with larger shapes indicating more substantial exploration. Additionally, the shapes represent the degree of connection to other keywords. For example, the central position of the keyword "augmented reality" in Figure 1 illustrates its pivotal role, linking it to various other keywords. This suggests that this particular keyword has garnered significant interest among researchers across different fields. However, the visual representation of the keyword "AR book" appeared as a small round shape, indicating that it has received relatively less attention from researchers.

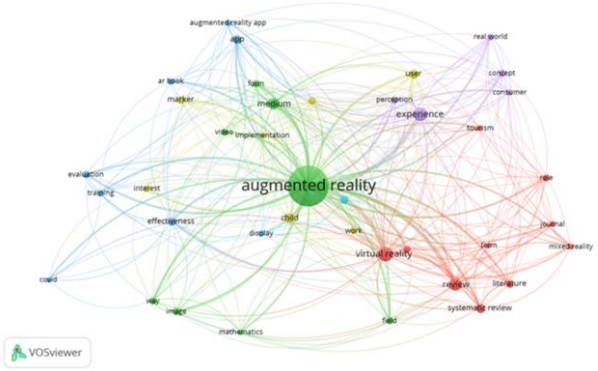


Fig. 1. Visual representation of the research about AR technologies by using Vos-viewer.

Finally, to analyze the need for the development of an AR book for science and social studies content in fifth-grade elementary school, we interviewed two senior elementary teachers regarding IPAS learning, student interest, the difficulty of IPAS learning, the use of learning media in IPAS learning, the use of AR technology in IPAS learning, and the implementation of IPAS learning in the context of literacy-numeracy skills. Based on our focused interview questions, several transcriptions of the interview responses were represented in Table 3. From this data, we gleaned several essential points regarding the use of technology in IPAS learning. This situation highlights the crucial role of AR books in IPAS learning, as they can support teachers in fostering literacy and numeracy skills in elementary school. Our investigation into the teachers' responses revealed that they still primarily utilize presentation-based learning media, such as PowerPoint, to display animations, aiming to facilitate understanding. Furthermore, they have not yet employed IPAS learning as a bridge to foster literacy and numeracy skills, despite it being a priority in the Indonesian elementary school curriculum. These empirical pieces of evidence underscore the necessity of introducing AR books in the Indonesian context to bridge the gap in the utilization of technological animations and the absence of a structured learning process aimed at enhancing literacy and numeracy skills.

Table 3. Responses of elementary teachers to IPAS learning, the use of AR technologies, and connection of IPAS learning to bridge literacy and numeracy skills

Interview questions	Responses of the teachers	
	Teacher-1	Teacher-2
How is the students' interest in participating in IPAS learning activities?	Some students were enthusiastic about IPAS learning, while others were still less enthusiastic.	Most students were very enthusiastic during IPAS learning activities, and they tend to prefer project-based learning.
What are the difficulties faced by teachers in facilitating IPAS learning activities?	The difficulties arose due to the limited facilities and equipment for IPAS learning activities that emphasized project-based learning, and the inability to integrate them with instructional technology.	There was also a lack of facilities for practical activities in science learning, making it challenging to explain to the students.
What instructional media do you often use in IPAS learning activities?	I primarily use physical textbooks.	The most frequently used media are textbooks and Student Worksheets.
What technology have you integrated into IPAS learning?	Technology-based on Power-Point media displaying contextual learning based on animation.	Power-Point media is occasionally used, so the approach is more conventional, with contextual learning.
Have you integrated AR into IPAS learning environment?	Some teachers have not integrated AR into IPAS learning.	The integration of IPAS learning is still combined with physical textbooks and project-based practical activities for students in the surrounding environment.
Have you applied Augmented Reality media	Not yet, as the use of Augmented Reality media	Augmented Reality media is still unfamiliar to teachers,

Interview questions	Responses of the teachers	
	Teacher-1	Teacher-2
in your IPAS learning activities?	is still relatively unfamiliar and not widely known among teachers	so no one has implemented it yet.
Do you use science learning as a bridge to foster literacy and numeracy skills?	Perhaps not directly, I focus on mastering the concepts of science and social studies within IPAS learning.	Not yet, as the focus is still on understanding the material.

What we have discovered clearly demonstrates the invaluable necessity of an AR book for integrated science and social studies content. As supported by other research findings, the use of AR technologies has been shown to enhance motivation, learning outcomes, and overall understanding (Jacsó, 2009), (Wang, et.al. 2023), (Traphagan, 1997), (Shrotryia and Dhanda, 2019). Additionally, the need to incorporate other types of technologies, rather than solely relying on PowerPoint, has become a prominent factor in the implementation of the Indonesian elementary school curriculum.

3.2 Design of AR Book

In the second stage, we endeavored to design a desirable framework or structure for the AR book, focusing on enhancing literacy and numeracy skills. Two crucial considerations during this process were the design structure of the AR book and the integration of AR technology. Initially, we divided the framework into three main facets: literacy in IPA, literacy in IPS, and numeracy. The facet of literacy in IPA encompassed four key activities, namely reading IPA content, writing new vocabulary, communicating written arguments, and reflecting. Similarly, the facet of literacy in IPS included four activities: reading IPS content, writing new vocabulary, communicating written arguments, and reflecting. The numeracy facet entailed four activities: reading with IPAS content, writing new vocabulary, communicating written arguments, and reflecting. To validate the initial framework, we consulted three experts with technological and educational expertise.

The results of this consultation are outlined in Table 3, showing a total agreement percentage of 0.83, falling into the 'fair' category, indicating the need for revision. After revising the framework, all experts reached a unanimous agreement on the final AR book framework developed. The revised framework can be observed in Figure 2. Based on the final framework, we developed the AR books, ensuring that the book's structure adhered to this revised framework. The development of this AR book was specifically centered around the chosen content, "Changes in Substance and Its Benefits" (Perubahan Zat dan Manfaatnya).

Table 4. Responses of Initial framework of IPAS-AR book

Facet	Sub-facets	Judgment result			NoA	PoA
		E-1	E-2	E-3		
Literacy IPA	Read IPA content Integrated AR	■	■	■	3	1
	Write new vocabulary	■	■	■	3	1
	Communicate written argument	■	■	■	3	1
	Reflect	■	■	■	3	1
Literacy	Read IPS content	■	■	■	3	1

IPS	integrated AR					
	Write new vocabulary	□	□	■	1	1/3
	Communicate written argument	□	□	■	1	1/3
	Reflect	□	□	■	1	1/3
Numeracy	Read IPAS content integrated AR	■	■	■	3	1
	Write new vocabulary	■	■	■	3	1
	Communicate written argument	■	■	■	3	1
	3.4. Reflect	■	■	■	3	1
PoA average						0.83

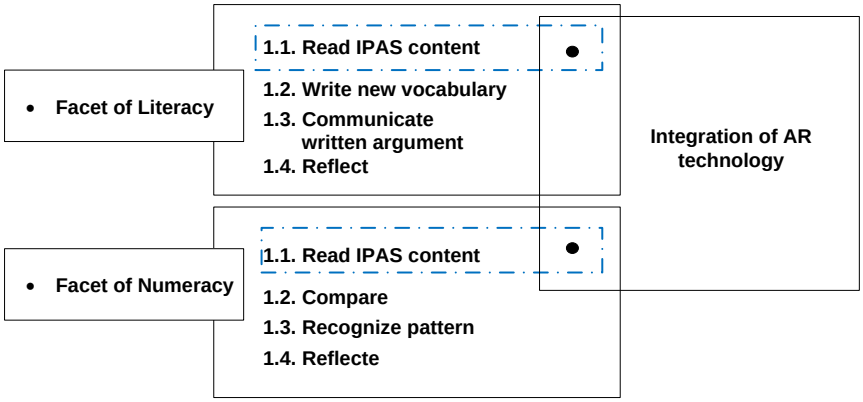
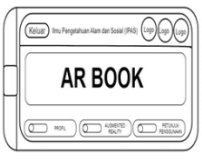
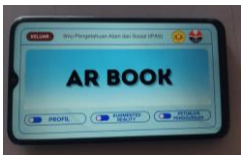


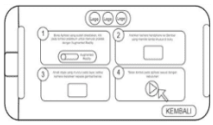
Fig. 2. Visual Final structure of AR book-based literacy and numeracy skills

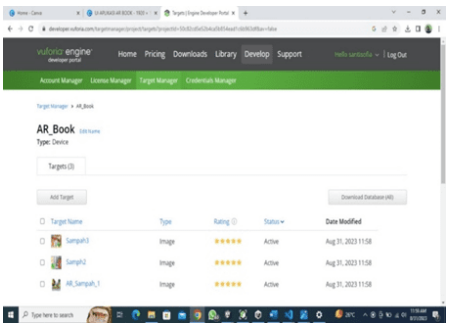
3.3 Development of AR book

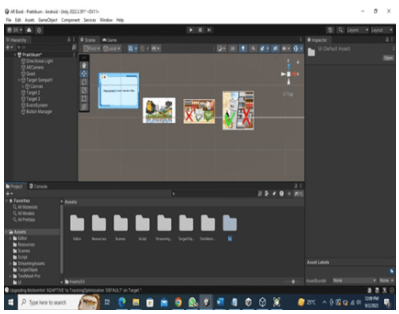
In the stage, we developed AR book, presenting integrated content of science and social studies, to two stages, started from creation of story board to integration of objects to the Vuforia Creator application, which is an essential companion for anyone developing Augmented Reality (AR) experiences using Vuforia Engine. The integration of AR to physical book was conducted by presenting video in a marker, which a two-dimensional picture embedded in IPAS textbook. We firstly made story board and it was then followed by creating user interface as presented in the Table 5.

Table 5. Story board and user interface of the application.

Feature	Story board	User interface	Information
Main Menu			The main menu display contains several menu buttons, namely the augmented reality menu to access the AR camera, usage instructions, and the profile menu. There is an exit button if the user wants to exit the application

AR Camera Menu			The AR Camera menu displays the view of the mobile phone camera.
Usage Instructions Menu			The Usage Instructions menu displays information about the step-by-step instructions for using the application, and there is a back button if the user wants to return to the main menu.
Profile Menu			This menu displays information about the developer's profile of the IPAS Book.





3A 3B

Fig. 3. Stages of Vuforia and Unity: the input of project to Vuforia (3A), and the import process of video to Unity (3B)

3.4 Implementation of AR Book

To examine whether or not the AR book developed has succeeded to be run in the devices such as mobile phone, we examined the application of AR book in two different tests: test of running application in the several mobile-phones called portability test, and usability tests, which 20 students were involved in this test.

Portability test: there were two aspects examined in this test, they were adaptability and install-ability test. The adaptability and install-ability aspects are tested by installing, running, and uninstalling the application on various devices and OS versions. The test

results for five different devices and different versions of the Android OS are shown in Table 6. Based on Table 6, it can be concluded that the AR book application was successfully installed and uninstalled on five different sample devices. Therefore, we can infer that the application meets the standards of adaptability and install-ability with a 100% success rate, or it is deemed valid. Furthermore, testing was also conducted to observe the application's capability to adjust to various screens. The following are example the test results of the application on five sample Android smartphones when examined in one type of smartphone, its detailed specification can be seen in the Figure 4.

Table 6. The results of the application testing on various devices and operating systems

No	Devices	Android types	Install	Uninstall
1	Vivo Y22	13	Successful	Successful
2	Redmi Note 9	10	Successful	Successful
3	Redmi 9 T	11	Successful	Successful
4	Vivo Y21	12	Successful	Successful
5	Samsung Galaxy J4+	9	Successful	Successful

4A 4B

Fig. 4. The example results of the application testing on one screen size: (4A) the specification of the mobile phone used to examine screen test, and (4B) the example of appearance of AR book in mobile phone screen.

Usability test: usability testing is conducted to assess the quality of the AR Book application, focusing on its ease of learning, operation, and use. This is intended to encourage users (students) to consistently utilize it in their learning activities. Usability testing is performed as it can depict users' subjective perceptions of a software system (Kruger, 2020). The test results can be seen in Table 7.

Table 7. The results of the application testing on various devices and operating systems

No	Codes	Score of questions (Q)										Total score	Scored in scale-100
		1	2	3	4	5	6	7	8	9	10		
1	S-1	2	3	3	1	3	2	3	3	3	0	23	58
2	S-2	3	3	3	1	3	3	3	3	3	1	26	65
3	S-3	3	4	4	1	3	3	4	3	3	1	29	73
4	S-4	3	3	3	1	3	3	3	3	3	1	26	65
5	S-5	4	4	4	3	3	3	3	3	3	3	33	83

No	Codes	Score of questions (Q)										Total score	Scored in scale-100
		1	2	3	4	5	6	7	8	9	10		
6	S-6	4	4	4	3	4	4	4	4	4	3	38	95
7	S-7	4	3	4	3	3	3	3	3	1	1	28	70
8	S-8	4	4	4	1	4	4	4	4	4	1	34	85
9	S-9	3	3	4	1	3	1	4	2	3	0	24	60
10	S-10	3	3	3	2	4	3	4	3	3	2	30	75
11	S-11	4	4	3	2	3	3	4	3	3	1	30	75
12	S-12	3	3	4	1	3	3	3	3	3	1	27	68
13	S-13	4	4	3	2	3	3	4	4	3	2	32	80
14	S-14	4	3	3	2	3	3	4	4	3	2	31	78
15	S-15	3	3	4	3	4	3	4	3	3	0	30	75
16	S-16	3	3	3	2	4	3	4	3	3	2	30	75
17	S-17	4	4	3	2	3	3	4	3	3	1	30	75
18	S-18	4	4	4	3	4	4	4	4	4	3	38	95
19	S-19	4	3	4	3	3	3	3	3	1	1	28	70
20	S-20	4	4	4	3	3	3	3	3	3	3	33	83
		Average of total score											75

Note: Code refers to student code (initial)

3.5 Evaluation of AR book

This stage marks the final phase in the development of the AR book for the IPAS subject. During the evaluation process, we assessed the four preceding stages. Firstly, we examined whether the AR book developed in this study met the requirements for analysis. Theoretically, this work contributes to the limited and uncommon research in AR books. Practically, it adequately addresses the needs of Indonesian elementary school teachers, offering technology beyond PowerPoint to visualize various phenomena in the IPAS subject. Secondly, our evaluation focused on the design of the AR book itself, which encompassed two learning aspects: literacy and numeracy skills. Our assessment, based on insights from educational technology experts, confirms that the AR book's design effectively incorporates both literacy and numeracy components. We anticipate that this AR book will significantly enhance literacy and numeracy skills when implemented widely among fifth-grade students. Our third evaluation centered around potential technical difficulties in developing AR books. Fortunately, no significant issues arose during the development process, as our team is well-versed in AR and AR book development. This demonstrates that AR and AR books, within the context of the IPAS subject, can be smoothly executed on various mobile devices. Lastly, based on the implementation of this AR book with sixth-grade elementary students, they appraised its potential usability, giving it predominantly high scores of 4 and 3, which ranked as the first and second highest scores in the System Usability Scale questionnaire. Overall, our evaluation of the previous processes indicates that the development of this AR book, specifically for content science and social studies concepts in the IPAS subject, has been successful and is now ready for implementation to enhance literacy and numeracy skills in fifth-grade elementary schools.

4. Discussion

To bear in mind, the content of natural science and social studies in elementary education refers to a subject called "IPAS" in the Indonesian curriculum context. IPAS itself is a unification of natural science (IPA) concepts and social studies (IPS) concepts in a book. It was introduced as a new subject in the latest Indonesian curriculum for primary and secondary schools. One of the contents we have developed is "change in substance and its benefits," which is taught to fifth-grade elementary students. The phrase "change in substance" refers to the content of natural sciences, and the phrase "its benefits" represents social studies related to the changes in substance (Setiawan, et.al. 2023).

Our primary concern was to foster literacy and numeracy skills for students in the fifth grade. To achieve this, both the natural and social studies content were complemented by literacy and numeracy activities. In terms of literacy skills, we integrated activities such as reading, writing, and communicating ideas presented in the AR books. Meanwhile, the AR books incorporated numeracy skills through two activities: recognizing patterns in basic mathematics and understanding the mass of substances. While we focused on literacy and numeracy skills, this study only examined the appropriateness of the AR book for thematic contents of natural science and social studies. Based on the data in table 7, the overall average score for the Usability test is 75, indicating that the AR Book application system can be classified as having an acceptable user acceptance level, a grade level of category C, and an Adjective Rating falling into the "good" category. The rating categories of the System Usability Scale (SUS) are based on the criteria established (Bangor, et al. 2008).

The huge benefits provided by AR technologies in the learning process has attracted many researchers to integrate AR technologies into textbooks. Although the role of AR technologies seems similar to other forms of media, which infused some multiple representations to the learning process, this can be an interesting aspect to be investigated. For instance, Gopalan et al. has investigated how the role of science textbooks integrating AR technology could enhance students' motivation (Gopalan, et.al. 2019). Literacy itself refers to the capacity to comprehend, utilize, and reflect on written texts to achieve a specific goal. On the other hand, numeracy encompasses a range of skills, from basic arithmetic and logical reasoning to advanced mathematics and interpretative communication skills (Ball, et.al. 2014). Currently, many countries have been faced to problems both literacy and numeracy in the context of the elementary skills. The rationale for this is because the literacy and numeracy skills are basic foundation of lifelong learning. In the other contexts, both literacy and numeracy are also basic social and cognitive skills, which the social interaction and everyday can be a part of the literacy and numeracy (Xiao, et.al. 2019), (Tett, et.al. 2006).

5. Conclusion

To bear in mind, our focus was to develop a well-designed AR book for the thematic content of science and social studies in elementary school. Based on the 'analysis' stage, we concluded that this AR book was directly prepared for literacy and numeracy skills. This finding has opened up potential research opportunities to develop AR books that directly foster literacy and numeracy skills. Unfortunately, the current study was limited to the development of the AR book only, and further research is needed to investigate how these AR books influence literacy and numeracy skills. In addition, based on the 'design' stage, we divided this framework into two facets: literacy and numeracy. There were some changes from the initial framework because experts evaluated it as redundant in presenting some facets of both literacy and numeracy. Some refinements were made to follow the expert recommendations, which ultimately resulted in a framework representing the final facets of literacy (reading IPAS content, writing new vocabulary, communicating written arguments, and reflecting) and numeracy (reading IPAS content,

comparing variables, recognizing patterns, and reflecting), which was valid to be developed (CVI score was 0.83). In the context of the 'develop' and 'implement' stages, this AR book had a 100% success rate when being installed on various Android systems, meaning that the AR book had no practical issues when run on a mobile phone to support IPAS learning. Furthermore, the AR book passed usability testing (SUS score 75), which categorizes it as having a 'good' performance according to the SUS scale.

Acknowledgements

The research has been funded by the Ministry of Education, Culture, Research and Technology of the Republic of Indonesia on the Collaborative Research Scheme in 2023

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