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Developing adaptive digital book (ADB) in enhancing students' numeracy literacy ability

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Abstract

Numeracy literacy is essential for students to solve interrelated problems across various subjects. However, students' numeracy literacy skills remain low, necessitating innovative learning resources. This research focuses on designing an Adaptive Digital Book (ADB) that is claimed to be valid, practical, and effective in improving students' numeracy literacy. This study adopted a design research approach in the context of development studies, which included two main phases: the preliminary phase and the formative evaluation phase, which included self-evaluation, expert evaluation, and iterative evaluation (one-to-one, small group, and field test). Quantitative and qualitative data were gathered through assessment of numeracy literacy, interviews, and distributing questionnaires. Results showed that ADB is practical and effective in its validity as well as in meeting the requirements of students with different learning needs. The combination of multimedia elements like videos caters to visual and auditory learners, which helps improve their numeracy literacy skills.

Keywords:
Adaptive digital book, Learning style, Numeracy literacy ability

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1. INTRODUCTION

Literacy numeracy is a vital skill for students. The United Nations (UN) targets that by 2030, all young people and most adults can achieve literacy and numeracy to ensure equal access for all men and women. This is because literacy and numeracy are essential skills that students need to fulfil the demands of life and participate in modern society.

Numeracy literacy is a person's ability to read, write and communicate effectively with others. Specifically, the concept of literacy refers to the ability to read and write to interpret information, make decisions, and solve unstructured problems in personal life, work, and society

(Hidayah et al., 2025). Numeracy literacy, which encompasses formula competency, logical reasoning, and critical thinking in problem-solving, is hence essential to mathematics. In order to handle difficulties in common life, one must be able to comprehend and interpret symbols and numbers (Atasoy & Güçlü, 2020). Moreover, students who possess numeracy ability are better able to comprehend how mathematics is used to solve problems in everyday life. Numeracy literacy refers to context-bound reading, writing and counting skills, which are acquired and developed through learning and application processes at school and in other appropriate environments (Hayati & Kamid, 2019). This indicates that numeracy literacy is an ability that is needed by students in the problem-solving process. Literacy and numeracy are intertwined in all important subjects taught in schools. When students have numeracy skills and dispositions, they will work harder to get better academic results.

However, in reality, students' literacy and numeracy skills tend to be low and decline throughout the years (Susanta et al., 2022). Indonesian students' performance in the context of international literacy competence remains inadequate. Students placed 67th out of 81 countries in the 2022 PISA rankings, demonstrating these (OECD, 2023). Students struggle to solve context-based problems and are not as familiar with real-world issues. Poor proficiency in writing or representing information, and also in translating mathematical statements and symbols, was discovered.

For this reason, it is important to make efforts to improve numeracy literacy. One of the important things to do is to create teaching materials to improve students' numeracy literacy skills. Teachers experience challenges and difficulties in improving students' literacy skills such as facilities and teaching materials (Hidayah et al., 2025). The use of digital technology has been shown to accelerate knowledge acquisition (Wijaya et al., 2024). Susanta et al. (2022) also found the effectiveness of electronic modules in improving students' mathematical literacy skills.

Several studies have conducted various teaching materials and media to overcome this. Susanta et al. (2022) have produced e-modules using the Bengkulu context on number patterns and rows. Supianti et al. (2022) have learned e-learning assisted by Edmodo to improve students' mathematical literacy skills. However, it has not specifically facilitated students' learning styles according to the demands of the Merdeka Curriculum.

Three categories–visual, auditory, and kinesthetic–generally represent learning styles. Since visual students, for example, depend on their sense of vision, it is best to present real data initially in order to enhance comprehension. In their notes, the students frequently use symbols and images. On the other hand, auditory students grasp and remember knowledge through hearing. Kinesthetic students usually enjoy engaged learning over prolonged study and utilize their bodies when learning issues. Using a combination of these various learning styles in the classroom helps students seem more successful, locks gaps in understanding, and retains information over time (Antelm-Lanzat et al., 2020).

For this reason, in this research, digital teaching materials that facilitate students' learning styles are created, called adaptive digital teaching books (ADBs) to improve students' numeracy literacy skills. Several studies have shown that students are more interested in reading digital books (e-book) compared to traditional books (Richter & Courage, 2017). In ADB, there are videos explaining the material provided that can support students with auditory and visual learning styles and the instructions provided support students with kinesthetic learning styles.

Teaching materials in the form of videos can make it easier for students to learn anywhere and anytime (Bano et al., 2018). The purpose of this research is to produce ADB that is valid, practical, and effective in improving students' numeracy literacy.

2. METHOD

This study employed a design research approach within the framework of development studies Tessmer (2013) and Fauziah and Putri (2020). This research was conducted in two phases, including preliminary analysis and formative evaluation. During the preliminary analysis, the curriculum, learning materials, and students' traits were carefully studied to assist in the development of the Adaptive Digital Book (ADB). This was done to ensure the content to be taught matched the students' needs and expectations and the requirements of the curriculum.

The formative evaluation phase followed a layered approach, incorporating self-evaluation, expert reviews, one-to-one evaluation, small group testing, and field testing, as shown in Figure 1. In the course of the development, instructional activities were developed for visual, auditory, and tactile respondents in order for all learners to participate in the learning experience. Expert validation and one-to-one testing was used to make the first adjustments to ADB, which was then followed by small group testing where students used the digital book and gave their feedback on its functionality and how engaging it was.

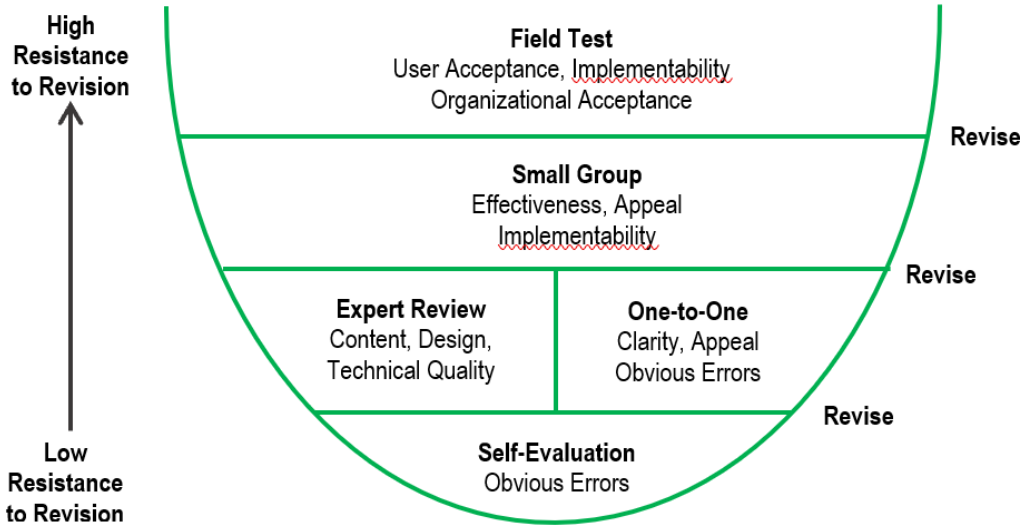

Figure 1. Layers of formative evaluation

An ADB field test was performed with the objective of evaluating its effects on students' numeracy literacy skills as part of an experimental research study. The participants included 31 seventh graders between the ages of 11 and 13 years old, some of whom had different levels of proficiency in mathematics. A 2 x 2 factorial research design was employed with ADB being the independent variable, while the students' initial numeracy ability and school level served as moderator variables. The outcome variable was numeracy literacy skill. In this case, the experimental group learned with ADB while the control group learned with traditional textbooks.

Data were collected through numeracy literacy skill tests, interviews, and questionnaires. Additionally, descriptive analysis was applied to evaluate the validity and practicality of ADB. Student and teacher feedback was gathered through structured questionnaires to assess its usability and effectiveness in enhancing numeracy literacy skills.

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. Preliminary Research

Curriculum Analysis

Based on the results of the curriculum analysis, it is known that the curriculum used by the school is the Merdeka curriculum. Curriculum analysis is focused on analysing Core Competencies (CC), Basic Competencies (BC), and Competency Achievement Indicators (CAI).

The results of the analysis of CC, BC, and CAI of straight line equation material can be seen in Table 1.

Table 1. Curriculum analysis

Core Competencies (CC)	Basic Competence (BC)	Competency Achievement Indicator (CAI)
a. Understand and apply knowledge (factual, conceptual, and procedural) based on his curiosity about science, technology, arts, culture related to visible phenomena and events. b. Processing, presenting, and reasoning in the concrete domain (using, parsing, assembling, modifying, and making) and abstract domain (writing, reading, calculating, drawing, and composing) in accordance with what is learned at school and other similar sources in the point of view/theory.	a. BC Knowledge: 3.4 Analyze linear functions (as straight-line equations) and interpret their graphs in relation to contextual problems. b. BC Skills: 4.4 Solve contextual problems related to linear functions as straight-line equations.	a. Analyze linear functions as straight-line equations. b. Draw a graph of a straight-line equation. c. Determine the slope of a straight-line equation. d. Determine the equation of a straight line with slope m and passing through the point (x_1, y_1). e. Determine the equation of a straight line through the points (x_1, y_1) and (x_2, y_2). f. Determine the properties of a straight-line equation. g. Solve contextual problems related to linear functions as straight-line equations.

Concept Analysis

Learning the material of straight line equations begins with understanding the meaning and general form of straight line equations. After knowing the general form of a straight line equation, students are directed to draw a graph of a straight line equation. In drawing the graph of a straight line equation, students can use several auxiliary points or determine the intersection points on the x-axis and y-axis. The next discussion is about the

gradient of a straight line equation. Students are guided to rediscover the formula for the gradient of a line with the equation y=mx+c, the gradient of a line with the equation ax+by=c, and the gradient of a line through two points. Learning continues by determining the equation of a straight line if the gradient is known and through the point (x_1, y_1). Furthermore, students are directed to determine the equation of a straight line through points (x_1, y_1) and (x_2, y_2). The last topic that students should master is the properties of straightline equations on parallel and perpendicular lines.

Student Analysis

Student analysis activities are carried out in class VII junior high school aged 13-15 years. Piaget revealed that children at that age have cognitive development at the formal operation stage. At the formal operation stage, children are able to solve problems and communicate using abstract things. The analysis of learning tendency, ability to work together, and social skills was obtained through direct observation during the learning process in the classroom. Firstly, students have a fairly high curiosity. This can be seen when the teacher presents new material, their attention is quite good. However, this situation did not last long. Secondly, students easily forget the concepts that have been learnt. Because learners are not directed to rediscover mathematical concepts so that what they learn does not last long in their memories. Third, learners like to use digital teaching materials in learning activities. Learners like teaching materials that are interesting, easy to understand, and colourful, learners prefer to learn in groups rather than individually.

3.1.2. Formative evaluation stages

The preliminary findings were used to construct the activity-oriented design throughout this phase. A preview of ADB designed especially for students who are visual and auditory is shown in Figure 2.

Figure 2. Video about explanation of lesson material descriptions

To help students understand the content being covered, ADB contained videos that explained the topics. Students can enjoy the offered videos to present evaluations if they have any questions regarding the material. Students have access to this video at any time and from any location. Regarding students' proficiency with digital literacy and numeracy,

learning videos are a successful teaching tool in the classroom. Students who study best via sound or sight might also benefit from these videos. The following contextual issues are offered (see Figure 3).

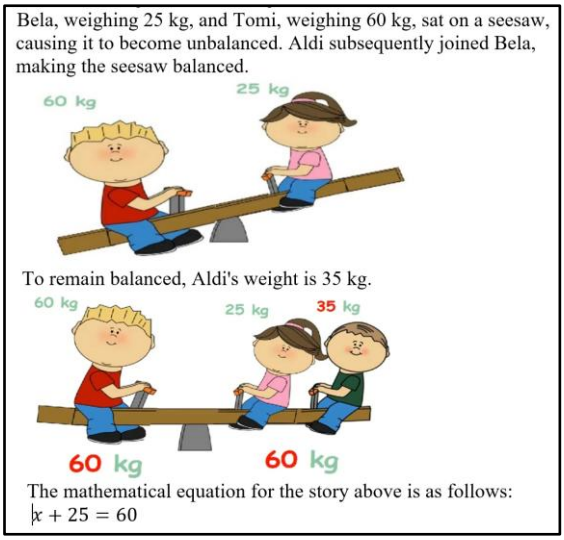

Figure 3. Presentation of linear equation material using the context of student life

A greater comprehension of the topic is facilitated by utilizing situations from everyday experiences of the students. Relevant illustrations not only assist in problem solving but also enhance one's proficiency with numbers. In Figure 3, the problem of Bela weighing 25 kg and Tomi weighing 60 kg riding a seesaw so that the seesaw is unbalanced is given. Bela, who weighs 25 kg, and Tomi, who weighs 60 kg, ride a seesaw so that the seesaw is unbalanced. To keep it balanced, Aldi's weight is 35 kg. So the mathematical form is x+25=60, which is called a one-variable linear equation.

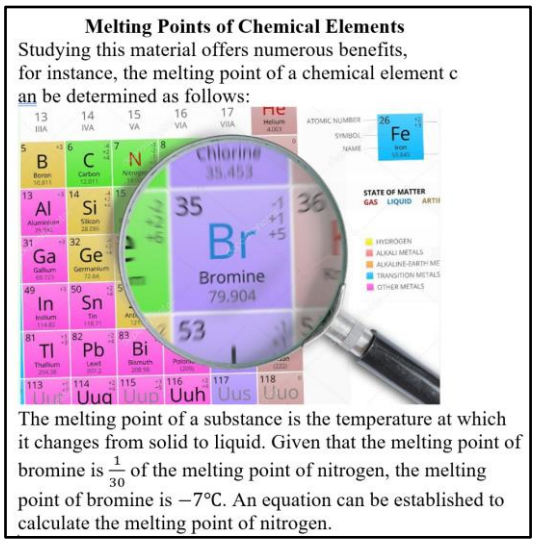

Figure 4. Numeracy literacy exercises

Also, the contextual problems were made available to aid with numeracy literacy. One of the contextual tasks relative to the melting point of chemical elements is portrayed in Figure 4.

Self-evaluation and expert reviews

After the ADB was developed, a self-evaluation was conducted to find errors in the ADB. Several typos were found, as well as inactive video buttons and the difficulty of moving from one page to the next. After being corrected, validation was carried out by experts. Validation was carried out by 5 validators with details as in Table 2.

Table 2. List of validators

Validator	Information
Validator 1, 2, 3	Validation of teaching materials as a material expert includes the suitability of the exercise questions in the teaching materials with CC and BC, the problems and exercises given are adequate to achieve the CAI by taking into account the prerequisite material and the level of difficulty of the material, the problems given are in accordance with the cognitive development of students, and the substance of the problems given is logical and correct based on mathematics.
	Validation of teaching materials as a didactic expert includes the organization of chapters in teaching materials arranged systematically, increasing the role of the teacher as a facilitator, and providing opportunities for students to learn actively.
Validator 4	Validation of teaching materials as a linguist includes teaching materials using good and correct Indonesian, the language used is communicative and in accordance with the level of understanding of students, the use of terms, symbols, and foreign language accompanied by an explanation to make it easier to understand.
Validator 5	Validation of teaching materials as a graphic expert includes cover design and content has an attractive color combination and represents the content of teaching materials, as well as the layout of images and text size is appropriate.

Validation was done following the creation of the ADB, as shown in Table 3.

Table 3. ADB validation results by experts

No	Rated aspect	Average Validity	Criteria
1	Content Aspects. Conformity of material to the curriculum and logicality and correctness of the material according to mathematics.	3.70	Very Valid
2	Language Aspects. Conformity of writing to language rules such as the use of punctuation, consistency, and integration between paragraphs.	3.79	Very Valid
3	Didactic Aspects. Systematic consistency of presentation of material, examples, exercises, and feedback.	3.50	Very Valid

No	Rated aspect	Average Validity	Criteria
4	Graphic Aspects. Layout of cover, content, and closing elements. Proportional font size and color.	3.60	Very Valid
	Average ADB Validity	**3.64**	**Very Valid**

One-to-one and small group evaluation

One-to-one and small group evaluation tasks were used to figure out the practicality of ADB. Three students–one for each of the ability levels–were used in the one-to-one evaluation. Upon finishing the reading of ADB, students needed to respond, mentioning any ambiguous instructions or phrases. Most students demonstrated a reasonable knowledge of the given ADB, proving its usefulness at the one-to-one evaluation. The results of interviews with students are as follows.

High Ability (HA)

Researcher : *What do you think ADB looks like?*
HA : *Interesting, because there are instructions for use like opening a textbook.*
Researcher : *Are the font types and sizes on ADB easy to read?*
HA : *Yes, the writing is legible.*
Researcher : *Can you understand the instructions for using ADB?*
HA : *Yes, I can.*
Researcher : *What do you think about the presentation of material in ADB?*
HA : *There is still material that I don't understand, such as data presentation material.*
Researcher : *What do you think about the sample questions and practice questions in ADB?*
HA : *Hmm…I think the questions were quite challenging.*
Researcher : *Have you experienced any difficulties while using ADB?*
HA : *Yes, I have. A little confused with the activities in the module, but helped by the instructions for use and how to use it.*
Researcher : *Do you think ADB can help with independent learning?*
HA : *Yes, I can use these digital adaptive teaching materials independently.*
Researcher : *Okay, can learning to use ADB help you understand the material well?*
HA : *Yes, because the material presented is clear and concise.*
Researcher : *Do you think studying with ADB is easier and cheaper than with printed modules?*
HA : *Yes, I think this book is easier and cheaper because I can open it on my smartphone, it is simple, and there is an explanatory video.*

Medium Ability (MA)

Researcher : *What do you think ADB looks like?*
MA : *Very interesting. There are videos and flip flop teaching materials.*
Researcher : *Are the font types and sizes on ADB easy to read?*
MA : *I think so too.*
Researcher : *Can you understand the instructions for using ADB?*

MA	:	*Yes, I can.*
Researcher	:	*What do you think about the presentation of material in ADB?*
MA	:	*I don't understand the material well, but I will try to repeat it again.*
Researcher	:	*How about the sample questions and practice questions in ADB?*
MA	:	*Good.*
Researcher	:	*Have you experienced any difficulties while using ADB?*
MA	:	*Not bad, because there is something new that I know about how to use Google Forms.*
Researcher	:	*Do you think ADB can help with independent learning?*
MA	:	*Hmm…yeah. I can use this book independently.*
Researcher	:	*Can learning to use ADB help you understand the material well?*
MA	:	*Yes, because the video makes it easier for me to understand the material.*
Researcher	:	*Okay, do you think studying with ADB is easier and cheaper than with printed modules?*
MA	:	*In my opinion this book is easier and cheaper than printed ones because they can be opened on a smartphone and there is an explanatory video.*

Low Ability (LA)

Researcher	:	*What do you think ADB looks like?*
LA	:	*I really liked it because it was colorful.*
Researcher	:	*Are the font types and sizes on ADB easy to read?*
LA	:	*Yes, I was able to read it well.*
Researcher	:	*Can you understand the instructions for using ADB?*
LA	:	*Yes, of course.*
Researcher	:	*What do you think about the presentation of material in ADB?*
LA	:	*My opinion, the material is easy to understand with explanations and example questions.*
Researcher	:	*How about the sample questions and practice questions in ADB?*
LA	:	*Hmm…the questions were challenging enough for me.*
Researcher	:	*Have you experienced any difficulties while using ADB?*
LA	:	*I am a bit confused because the Google Form link is something new for me, but because there is a way to use it, I understand quite well.*
Researcher	:	*Do you think ADB can help with independent learning?*
LA	:	*I think so.*
Researcher	:	*Can learning to use ADB help you understand the material well?*
LA	:	*Yes, it is easy for me to understand because there are clear explanation videos and example questions.*
Researcher	:	*Do you think studying with ADB is easier and cheaper than with printed modules?*
LA	:	*It's interesting and new to me. This teaching material can be opened on a smartphone and there is an explanation video.*

The next step was a small group evaluation observing the modification of ADB in view of the findings from the one-to-one evaluation. Through the use of ADB, students and educators likewise were surveyed for their feedback, as shown in Table 4. According to the

findings of the questionnaires given to teachers and students, ADB is an extremely helpful tool to support the study of mathematics.

Table 4. Results of practicality test questionnaire by teachers and students

No	Assessed Aspects	Teachers		Students	
		Average	Criteria	Average	Criteria
1	Usable	3.60	Very Practical	3.63	Very Practical
2	Easy to Use	3.33	Practical	3.44	Practical
3	Appealing	3.71	Very Practical	3.50	Very Practical
4	Efficient	3.50	Very Practical	3.54	Very Practical
Average Practicality		**3.52**	**Very Practical**	**3.51**	**Very Practical**

Field Test

Students' numeracy ability emphazises the effectiveness of ADB. Table 5 presents data on the literacy level in numeracy.

Table 5. Descriptive data of students' numeracy literacy ability

Class	Initial Ability	N	$\bar{x}$	s
Experiment	High	9	14.67	1.50
	Medium	11	14.27	2.15
	Low	8	13.00	2.00
	Total	28	14.04	1.97
Control	High	8	10.75	2.66
	Medium	12	11.00	1.95
	Low	11	9.91	2.34
	Total	31	10.55	2.26

According to Table 5, overall and based on initial ability, students in the ADB experimental class confirmed a higher level of numeracy literacy ability than students in the conventional class. Additionally, two preliminary tests were performed in preparation for the analysis: a Levene homogeneity test and a Kolmogorov-Smirnov normality test. Tables 6 and 7 display the test the outcomes.

Table 6. Normality test of students numeracy literacy data

Class	Initial Ability	Sig.	Description
Experiment	High	0.087	Normal
	Medium	0.067	Normal
	Low	0.018	Not Normal
	Total	0.003	Not Normal
Control	High	0.027	Not Normal
	Medium	0.200	Normal
	Low	0.126	Normal
	Total	0.005	Not Normal

Data on numeracy literacy in the experimental and control groups were not normally distributed (see Table 6). Regardless of not being normally distributed, Table 7 highlighted that the numeracy literacy data in the experimental and control classes had homogenous variances, Mann-Whitney U test was performed and the interaction was investigated using the two-way ANOVA test. The Mann-Whitney U test results, which are displayed in Table 7, demonstrated that students using ADB were more proficient in numeracy literacy than those using conventional instructional strategies.

Table 7. Average difference in students' numeracy literacy ability

Class	N	Average	U	Z	Asymp. Sig. (2-tailed)
Experiment	28	14.04	103.000	-5.064	0.000
Control	31	10.55			

Educators were encouraged to employ technology in order to increase the efficacy and efficiency of instruction in keeping with the expectations of the industry 4.0 era. By emphasizing student-centered learning, online teaching resources and instructional videos may contribute to schools adopt independent learning. With the integration of technology, an intentional attempt was made to connect the adaptive e-module in mobile device format with the educational preferences of students in the twenty-first century. To create interest in children, ADB has an interesting and appealing presentation. Students may easily examine content utilizing laptops or smartphones because to its high degree of efficacy and adaptability.

By accommodating individuals' unique learning preferences, ADB facilitates individualized instruction in the classroom. DL might be used to enhance learning objectives and activities, increase student interest and motivation, and create effective and learning by itself settings (Haelermans, 2022). Students with high initial ability learning via ADB had superior numeracy literacy potential than those embracing conventional learning, according to the Mann-Whitney U test findings in Table 8.

Table 8. Average difference in numeracy literacy ability of SMPN B students with high initial ability

Class	N	Average	U	Z	Asymp. Sig. (2-tailed)
Experiment	9	14.67	6.000	-2.934	0.003
Control	8	10.75			

The outcomes demonstrated that even students with excellent initially ability could strengthen their numeracy literacy skills by employing ADB. Even the most intelligent students were adept at giving precise answers. High initial ability students are able to solve and analyze issues, execute processes efficiently, deal with difficult situations, use reasoning to solve problems, interpret various representations, and make relationships with real-world settings. The t-test findings demonstrated that, while employing ADB, students with medium initial ability had stronger numeracy literacy ability as compared to those who adopted conventional learning methods (see Table 9).

Table 9. Average difference in numeracy literacy ability of SMPN B students with medium initial ability

Class	N	Average	t	Asymp. Sig. (2-tailed)
Experiment	11	14.27	3.826	0.001
Control	12	11.00		

The advantages of ADB for children with medium initial ability in numeracy literacy have been proven by the results obtained. Despite missing of visual representation and the chaotic format of the solving method, students with medium initial ability can handle tasks properly. Students with low initial ability employing ADB had over numeracy literacy capability than those adopting conventional learning, according to the Mann-Whitney U test findings in Table 10.

Table 10. Average difference in numeracy literacy ability of SMPN B students with low initial ability

Class	N	Average	U	Z	Asymp. Sig. (2-tailed)
Experiment	8	13.00	15.500	-2.383	0.017
Control	11	9.91			

The findings demonstrated that student numeracy literacy skills hadn't been adequately reinforced by traditional classes. Low initially ability students have challenges deciphering mathematical phrases and symbols, comprehending concepts, and accurately recording the material. Having trouble in processing information provided in many types and the frequency of contextual problem-based questions in tests such as TIMSS and PISA are the main causes of students' inadequate numeracy literacy abilities.

3.2. Discussion

The results showed that the use of ADB can improve numeracy literacy skills. These results are in line with several other studies that use electronic teaching materials such as e-books, e-modules, e-worksheets can improve numeracy literacy skills. The results of Hidayat and Aripin's research (2023) showed that e-LKPD had an effect on students' mathematical communication skills. Susanta et al. (2022) found that e-modules using the Bengkulu context had a potential effect on students' numeracy literacy skills on number patterns and rows. Tobing et al. (2021) also found that e-modules have the potential to influence HOTS with a very good average score. Widiantari et al. (2022) reported that the development of e-modules has successfully improved students' numeracy literacy by using ethnomathematics which makes learning more contextual and meaningful. Furthermore, Miller (2018) suggested that it is necessary to apply interactive technology in learning mathematics to improve the quality of learning.

The results of research by Fonda and Sumargiyani (2018) show that mathematics e-modules with a scientific approach to derivative material for class XI SMA even semester are feasible to use in the classroom learning process. Palinussa et al. (2021) and Palinussa et

al. (2024) found that the RME learning approach based on the E-Module System was also more effective in improving student learning outcomes than the traditional learning model.

The use of digital technology greatly helps students understand the material. The use of digital applications is seen as an increasingly attractive tool for improving students' basic literacy and maths skills (Kim et al., 2021). In other words, the use of mobile technology is highly effective and encourages students to see immediate progress in their literacy skills. With the effective use of mobile phones (Irwanto et al., 2023), students are expected to read and understand the subject matter thoroughly, so mobile technology can facilitate students' learning experiences both inside and outside the classroom (Irwanto et al., 2023). Teaching materials in the form of videos can be stored on mobile devices that can be carried anywhere (moving learning) making it easier for students to learn anywhere and anytime (Bano et al., 2018). In addition, they can construct knowledge from self-learning activities carried out using videos so that the process of developing thinking skills for students occurs. The ownership of mobile devices by students supports the creation of learning outside the classroom using mobile learning (Fu & Hwang, 2018). The use of learning videos in mobile learning is a promising learning strategy, relevant and can improve the quality of education (Winarni et al., 2021).

With the existence of electronic teaching materials, it will help in online learning. Online learning is practical because it can be used anywhere and anytime (Irfan et al., 2020). Supianti et al. (2022) found that the use of online teaching materials can improve students' literacy skills. Students can use their knowledge to solve routine problems with a general context, can complete procedures well, and work effectively and integrate with real problems. So that students feel more helpful in understanding the material and can follow the learning process well even though it is done online.

The use of audiovisual media can benefit students more because it does not require a lot of time to explain the material and make students active in the classroom so that it is effectively used in improving student learning outcomes (Nasrum & Herlina, 2019). During reading e-books, teachers can provide scaffolding on how to explore knowledge through functions and navigation in the e-book (Neumann & Merchant, 2022).

4. CONCLUSION

This study successfully developed an Adaptive Digital Book (ADB) that was found to be valid, practical, and effective in enhancing students' numeracy literacy skills. The findings indicate that ADB effectively supports diverse learning styles, particularly visual and auditory learners, through the integration of instructional videos and interactive digital content. Contextualized problem-solving activities also enhanced students' engagement, understanding and retention of mathematical concepts.

Furthermore, the use of ADB was found to have a positive effect on students' numeracy literacy with improved performance in the experimental tests compared to those using conventional learning materials. However, this study also found a shortcoming in ADB's ability to cater to kinesthetic learners because there are no interactivities with movement. For this reason, further studies should develop procedures that incorporate movement with the aid of dynamic software such as GeoGebra, which allows manipulation

of mathematical objects for hands-on experience in a digital setting. Also, other studies could investigate the ADB's implementation scope, its permanent impacts on numeracy literacy, use in different grades, and versatility to various mathematical topics.

In an era where digital learning is becoming increasingly essential, the development of adaptive digital teaching materials like ADB offers a promising avenue for personalized learning. Further improvements should be directed toward increasing interactivity, accessibility, and adaptability to optimize the learning experience for all students and foster inclusionality in digital learning environments.

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Declarations

Author Contribution : Y: Conceptualization, Visualization, and Writing - original draft; A: Formal analysis, and Writing - review & editing; S: Methodology, Supervision, and Validation; IMA: Writing - review & editing; CS: Supervision, and Writing - review & editing; LA: Writing - review & editing.

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REFERENCES

Antelm-Lanzat, A. M., Gil, A. J., Cacheiro-González, M. L., Pérez-Navío, E., & Fonseca-Pedrero, E. (2020). Learning styles and vocational guidance in secondary education. *Educational Sciences: Theory and Practice*, *20*(3), 1–15.

Atasoy, R., & Güçlü, N. (2020). Evaluation of numeracy skills of adults according to the results of PIAAC 2015 in Turkey. *World Journal of Education*, *10*(2), 27–49. https://doi.org/10.5430/wje.v10n2p27

Bano, M., Zowghi, D., Kearney, M., Schuck, S., & Aubusson, P. (2018). Mobile learning for science and mathematics school education: A systematic review of empirical evidence. *Computers & Education*, *121*, 30–58. https://doi.org/10.1016/j.compedu.2018.02.006

Fauziah, A., & Putri, R. I. I. (2020). Developing PMRI learning environment through lesson study for pre-service primary school teacher. *Journal on Mathematics Education*, *11*(2), 193–208. https://doi.org/10.22342/jme.11.2.10914.193-208

Fonda, A., & Sumargiyani, S. (2018). The developing math electronic module with scientific approach using Kvisoft Flipbook Maker Pro for XI grade of senior high school

students. *Infinity Journal*, *7*(2), 109–122. https://doi.org/10.22460/infinity.v7i2.p109-122

Fu, Q.-K., & Hwang, G.-J. (2018). Trends in mobile technology-supported collaborative learning: A systematic review of journal publications from 2007 to 2016. *Computers & Education*, *119*, 129–143. https://doi.org/10.1016/j.compedu.2018.01.004

Haelermans, C. (2022). The effects of group differentiation by students' learning strategies. *Instructional Science*, *50*(2), 223–250. https://doi.org/10.1007/s11251-021-09575-0

Hayati, T. R., & Kamid, K. (2019). Analysis of mathematical literacy processes in high school students. *International Journal of Trends in Mathematics Education Research*, *2*(3), 116–119. https://doi.org/10.33122/ijtmer.v2i3.70

Hidayah, I. R., Sa'dijah, C., Anwar, L., Yerizon, Y., & Arnawa, I. M. (2025). Empowering students' numeracy skills: Mathematics teachers' perceptions regarding the effectiveness and challenges of Indonesian national curriculum and the programs–A mixed method study. *Infinity Journal*, *14*(1), 163–188. https://doi.org/10.22460/infinity.v14i1.p163-188

Hidayat, W., & Aripin, U. (2023). How to develop an e-LKPD with a scientific approach to achieving students' mathematical communication abilities? *Infinity Journal*, *12*(1), 85–100. https://doi.org/10.22460/infinity.v12i1.p85-100

Irfan, M., Kusumaningrum, B., Yulia, Y., & Widodo, S. A. (2020). Challenges during the pandemic: Use of e-learning in mathematics learning in higher education. *Infinity Journal*, *9*(2), 147–158. https://doi.org/10.22460/infinity.v9i2.p147-158

Irwanto, I., Saputro, A. D., Widiyanti, W., & Laksana, S. D. (2023). Global trends on mobile learning in higher education: A bibliometric analysis (2002–2022). *IJIET: International Journal of Information and Education Technology*, *13*(2), 223–231. https://doi.org/10.18178/ijiet.2023.13.2.1816

Kim, J., Gilbert, J., Yu, Q., & Gale, C. (2021). Measures matter: A meta-analysis of the effects of educational apps on preschool to grade 3 children's literacy and math skills. *AERA Open*, *7*. https://doi.org/10.1177/23328584211004183

Miller, T. (2018). Developing numeracy skills using interactive technology in a play-based learning environment. *International journal of STEM education*, *5*(1), 1–11. https://doi.org/10.1186/s40594-018-0135-2

Nasrum, A., & Herlina, H. (2019). Developing of calculus teaching materials based on audiovisual. *Infinity Journal*, *8*(2), 209–218. https://doi.org/10.22460/infinity.v8i2.p209-218

Neumann, M. M., & Merchant, G. (2022). "That's a Big Bad Wolf!": Learning through teacher-child talk during shared reading of a story book app. *Early Childhood Education Journal*, *50*(3), 515–525. https://doi.org/10.1007/s10643-021-01171-8

OECD. (2023). *Results (volume II): Learning during-and from-disruption*. OECD Publishing. https://www.oecd-ilibrary.org/education/pisa-2022-results-volume-ii_a97db61c-en

Palinussa, A. L., Molle, J. S., & Gaspersz, M. (2021). Realistic mathematics education: Mathematical reasoning and communication skills in rural contexts. *International Journal of Evaluation and Research in Education*, *10*(2), 522–534. https://doi.org/10.11591/ijere.v10i2.20640

Palinussa, A. L., Tupamahu, P. Z., Sabandar, V. P., Makaruku, Y. H., & Sabandar, J. (2024). Realistic mathematics education: Mathematics e-modules in improving student learning outcomes. *Infinity Journal*, *14*(1), 45–64. https://doi.org/10.22460/infinity.v14i1.p45-64

Richter, A., & Courage, M. L. (2017). Comparing electronic and paper storybooks for preschoolers: Attention, engagement, and recall. *Journal of Applied Developmental Psychology*, *48*, 92–102. https://doi.org/10.1016/j.appdev.2017.01.002

Supianti, I. I., Yaniawati, P., Osman, S. Z. M., Al-Tamar, J., & Lestari, N. (2022). Development of teaching materials for e-learning-based statistics materials oriented towards the mathematical literacy ability of vocational high school students. *Infinity Journal*, *11*(2), 237–254. https://doi.org/10.22460/infinity.v11i2.p237-254

Susanta, A., Sumardi, H., & Zulkardi, Z. (2022). Development of e-module using Bengkulu contexts to improve literacy skills of junior high school students. *Jurnal Pendidikan Matematika*, *16*(2), 171–186. https://doi.org/10.22342/jpm.16.2.17698.171-186

Tessmer, M. (2013). *Planning and conducting formative evaluations*. Routledge.

Tobing, H. E. L., Somakim, S., & Susanti, E. (2021). Development of e-module based on hots questions on distance material for high school students. *Jurnal Pendidikan Matematika*, *16*(1), 1–14. https://doi.org/10.22342/jpm.16.1.14694.1-14

Widiantari, N. K. K., Suparta, I. N., & Sariyasa, S. (2022). Meningkatkan literasi numerasi dan pendidikan karakter dengan e-modul bermuatan etnomatematika di era pandemi COVID-19 [Increasing numeracy literacy and character education with e-modules containing ethnomathematics in the era of the COVID-19 pandemic]. *JIPM (Jurnal Ilmiah Pendidikan Matematika)*, *10*(2), 331–343. https://doi.org/10.25273/jipm.v10i2.10218

Wijaya, T. T., Hidayat, W., Hermita, N., Alim, J. A., & Talib, C. A. (2024). Exploring contributing factors to PISA 2022 mathematics achievement: Insights from Indonesian teachers. *Infinity Journal*, *13*(1), 139–156. https://doi.org/10.22460/infinity.v13i1.p139-156

Winarni, S., Kumalasari, A., Marlina, M., & Rohati, R. (2021). Efektivitas video pembelajaran matematika untuk mendukung kemampuan literasi numerasi dan digital siswa [The effectiveness of mathematics learning videos to support students' numeracy and digital literacy skills]. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *10*(2), 574–583. https://doi.org/10.24127/ajpm.v10i2.3345