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E-BOOK DEVELOPMENT TO IMPROVE SPATIAL LITERACY IN ELEMENTARY GEOMETRY LEARNING

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ABSTRACT

The low level of spatial literacy among elementary school students in geometry is one of the main challenges in mathematics education. This issue is largely due to the lack of interactive learning media and the limited use of instructional methods that support spatial understanding. This study aims to develop a multimedia-based interactive e-book on plane geometry to ence the spatial literacy of fifth-grade students. The research employed a Research and Development (R&D) approach using the ADDIE model (Analysis, Design, Debelopment, Implementation, Evaluation). The participants were 32 Fifth-grade students from SDN Kebon Jeruk 08, West Jakarta. Resesrch instruments included observaitions, interviews, expert validation questionnaires, and pre-test and post-test assessment. The validation results indicated that the interactive e-book is feasible for use, with a feasibility score of 94%. The effectiveness test showed a significant improvement in students' spatial literacy, with a t-test revealing a mean difference of 26.48 points ($p<0.001$) between the pre-test and post-test scores. Students became more active, motivated, and cable of communicating spatial ideas more effectively. Therefore, the interactive e-book has proven to be an effective innovarive learning medium for improving elementary students' spatial literacy. This study recommends the integration of e-books into geometry instruction and teacher training programs to optimize the use of digital media in the classroom.
Keywords: E-book, Geometry, Spatial literacy

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PRELIMINARY

Mathematics education plays a crucial role in developing students' logical, analytical, and critical thinking skills from an early age, particularly at the elementary level. One fundamental yet often challenging topic is geometry. Geometry not only involves abstract concepts but also demands students' spatial thinking skills to understand the relationships between objects in space. Limited understanding of these concepts can lead to low levels of spatial literacy among students.

Several previous studies have highlighted that spatial literacy among Indonesian elementary school students remains relatively low. Research conducted by Pratiwi et al., (2024) dan Parawansa et al. (2023) demonstrated that the use of e-books in learning can effectively improve student achievement and engagement. However, these studies did not

specifically focus on enhancing spatial literacy, instead concentrating on general learning outcomes or critical thinking. Meanwhile, a study by Maulida dan Zulherman, (2024) showed that interactive e-books can improve students' literacy, although their research was limited to the context of the IPAS (science and social studies) subject, not mathematics.

This reveals a gap in the existing literature: there has been no research explicitly aimed at developing interactive e-book media to enhance elementary students' spatial literacy in geometry. Yet spatial ability can be improved through visual and interactive representations that allow students to imagine, analyze, and communicate spatial objects effectively.

Based on initial observations conducted using questionnaires on students' interest and preferences in learning geometry, learning styles, classroom observations, and interviews with homeroom teachers at SDN Kebon Jeruk 08, West Jakarta, it was found that 60% of fifth-grade students showed low interest in geometry. Students also had difficulties distinguishing between geometric shapes and understanding their properties. The teacher stated that students struggled to grasp geometric concepts, particularly in identifying different shapes and comprehending their characteristics, which indicates a lack of spatial literacy skills. Students also experienced difficulties in understanding formulas, calculating correctly, and applying them to real-life situations. According to the teacher, there is a strong need for interactive media that utilizes technology, such as e-books, to help students understand geometry and improve their spatial literacy skills.

Zulkarnaen stated that one of the causes of low spatial ability is that many students perceive geometry as an abstract subject and are unable to construct mathematical models based on real-life situations and problems (Kharisma & Lailiyah, 2024, p.143). Meanwhile, Abidin argued that spatial literacy is the development of spatial thinking processes to enhance knowledge and skills in reasoning, acting, and thinking about spatial objects and their relationships in everyday life and the surrounding environment (Ningsih et al., 2021, p.1531). Therefore, teachers are expected to play a key role in creating an enjoyable learning environment and facilitating students' needs.

In this era of rapid technological advancement, teachers can leverage technology in the learning process. Not only teachers but also the government strives to enhance students' technological competencies through curriculum changes to prepare a generation that is capable and ready to face the challenges of the times. The integration of technology in education involves the application of ideas, concepts, and interdisciplinary knowledge

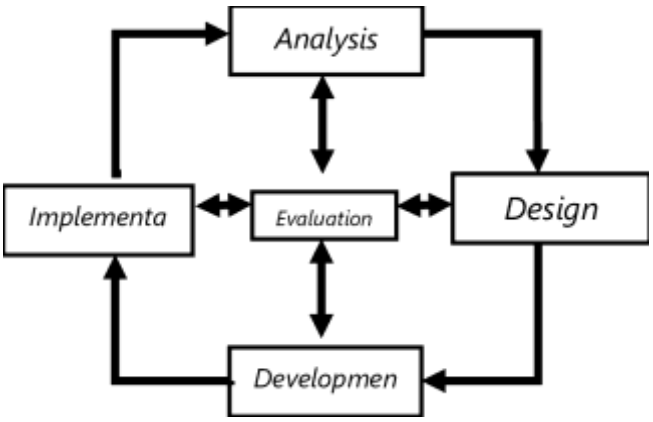
aimed at improving students' cognitive, emotional, and psychomotor abilities in response to technological development.

The use of technology is especially important in the teaching of mathematics, particularly geometry. Through technology, teachers can develop e-books based on relevant material and tailor them to students' learning needs. As a result, the rapid advancement of technology has given rise to new forms of literacy across various fields, including spatial literacy. The use of e-books is expected to enhance students' spatial literacy in learning fifth-grade geometry.

To address this challenge, this study developed a multimedia-based interactive e-book as an innovative solution for geometry instruction. The e-book was designed using the ADDIE development model and was grounded in constructivist learning principles and multimedia learning theory. The aim of this study is to develop an interactive e-book that is both feasible and effective for use in geometry instruction, with the specific goal of improving fifth-grade students' spatial literacy. The e-book focuses on providing a more engaging, active, and meaningful learning experience that helps students understand shapes, sizes, and spatial relationships among objects.

METHODS

This study is a Research and Development (R&D) study aimed at producing and testing the effectiveness of a digital-based interactive e-book in geometry learning to enhance the spatial literacy of fifth-grade students. The development model used is the ADDIE model, which consists of five main phases: Analysis, Design, Development, Implementation, and Evaluation.



In the Analysis phase, a preliminary study was conducted through observation and interviews to identify learning needs, student difficulties in understanding the concept of geometric shapes, student characteristics, and curriculum-based content analysis. The

Design phase included planning the e-book's content structure, visual design, and the development of interactive features such as animations and context-based practice questions. The Development phase included producing the e-book using multimedia software and conducting initial validation by media and material experts using a Likert-scale questionnaire, followed by product revisions. In the Implementation phase, the e-book was implemented in the classroom after teacher training, and students used it to teach geometric shapes such as squares, rectangles, triangles, trapezoids, parallelograms, and rhombuses. The Evaluation phase included formative evaluation during development and summative evaluation through pre- and post-tests, student satisfaction questionnaires, and observations of student engagement to assess the effectiveness and impact of the e-book.

The subjects of this study were 32 fifth-grade students and one classroom teacher at SDN Kebon Jeruk 08, selected based on initial observations of low interest in learning geometry and the need for interactive media. The research instruments included expert validation questionnaires, student satisfaction questionnaires, student interaction observation sheets, and spatial literacy tests in the form of pre-tests and post-tests.

All instruments were validated by expert lecturers and teachers using content validity techniques. Two types of validation were conducted: media validation and material validation. Based on the results of the media validation conducted by the expert team Martin, S.Pd., M.Pd., Dr. Arum Fatayan, M.Pd., Dr. Mimin Ninawati, S.E., M.Pd., Kanez Atiyah, S.Pd., and Warta, M.Pd. the e-book achieved a validity level of 94%, categorized as "Highly Valid." Therefore, the developed e-book is deemed highly feasible for use and suitable for trials in both small-scale and large-scale research in Grade V at SDN Kebon Jeruk 08.

Table 1. Media Validation Calculation Table

Total Skor				24	70
Persentase = $\frac{\text{Total skor}}{100}$ x 100%					94%

Meanwhile, based on the material validation conducted by the mathematics subject matter experts, the material achieved a score of 94%, classified as "Highly Feasible." Thus, the geometry content in the developed e-book is considered appropriate for implementation in classroom learning at SDN Kebon Jeruk 08.

Table 2. Material validation calculation table

Total Skor	**94**
Persentase = $\frac{\text{Total skor}}{100}$ x 100%	**94%**

After the validation process, the researcher conducted the study using data collection techniques including observation, interviews, questionnaires, and tests. Data analysis was carried out qualitatively for descriptive data using triangulation, and quantitatively using percentages and statistical tests. The effectiveness of the e-book was tested by comparing pre-test and post-test results using the paired sample t-test for normally distributed data or the Wilcoxon signed-rank test for non-normally distributed data.

RESULT AND DISCUSSION

Geometry is one of the core branches of mathematics that deals with shapes, sizes, relative positions of figures, and the properties of two-dimensional objects. At the elementary level, particularly in Grade V, plane geometry is a crucial topic aimed at helping students understand two-dimensional shapes such as squares, rectangles, triangles, parallelograms, trapezoids, rhombuses, kites, and circles. This topic is closely linked to the development of spatial literacy, which involves the ability to visualize, analyze, and mentally transform geometric objects.

In practice, however, learning geometry is often perceived as a challenge by students due to its abstract nature and the high level of visualization it requires. This challenge becomes even more pronounced when the learning process lacks adequate instructional media. According to a study by Zulkarnaen in (Kharisma & Lailiyah, 2024:143), many students struggle to understand geometric concepts because the instructional approach is insufficiently contextual, lacks interactivity, and relies heavily on static text and images.

To address these challenges, the development of interactive e-books as digital-based learning media has proven to be an innovative and effective solution. These e-books not only present material in textual form but also incorporate various multimedia elements such as videos, animations, interactive quizzes, and problem-based exercises. This advantage aligns with the principles of constructivist theory, which emphasizes that knowledge is actively constructed by learners through experience, interaction, and direct engagement in the learning process (Masgumelar & Mustafa, 2021:50). In this sense, students are not passive recipients of information but active participants who construct understanding through interaction with content and their learning environment.

The development of this e-book refers to the ADDIE model, which consists of Analysis, Design, Development, Implementation, and Evaluation. This model is widely

used in instructional media development due to its systematic and flexible approach (Fayrus & Slamet, 2022). In the analysis phase, the researcher conducted a needs analysis through classroom observation, identification of students' learning styles, distribution of questionnaires regarding students' interest in geometry and spatial literacy, as well as interviews with fifth-grade teachers. These steps enabled the researcher to identify the content needs expected by the school for the e-book development.

The design phase involved designing the e-book based on the needs analysis results. The initial design included content planning, interaction design, and visual layout. During this stage, the principles of multimedia learning as proposed by Rowe (2015) were integrated, including the use of narrative text combined with visual animations, audio, and interactive elements that stimulate student exploration and reflection. Additionally, an active learning approach, as suggested by Silberman (2018), was applied by encouraging students to participate actively through quizzes, virtual experiments, and small group discussions.

In the development phase, the researcher conducted instrument validation, material validation, and media validation by involving subject matter experts, including academic advisors, mathematics experts, and media specialists. Once the e-book model was validated and deemed feasible by the experts, the implementation phase was carried out by using the e-book in classroom learning. Field testing was conducted through small-group and large-group trials.

The evaluation phase involved assessing each stage of the ADDIE development model used in this study. In the analysis stage, the evaluation focused on students' characteristics and identified problems. In the design stage, the evaluation addressed the initial e-book design. During the development stage, the evaluation involved revisions based on expert validation feedback. In the implementation stage, the evaluation included revisions based on the practicality test results from both small and large class groups.

The integration of these components significantly enhanced students' spatial literacy skills. Through virtual object manipulation features, students were not only able to view geometric shapes but also resize, rotate angles, and compare properties of plane figures. These activities helped them build stronger mental representations, enabling them to reason more effectively about relationships between shapes and articulate spatial ideas more logically.The e-book design also supports individualized and self-directed learning. Students are given the freedom to explore the material at their own pace and according to their interests, making connections to personal experiences. This fosters the development

of critical and reflective thinking skills, enabling students to evaluate information, construct arguments, and provide reasoning based on visual and conceptual evidence. Observations during the learning process indicated increased student enthusiasm. Students became more active in asking questions, participating in discussions, and confidently expressing their thoughts and understanding.

For teachers, the e-book provides a more creative, flexible, and structured means of delivering content. With the support of visual and interactive features, teachers can design more engaging and meaningful lessons that accommodate various learning styles visual, auditory, and kinesthetic. This transforms geometry learning beyond the confines of blackboards and printed textbooks into a more dynamic and immersive learning experience.

The primary strength of this interactive e-book lies in its ability to integrate various instructional approaches into a cohesive digital platform. It combines constructivist principles, problem-based learning, visual-spatial strategies, and multimedia technology in one environment. This approach has proven to be more effective than conventional methods, which often rely on lectures and practice exercises without interactivity.

Nevertheless, the implementation of this e-book also presents several challenges. The most prominent is the need for adequate access to technology, both in terms of hardware (devices, laptops) and internet connectivity. Not all students have equal access to such resources, especially in regions with limited infrastructure. Additionally, teachers' ability to manage digital media is another concern. Without sufficient training, the full potential of the e-book may not be realized.

In general, the advantages of this interactive e-book include:

1. The integration of elements from constructivist learning models, problem-based learning, and multimedia.
2. The availability of interactive features that support self-directed and active learning.
3. Immediate feedback provided through exercises and quizzes.

On the other hand, its limitations include:

1. Dependence on adequate access to technology.
2. The need for teacher capacity-building through training in e-book utilization.

The visual design of this e-book has been carefully developed to assist students in constructing accurate mental representations of geometric objects. The ability to manipulate objects virtually provides a more realistic learning experience compared to merely viewing static two-dimensional images. The embedded interactive elements also

enhance student engagement and encourage independent exploration both of which are essential for strengthening spatial literacy. The following images illustrate the developed interactive e-book on plane geometry :

Figure 1. Cover

Figure 2. List of Contents

Figure 3. Contents

Based on the validation results from media experts and subject matter experts, the e-book received a score of 94. The percentage calculation indicates that the feasibility level of the e-book reached 94%, which falls into the "highly feasible" category.

Total Skor	**94**
Persentase = $\frac{\text{Total skor}}{100}$ x 100%	**94%**

This assessment encompassed content feasibility, visual and design quality, level of interactivity, and effectiveness in supporting learning evaluation. Feedback from the experts was then used to refine specific components, such as adjusting geometric formulas, enhancing visualizations, and developing features to support kinesthetic learning styles.

To empirically assess the effectiveness of the e-book, testing was conducted with fifth-grade students at SDN Kebon Jeruk 08 Jakarta through readability analysis, interaction observation, and a student satisfaction questionnaire. The readability results

showed scores ranging from 4.6 to 5, indicating that the language used was clear, the content structure was logical, the visualizations supported understanding, and the interactive features were easily accessible. Classroom observations recorded a score of 4.5, with students demonstrating active engagement, making optimal use of the e-book features, and being able to independently explain geometric concepts.

Meanwhile, the student satisfaction score for using the e-book was 94 out of 100, indicating that students felt significantly supported and enjoyed using the e-book. They perceived the learning process as more engaging, easier to understand, and less monotonous.

From the research instrument perspective, the results of validity and reliability tests showed that the measurement tools used were of excellent quality. Pearson correlation for 15 questionnaire items confirmed that all instruments were valid (r count > 0.349; p < 0.05), and the reliability test yielded a Cronbach's Alpha of 0.811, indicating that the instruments were consistent and reliable.

Table 3 Normality Test Results

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Kelas	Statistic	df	Sig.	Statistic	df	Sig.
Hasil	Pretest Kelas Kecil	.214	10	.200*	.852	10	.061
	Postest Kelas Kecil	.202	10	.200*	.878	10	.124
	Pretest Kelas Besar	.150	32	.067	.945	32	.107
	Postest Kelas Besar	.169	32	.020	.948	32	.124

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Based on the normality test using the Kolmogorov-Smirnov and Shapiro-Wilk methods, most of the data were found to be normally distributed.

Table 4 Homogeneity Test Results

Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
Hasil	Based on Mean	.618	3	80	.605
	Based on Median	.694	3	80	.559
	Based on Median and with adjusted df	.694	3	75.040	.559
	Based on trimmed mean	.633	3	80	.596

The homogeneity test using Levene's Test showed significance values greater than 0.05 across all approaches, indicating that the variances between groups were

homogeneous. Therefore, the t-test could be appropriately used to compare learning outcomes between the groups.

Table 5 T-Test

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means					
								95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Nilai	Equal variances assumed	2.067	.158	-10.390	40	.000	-26.844	2.584	-32.065	-21.622
	Equal variances not assumed			-13.142	24.380	.000	-26.844	2.043	-31.056	-22.631

The effectiveness test using an independent t-test showed a significant difference ($p < 0.001$) with a mean difference of 26.84 points between the small and large classes. This confirms that the developed e-book had a significant impact on improving students' spatial literacy. The combination of text, images, and interactive elements in the learning media effectively enhanced both conceptual and spatial understanding.

Based on the results of the e-book effectiveness test, it was found that most of the evaluation instrument items were valid and had a high correlation with the total score, indicating that the instrument accurately measured students' spatial literacy abilities. This aligns with Sugiyono's (2018) assertion that validity refers to the extent to which a measurement tool accurately measures what it is intended to measure. The Cronbach's Alpha value exceeding 0.7 indicates that the instrument is consistent and reliable for use in educational research.

The normality test showed that most of the data were normally distributed, allowing for the use of parametric tests such as the t-test. Homogeneity of variance was also met, fulfilling the basic assumptions of the t-test (Ghozali, 2016). The t-test results revealed a significant difference in post-test scores between the small and large classes, with the large class showing a higher average score. The substantial score difference indicates that the use of a geometry-based e-book had a positive impact on improving students' spatial literacy. These findings are consistent with Mayer's theory (2009), which states that interactive visual media can significantly enhance students' spatial understanding. This demonstrates that the developed e-book is not only valid and practical but also effective in improving learning outcomes, particularly in developing spatial literacy skills among elementary school students.

CONCLUSION

Based on the research findings and data analysis, it can be concluded that the interactive e-book developed for fifth-grade geometry material in primary school is valid and feasible to be used as a learning medium. This e-book significantly enhances students' spatial literacy, particularly in the aspects of visualization, reasoning, and spatial communication. The integration of multimedia elements and interactivity within the e-book provides a more meaningful and engaging learning experience for students. Expert validation results indicated a feasibility score of 94% (highly feasible), while the readability tests, interaction observations, and student satisfaction questionnaires also showed very positive responses. The effectiveness of the e-book was further supported by statistical tests that demonstrated a significant improvement in student learning outcomes.

Several recommendations can be made: (1) Teachers are encouraged to utilize this interactive e-book as an alternative learning medium for geometry to make the learning process more engaging, contextual, and interactive. (2) Schools should provide adequate technological facilities, such as digital devices and internet access, to ensure optimal use of the e-book. (3) Teacher training on the use of interactive digital media is also essential to support effective integration of technology into the learning process. (4) Further research is recommended to develop e-books covering a broader range of mathematical content and to test their effectiveness in different school contexts.

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