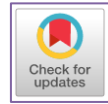


The effectiveness of augmented reality-based pocket books to improve numeracy literacy skills of elementary school students



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Abstract: Elementary school students' numeracy literacy skills remain low, particularly in understanding the concepts of two-dimensional and three-dimensional shapes, due to the limited use of instructional media. This study aims to examine the effectiveness of an augmented reality-based pocket book in improving students' numeracy literacy. The research employed a Research and Development (R&D) method using the ADDIE model, which includes the stages of Analysis, Design, Development, Implementation, and Evaluation. The study involved 100 students from five elementary schools in Pakel District, using a pretest–posttest design. Data analysis was conducted using the N-Gain test to measure the improvement in students' skills after utilizing the media. The results revealed an N-Gain score of 0.85, which falls into the high category, indicating a significant improvement in students' understanding of mathematical concepts through interactive visualization. Thus, the augmented reality-based pocket book is proven to be effective and feasible for broader implementation in elementary numeracy literacy learning.

Keywords: Pocket Book; Augmented Reality; Numeracy Literacy

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INTRODUCTION

Numeracy literacy is a very important basic skill for students at the basic education level. Success in numeracy literacy allows students to understand and apply mathematical concepts in everyday life (D. N. Ramadhan et al., 2023). However, in reality, many students still have difficulty in understanding the basic concepts of mathematics, especially in the material of flat and spatial shapes (Sitompul & Wijaya, 2024). This is due to the lack of in-depth understanding of the shape and nature of the shapes, as well as the limitations of existing learning media (Azizah et al., 2024). For this reason, an innovative and fun learning approach is needed so that students are more interested and easily understand the material. Augmented reality-based pocket book offers a solution by providing a more interactive and visual learning experience (Ndoang et al., 2024).

Based on observations made in January 2025 at SDN Pakel Sub-district, many students still have difficulty understanding the material on flat and spatial shapes. Most students find this material difficult because they cannot clearly imagine the three-dimensional shape of the shapes. Conventional learning methods, such as using textbooks and two-dimensional images, tend to be less effective in helping students visualize mathematical objects. This poses a challenge for teachers to develop more

interesting and effective teaching methods (Listrianti et al., 2023). Therefore, media is needed that can present clearer and more interesting visualizations, such as augmented reality-based pocket books that allow students to interact directly with mathematical objects (W. S. Ramadhan et al., 2023).

The material of flat and spatial shapes is an important part of mathematics lessons that must be mastered by students (Rachmawati et al., 2023). Flat shapes, such as triangles, squares, and circles, as well as spatial shapes, such as cubes and spheres, require a strong visual understanding for students to grasp the concepts of area, perimeter, and volume (Wedayanti & Wiarta, 2022). However, most students find it difficult to understand the characteristics and properties of these shapes with only a two-dimensional image (Aprianty et al., 2021). Without a clearer visual representation, students will have difficulty understanding the relationship between theory and application. The use of augmented reality-based pocket books can provide a three-dimensional representation that allows students to see and manipulate the shapes directly, to deepen students' understanding (Laksana, 2024).

Pocket books as learning media have many advantages, especially in terms of portability and ease of access (Parniati et al., 2021). The pocket book allows students to study independently outside of class hours, supporting continuous learning (Elviya & Sukartiningsih, 2023). However, traditional pocket books are limited in terms of interactivity and the ability to show math concepts in three-dimensional form (Anggraeni et al., 2024). To overcome this limitation, the augmented reality-based pocket book offers a solution by allowing students to interact directly with mathematical objects in three-dimensional form (Mulyani, 2022). Thus, this pocket book not only provides theoretical information but also helps students to better understand the material through a more immersive visual experience.

In today's technological era, the utilization of technology in learning has become very important to support more effective learning (Karyadiputra et al., 2023). Technology can enrich students' learning experience, make difficult-to-understand material easier to digest, and increase students' motivation to learn (Anggraeni et al., 2024). However, despite the increasing development of technology, its application in numeracy literacy learning in many primary schools is still limited (D. N. Ramadhan et al., 2023). Many schools still rely on conventional learning media, which tend to be less interesting for students (Laila et al., 2021). Therefore, it is important to utilize the latest technology, such as augmented reality, to enhance students' learning experience, especially in understanding more abstract mathematical concepts, such as flat and spatial shapes.

Augmented reality (AR) is a technology that allows users to view virtual objects added to the real world through devices such as smartphones or tablets (Prihatiningsih et al., 2024). In the context of education, augmented reality can provide a more interesting and interactive learning experience by allowing students to see a three-dimensional model of the object being studied (Imron et al., 2023). This technology is very useful in math lessons, especially in understanding flat and spatial shapes, as it can provide a clearer visual representation. By using augmented reality-based pocket books, students can see and interact with three-dimensional models of the shapes, which can help them better understand the geometric properties and relationships between the shapes (Lestari & Wirasty, 2019). The use of augmented reality in math learning can also increase students' interest in this subject, which is often considered difficult and boring (Afandi et al., 2024).

Overall, numeracy literacy is a fundamental skill that must be mastered in basic education. However, many elementary students still struggle to understand essential mathematical concepts, particularly flat and spatial shapes, due to the lack of engaging and effective learning media. To address this gap, this study aims to develop and evaluate the effectiveness of an augmented reality-based pocket book as an innovative learning medium to enhance students' numeracy literacy, especially in geometry-related content. The goal is to determine whether this technology can significantly improve students' understanding and make mathematics learning more interactive and meaningful.

METHOD

This type of research is a Research and Development (R&D org, W. R., & Gall, M. D. (2003) development research that aims to test the effectiveness of augmented reality-based pocket books in improving the numeracy literacy skills of elementary school students on the material of flat and spatial shapes. This research uses the ADDIE model through the stages of analysis, design, development, implementation, and evaluation (Rahayu et al., 2023). The stage of testing the effectiveness of augmented reality-based pocketbooks was carried out twice, namely on small-scale and large-scale testing. This testing was carried out in February 2025 in five elementary schools in Pakel District for students in grades 4, 5, and 6 with a total of 100 students. Small-scale testing was conducted at SDN 1 Pakel with 20 students, while large-scale testing was conducted at SDN 1 Bangunmuljo, SDN 2 Bangunmuljo, SDN 1 Tamban, and SDN 2 Tamban with 80 students. Data collection techniques in the form of pretest questions given before the use of augmented reality-based pocket books and posttests given after the use of augmented reality-based pocket books. The data analysis technique uses the N-Gain test to measure the improvement of students' numeracy literacy skills.

Effectiveness data obtained from pretest and posttest results on small-scale and large-scale testing were analyzed using the N-Gain test. The formula for calculating N-Gain is as follows (Rojikin et al., 2022).

$$N\text{-Gain} = \frac{\text{Posttest} - \text{Pretest}}{\text{Ideal Max Score} - \text{Pretest}} \dots\dots\dots 1]$$

Posttest= Score after using learning media

Pretest= Score before using learning media

Ideal Max Score = The maximum score that can be achieved on the posttest

The N-Gain test decision is made by comparing the results of the calculation of student N-Gain with the following criteria to determine how effective the augmented reality-based pocket book is in improving students' numeracy literacy skills. Based on the calculated N-Gain value, decisions can be made as follows (Mahendra et al., 2020).

Table 1. N-Gain test decision criteria

N-Gain	Statistic Mean		
	$g < 0,3$	$0,3 \leq g \leq 0,7$	$> 0,7$
Results	Low	Medium	High
Criteria	Ineffective	Effective	Highly Effective

The decision regarding the effectiveness of the augmented reality-based pocket book can be taken based on the N-Gain value obtained from the pretest and posttest results. Based on the N-Gain test criteria set, if the N-Gain value is less than 0.3, then the results are categorized as low and declared ineffective. If the N-Gain value is between 0.3 to

0.7, then the result is categorized as moderate, and this learning media is declared effective. Meanwhile, if the N-Gain value is more than 0.7, the result is categorized as high and considered very effective. This criterion is used to assess how much the students' numeracy literacy skills have improved after using the augmented reality-based pocket book.

RESULTS AND DISCUSSION

Result

The ADDIE model is used in this study to develop and test the effectiveness of augmented reality-based pocket book in improving students' numeracy literacy skills. Each stage of ADDIE, namely analysis, design, development, implementation, and evaluation, is carried out systematically to ensure the quality and effectiveness of this learning media. The following is a detailed description of how the ADDIE stages were applied in this study.

Analysis

At the analysis stage, problems faced by students in understanding mathematical concepts, especially in the material of flat and spatial shapes, were identified. Based on observations at SDN Pakel Sub-district, it was found that most students had difficulty imagining the three-dimensional shape of flat and spatial shapes. The learning media that have been used, such as textbooks and two-dimensional images, are not enough to help students understand these mathematical objects. Therefore, this research aims to develop and test an augmented reality (AR) based pocket book as a more interactive and visual learning media. The analysis stage also involves the study of technology needs in schools, as well as the readiness of devices and students' understanding of the use of augmented reality technology. In addition, the curriculum and learning materials that students must master are analyzed to ensure that the augmented reality pocket-book developed is relevant to the learning needs.

Design

In the design stage, the augmented reality (AR)-based pocket book is designed to present brief material about flat and spatial shapes. This book includes explanations of definitions, formulas, images, and illustrations of flat and spatial shapes that can help students understand basic concepts. Each page of the pocket book is equipped with a barcode that can be scanned using the AR application to access detailed material, evaluation questions, and visualization of spatial shapes in three dimensions. The GeoGebra application is used to create 3D models of the shapes that can be rotated, enlarged, and manipulated, so that students can see and learn the shapes and properties of the shapes more clearly and interactively. This design aims to enrich students' learning experience with more real and in-depth visualization, and help them understand mathematical concepts that are difficult to understand through conventional media.

The design image shows the interface of the Augmented Reality (AR) application integrated with the pocket book. The Augmented Reality (AR) display is focused on the object of building space in the form of a 3D model so that students can see the shape visually. Underneath there is a selection button of various types of space buildings, such as blocks, prisms, pyramids, tubes, cones, and spheres that users can use to explore other 3D models. It is designed with bright colors and high contrast to attract the

attention of elementary school students and support fun and intuitive learning interactions.

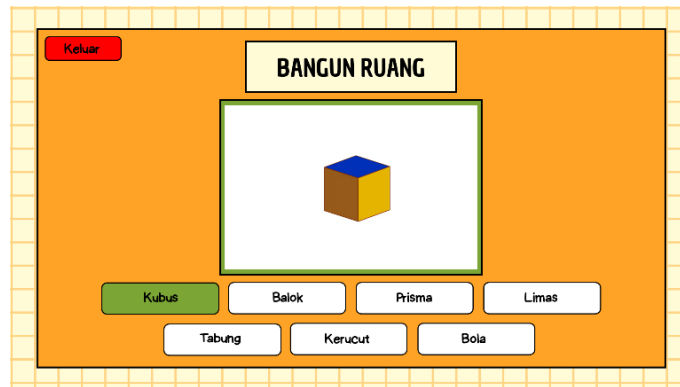


Figure 1. Augmented Reality (AR) design on pocket books

Development

The media developed is a printed pocket book aimed at grade 4, 5, and 6 elementary school students. The design of the front cover of the book features cheerful and educational visual elements such as images of flat shapes, rulers, calculators, and other math icons, which are designed to attract students' interest in learning. On the back, there are motivational quotes that foster students' enthusiasm in understanding math. This book is combined with augmented reality (AR) technology through barcodes on each page that can be scanned using mobile devices, so that students can access flat and spatial models in 3D. This book not only presents the material in a concise and interesting manner, but is also designed to be practical to use and support a more enjoyable and interactive learning experience.

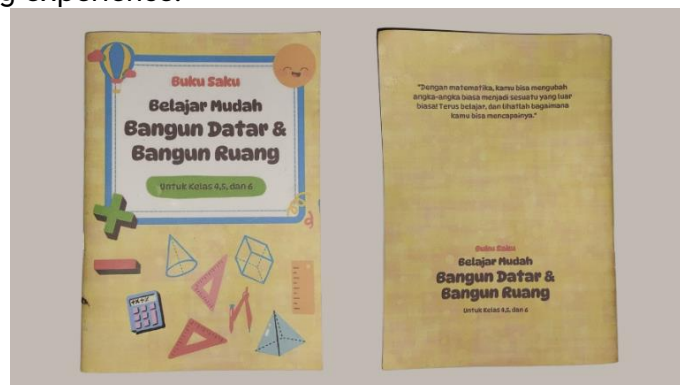


Figure 2. Pocketbook view

In the development stage, the pocket book based on augmented reality that has been designed previously begins to be realized into a product that is ready to be tested. The development process involves creating three-dimensional visual content that will be displayed in the augmented reality application, such as models of triangles, squares, cubes, spheres, and other spatial shapes. Each 3D object is created in detail and can be rotated or zoomed in to provide a more interactive learning experience. In addition, the augmented reality application is also programmed to be easily accessed by students through mobile devices such as smartphones and tablets, without the need for special devices. After the augmented reality pocket book was developed, the product was then tested in small-scale testing at SDN 1 Pakel, involving 20 students to ensure that the pocket book could run well and as expected, as well as to get initial feedback on the

clarity of the content and ease of use of the augmented reality-based pocket book. The following are the results of small-scale N-Gain testing.

Table 2. Small-scale N-Gain testing results

Data	Statistic		
	N	Mean	Std. Deviation
N-Gain	20	0.61	0.20530

The results of N-Gain testing on a small scale showed that the augmented reality-based pocket book obtained an N-Gain value of 0.61, which was included in the moderate category. This shows that the use of augmented reality-based pocketbooks is effective in improving students' numeracy literacy skills in flat and spatial building materials. Although the N-Gain value is in the moderate category, this result still shows a significant increase in students' understanding of mathematical concepts, making augmented reality-based pocketbooks an interesting and effective medium to be used in the learning process.

Implementation

In the implementation stage, the augmented reality-based pocket book that has been developed and tested on a small scale is applied in large-scale testing. This large-scale testing was conducted at SDN 1 Bangunmulyo, SDN 2 Bangunmulyo, SDN 1 Tamban, and SDN 2 Tamban with 80 students as test subjects. Each student was given the opportunity to use the augmented reality-based pocket book during the learning process. At this stage, students took a pretest before starting learning using augmented reality-based pocketbooks to measure their initial ability to understand the concept of flat and spatial shapes. After using the augmented reality-based pocket book during learning, students are then given a posttest to measure the improvement of their numeracy literacy skills. This implementation aims to test the extent to which the use of augmented reality-based pocketbooks can affect students' understanding of mathematics material, especially in the visualization aspect of flat and spatial shapes. Table 3 is the results of large-scale N-Gain testing.

Table 3. Large-Scale N-Gain Testing Results

Data	Statistic		
	N	Mean	Std. Deviation
N-Gain	20	0.85	0.18630

The results of N-Gain testing on a large scale showed that the augmented reality-based pocket book obtained an N-Gain value of 0.85, which was included in the high category. This value indicates that the use of augmented reality-based pocketbooks is very effective in improving students' numeracy literacy skills in flat and spatial building materials. This significant increase indicates that the augmented reality-based pocket book is not only able to attract students' interest, but also provide a deeper and clearer understanding of mathematical concepts. With a high N-Gain value, the augmented reality-based pocket book is proven to be a very effective medium to improve students' numeracy literacy skills.

Evaluation

At the evaluation stage, the focus is on analyzing the results of the development of augmented reality-based pocket book learning media. This evaluation collects data

from pretests and posttests conducted during testing to assess the effectiveness of the media in improving students' numeracy literacy skills. Based on the results of the N-Gain test analysis, the augmented reality-based pocket book is proven to be effective in improving students' understanding of flat and spatial building materials. The N-Gain test results show that this media is interesting and effective in helping students understand mathematical concepts, so no significant improvements are needed on the media. However, some students revealed that the barcode scanning process can slightly affect the smoothness of learning if not using adequate devices. Nonetheless, feedback from students and teachers indicated that the augmented reality pocketbook was easy to use, the material was presented clearly, and the 3D visualization had a positive impact on concept understanding. The results of this evaluation confirm that the augmented reality pocket book has successfully achieved the development objectives with few shortcomings that can still be overcome with the use of better devices.

Discussion

The product developed in this study is an augmented reality (AR)-based pocketbook designed to enhance students' numeracy literacy skills. This pocketbook utilizes AR technology to present mathematical material, specifically related to flat and spatial shapes, in a more visual and interactive manner. By incorporating AR, the material is displayed in 3D visual representations, which help students better understand mathematical concepts that are typically difficult to grasp through traditional media. The N-Gain value of 0.85, which falls into the high category, demonstrates a significant improvement in students' numeracy skills, indicating that this product is highly effective in enhancing student comprehension.

Several relevant studies highlight similar trends in the use of AR technology in mathematics education. For instance, research by (Astri et al., 2022; Listrianti et al., 2023; Rachmawati et al., 2023) show that AR use in mathematics education improves students' understanding of complex concepts, such as geometry. Additionally, AR offers a more engaging learning experience, which can boost student involvement and motivation.

Compared to existing products, the AR-based pocketbook has an advantage in providing deeper 3D visualization. Previous learning products utilizing AR, such as those discussed by (Laksana, 2024; Rojikin et al., 2022), also emphasize the importance of visual representation in understanding geometry. However, this product stands out due to its practical and portable format, making it easier for students to carry around and access, offering more flexibility than other AR learning tools.

The impact of the AR-based pocketbook is reflected in the significant improvement in students' numeracy skills, as evidenced by the N-Gain value of 0.85, which falls within the high category. This suggests that AR can help students grasp complex mathematical concepts, such as flat and spatial shapes, more easily. Previous studies by (Ndoang et al., 2024; Sitompul & Wijaya, 2024) have also shown that the use of AR technology is effective in increasing students' motivation and interest in mathematics learning.

In comparison with previous research outcomes, this product demonstrates a more substantial impact, particularly in enhancing students' understanding of challenging mathematical material. Research by (Mulyani, 2022) has shown that AR technology can significantly improve students' interest and motivation, aligning with the findings of this study that the AR-based pocketbook effectively engages students in mathematics

learning. Thus, this product can be considered more effective than traditional learning media in improving students' numeracy literacy in elementary schools.

Overall, this AR-based pocketbook proves to be highly effective in enhancing students' numeracy literacy skills, with a greater impact compared to traditional learning media.

CONCLUSION

Based on the results of this development research, it can be concluded that the augmented reality (AR)-based pocket book is very effective in improving the numeracy literacy skills of elementary school students, especially on the material of flat and spatial shapes. The N-Gain test results show a value of 0.85, which is included in the high category, indicating that the use of augmented reality-based pocketbooks has succeeded in significantly improving student understanding. Therefore, it is recommended that this augmented reality-based pocket book be applied more widely in elementary schools as an interactive and effective learning medium, and for further research to explore the use of augmented reality in other numeracy literacy materials.

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