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"MATHAR BOOK" TECHNOLOGY-BASED MATHEMATICS LEARNING INNOVATION: UTILIZATION OF AUGMENTED REALITY BOOKS TO INCREASE LEARNING EFFECTIVENESS

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***Abstract*—The challenge often faced in the mathematics learning process is creating an exciting learning experience that can increase the effectiveness of student learning. This research aims to design a learning media using Augmented Reality Book technology in an educational context, focusing on creating an exciting learning experience for high school students. The research method used is Research and Design, which combines research and development stages to create an innovation based on user needs. Data collection was obtained from testing using a questionnaire to determine the suitability of learning media. Questionnaires were given to material experts, media experts, and practitioners. The results of the media expert questionnaire obtained an average percentage of 83% in the feasible category, the results of the material expert questionnaire obtained a percentage of 86.36% in the appropriate category, and the results of the questionnaire given to practitioners received a percentage of 87.06% in the proper category. Based on the research results, it can be concluded that the MathAR Book learning media is suitable for use as a mathematics learning media, significantly contributes to education development with Augmented Reality technology, and provides practical guidance for educators in creating a motivating learning environment.**

Keywords—***Augmented Reality; Augmented Reality Book; Technological Innovation; Mathematics***

I. INTRODUCTION

Developments in the 21st century are rapidly developing, especially in science and technology (IPTEK), which is growing in all fields, including education. Education is the main foundation in forming the potential and abilities of human resources and is a vital necessity for human life [1]. In the current era of information technology, integrating technology into education has become necessary to facilitate a more innovative, creative, and meaningful learning process [2]. Many innovative developments have been introduced to positively contribute to the education sector, such as using computers as presentation tools, using e-learning to increase students' enthusiasm for learning, and using smartphones to support student learning [3]. Improving learning methods must be continuous and aligned with learning needs by implementing integrated and structured activities. This aims to form a high-quality academic culture [4]. Many academic studies examine teaching methods in interactive environments to establish optimal norms or evaluation standards to measure students' ability to participate interactively in a classroom setting [5]. Technology-based media can support students in increasing motivation, curiosity, thinking abilities, and learning outcomes [6]. Mathematics, a complex and

challenging subject, requires a creative learning approach to be accessed more pleasantly and efficiently.

One technological development that can be utilized in this context is Augmented Reality (AR). Augmented Reality (AR) is a technology that presents visualization of virtual objects originating from a computer into a real-world physical environment, creating an interactive experience for users [7]. Research in the field of Augmented Reality aims to design technology that facilitates the integration of computer-generated digital content with the physical environment directly and in real time [8]. The implementation of AR in educational research produces positive impacts, including increased collaboration, deeper understanding, and student motivation when using learning media based on Augmented Reality [9]. By applying Augmented Reality (AR) in an educational context, students can experience innovative and exciting learning experiences, providing a more interactive approach during the learning process [7]. Several recent studies show that Augmented Reality (AR) is recognized as an innovative technology that continues to develop, positively contributing to improving the user experience [10]. The use of augmented reality (AR) technology integrated with media in education has five main reasons that are very relevant. First, AR enables interactive learning where students can more effectively understand the concepts of teaching materials through direct experience with three-dimensional objects. Second, portability and low cost are essential because AR learning does not require significant investments in physical materials, such as prototypes or models, but combines illustrations with multimedia animation. Third, flexibility and ease of learning are realized by allowing students to access material anytime and anywhere through AR technology, providing high flexibility in the educational process. Fourth, AR creates a lifelong learning cycle by providing a continuous learning experience that is easy to remember for a long time and is integrated with various access media via the internet. Finally, using AR improves students' critical thinking skills through a more exciting and interactive learning approach, enriching their learning experience [3]. This creates a learning environment where students can receive continuous feedback, creating comfort and confidence in using the media [11].

To increase the effectiveness of mathematics learning, we propose an innovation called "MathAR Book" or "Mathematics Book Based on Augmented Reality." Augmented Reality (AR) based books are physical books enriched with computer applications that can be accessed through image markers known as bookmarks [12]. The main goal of this project is to incorporate augmented Reality (AR) technology into illustrated books to enrich and motivate students' reading experience. Illustrated books are a unique educational method for children that can fulfill their desires for exploration and imagination and play a significant role in children's development and growth [13]. Through analysis of language and visual dimensions, the research results show the significance of picture books in the cognitive development of children and adolescents. Picture books provide non-linguistic lessons such as art, numbers, and music and become a means for students to gain knowledge, understand culture, and improve their cognitive abilities through visual communication [13]. Mathematics learning often faces challenges, such as difficulty understanding concepts, student boredom, and limited learning resources. The use of AR technology in learning can be a solution to overcome these obstacles. With MathAR Book, we combine math learning concepts with AR elements to create a more engaging, interactive, and easy-to-understand learning experience. Relevant studies are related to research that researchers will carry out, such as research [14]. The development of augmented reality-based mathematics magic book media shows that it is a valid product suitable for use.

This research aims to design learning media using Augmented Reality Book technology in an educational context, focusing on creating an exciting learning experience for high school students. This research also aims to evaluate the feasibility and effectiveness of learning media developed through trials involving material experts, media experts, and practitioners and to identify the contribution of this innovation to increasing the effectiveness of mathematics learning and student learning motivation.

II. METHOD

The research method used is the Research and Design (RnD) method, which focuses on developing the MathAR Book product. This approach includes a research and product design process to produce innovation or improvement. This research and development adopts the 4D model created by [15]. This model has four main stages: definition, design, development, and deployment. Figure 1 illustrates this stage.

Figure 1. Research and development procedures

First, in the definition stage, this research focuses on identifying the needs and preferences of high school (SMA) students. This effort aims to understand that students are

interested in exciting learning media that can create an engaging learning experience. This process involves interviews, surveys, or observations of high school students to explore their views regarding the types of learning media that can generate interest, involvement, and positive learning experiences regarding event opportunity material. By understanding student preferences, defining these needs becomes the basis for designing learning media development strategies that are appropriate and effective for this target user.

In the second design stage, in designing learning media that suits the preferences and needs of high school students, the design approach is carried out by paying attention to exciting elements that support a positive learning experience. This design includes the use of attractive visual elements, an interactive approach, and the presentation of information that is easy to understand. Mathematics Books Based on Augmented Reality (MathAR Book) can be published in hardcover or light format with a spiral mechanism (plif book). In this book, a barcode is embedded that can be scanned using a mobile device, and a link is also included to make it easier to access if there are problems using a cellphone.

Figure 2. Mathew Book design

The third stage of development aims to implement the media design that has been prepared and validate it to ensure that the media has been revised according to input from experts. Augmented Reality was developed by Asemblr Edu application for 3D images. 3D animation was created using the Madibang and Ibis Paint applications. In the product testing stage, the research used a questionnaire instrument, which involved validation from media experts, material experts, and practitioners. Media expert validation questionnaires are designed to assess product-related media's readability, clarity, and effectiveness. Material expert validation questionnaires are used to evaluate the accuracy and relevance of the material in the product to applicable standards or curriculum. Meanwhile, the practitioner questionnaire is intended to obtain the views of practitioners who have used or have experience using the product.

Using a questionnaire as a research instrument is expected to provide comprehensive data to assess the quality and effectiveness of products developed in the context of this research. The RnD method with the questionnaire instrument is expected to provide in-depth insight regarding product improvement and development by applicable needs and standards. This research used data analysis techniques, namely qualitative descriptive and quantitative descriptive data analysis techniques. The quantitative data obtained is in the form of assessment scores from learning material experts, learning media experts, and practitioners in the form of filling in validation sheets.

The final stage is the dissemination stage. This stage aims to publish and disseminate the developed media so that it can be accessed and utilized by the wider community. The distribution process is carried out through participation in international seminars and outreach efforts to stakeholders in the world of education. The collected data was analyzed using descriptive analysis with the percentage criteria formula, as in Table 1.

Table 1 Criteria for assessing the results of questionnaire data processing.

No	Percentage (%)	Eligibility Level	Information
1	76 – 100	Valid	It is decent and does not need to be revised/needs a little revision
2	51 – 75	Fairly Valid	It is pretty decent and needs to be revised
3	26 – 50	Less Valid	It is not feasible and needs to be revised
4	< 26	Invalid	It is not worth it, and a total revision

III. RESULTS AND DISCUSSION

The development of AR-based learning media focuses on integrating technology with relevant educational content to improve learning outcomes. These adjustments ensure that AR apps are engaging and have educational value. Previous studies have shown that AR can significantly improve students' understanding of complex concepts by providing interactive and immersive experiences [16][17].

Media Expert Validation

Validation by media experts ensures that the media to be tested is appropriate and suitable for use in the research

context. Three expert media lecturers evaluated the development product. The validation and expert learning media assessment results for each aspect are presented in the following table.

Table 2 Results of Media Expert Validation Analysis

No	Assessment Aspects	Expected Score	Average Evaluation Score	Percentage (%)
1	Presentation Components	32	27	84,38
2	Components of Appearance	44	36	81,82
3	Software engineering	8	7	87,50
4	implement ability	16	13	81,25

In theIn the next step, the researcher conducted a thorough analysis of the material expert's assessment results.

∑ Average evaluation score = 83

∑ Expected score = 100

After that, the information above is processed using the following formula.

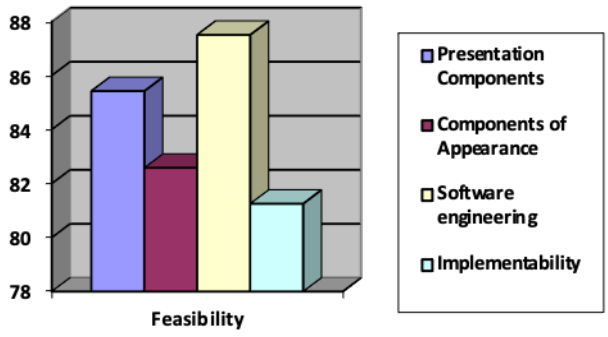
Percentage = (∑ Average evaluation score / ∑ Expected score) * 100%

Percentage = (83/100)*100% = 83%

According to media expert assessments, these calculations reach the feasibility level of MathAR Book at 83%. Once converted into the appropriate conversion scale, the MathAR Book ranges from 76% to 100%. So

, place the position on the relevant criteria. The clustered column graph in the following image shows the percentage score for each aspect of the media validation process described previously.

Figure 3. Media Expert Validation Results



Media members provided input, especially the need for instructions on how to use the MathAR Book.

Material Expert Validation

Validation by material experts ensures that the media to be tested is appropriate and suitable for use in the research context. Three lecturers who were experts in the material about event opportunities evaluated the development product. The validation and expert learning media assessment results for each aspect are presented in the following table.

Table 3 Results of Material Expert Validation Analysis

No	Assessment Aspects	Expected Score	Average Evaluation Score	Percentage(%)
1	Material Coverage	20	17	85
2	Material Accuracy	12	10	83,33
3	Science	28	24	85,71
4	Facilitates Concept Understanding	28	25	89,29

The researcher thoroughly analyzed the material expert's assessment results in the next step.

∑ Average evaluation score = 76

∑ Expected score = 88

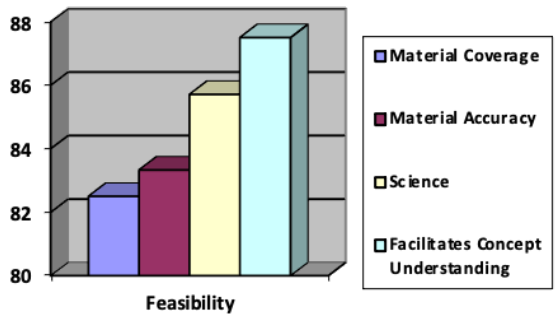
After that, the information above is processed using the following formula.

Percentage = (∑ Average evaluation score / ∑ Expected score) * 100%

Percentage = (76/88)*100% = 86.36%

Based on these calculations, the feasibility level of the MathAR Book reached 86.36%, according to media experts' assessment. Once converted into the appropriate conversion scale, the MathAR Book is 76% to 100%. So, place the position on the relevant criteria. The clustered column graph in the following image shows the percentage score for each aspect of the material validation process described previously.

Figure 4. Material Expert Validation Results



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erial experts suggest replacing illustrations with illustrations closely related to the probability of the event and providing

trigger questions first at each stage so that students discover the concept themselves.

Practitioner Validation

Practitioner validation is carried out to ensure that the media to be tested is appropriate and suitable for use in the research context. Three colleagues evaluated the development product. The results of validation and assessment by learning practitioners for each aspect are presented in the following table.

Table 4 Practitioner Test Analysis Results

No	Assessment Aspects	Expected Score	Average Evaluation Score	Percentage (%)
1	Material	36	31	86,11
2	Language	16	16	100
3	Presentation	8	8	100
4	Appearance	20	18	90
5	Physique	30	22	73,33
6	Usage	8	7	87,50
7	Media Design	36	32	88,89
8	Suitability of Illustration Design	16	14	87,50

The researcher thoroughly analyzed the material expert's assessment results in the next step.

∑ Average evaluation score = 148

∑ Expected score = 170

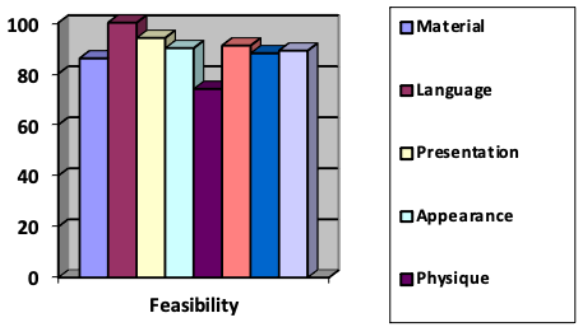
After that, the information above is processed using the following formula.

Percentage = (∑ Average evaluation score / ∑ Expected score) * 100%

Percentage = (148/170) * 100% = 87.06

Based on these calculations, the feasibility level for MathAR Book has reached 87,06%, according to the practitioner's judgment. Once converted into the appropriate conversion scale, the MathAR Book is 76% to 100%. The position should be based on the feasible criteria. The clustered column graph in the following image shows the percentage score for each aspect of the material validation process described previously.

Figure 5. Practitioner Test Analysis Results



Practitioners provide input. The images are adjusted to the level of material being taught, and varied questions are added.

IV. CONCLUSIONS

Media experts rated the MathAR Book's engagement and appeal highly, indicating that it effectively captures students' attention. Material experts consider the MathAR Book to provide adequate support for understanding mathematical concepts, meaning that this medium can help students understand the material better. Practitioners see the MathAR Book as a potential tool for improving teaching effectiveness, indicating that its implementation can positively impact the learning process. Suggestions and recommendations from media experts, material experts, and practitioners provide valuable guidance to improve the quality of the MathAR Book, emphasizing expanding the range of concepts and varied questions. Overall, MathAR Book is rated positively by experts and practitioners, showing great potential as a mathematics learning medium. The recommendations provided can become a basis for further improvement and development so that MathAR Book can become a more effective solution for improving mathematics learning.

Suggestions for future researchers, educators, or readers to explore MathAR Book actively as an addition to experiencing an interactive learning experience. Provide constructive feedback regarding using MathAR Book so developers can continue improving its quality. Utilize various supporting resources, including teacher guidance and additional materials, to maximize understanding of mathematical concepts. Get involved in discussions or learning forums to share experiences and learning strategies using the MathAR Book. Remain open to developments in

learning technology and utilize it optimally to improve students' mathematical abilities.

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