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Research Article

Development of Augmented Reality Media to Grow Numerical Literacy of Elementary School Students

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Abstract

The use of augmented reality (AR) in education has shown potential to improve primary school students' numeracy skills. However, AR research for elementary school geometry is still rare. This study aims to develop augmented reality (AR)-based interactive learning media using the assembler edu platform to improve students' numeracy literacy in geometry subjects. The development method uses ADDIE, the research stages include needs analysis, design, development, implementation, and evaluation. The needs analysis identified problems such as the lack of interactive learning materials and students' difficulties in understanding geometry material. At the design stage, the storyboard and flowchart are made using assembler applications. Media development is done by combining components such as materials, geometry images, animations, and music. Implementation is done through trials by material experts, media experts, and field practitioners, as well as small group and large group trials. The evaluation results show that the developed media has high validity with a percentage of 92% from material experts and 88% from media experts, as well as a significant increase in student numeracy literacy with the percentage of completeness increasing from 6.15% (pre-test) to 79.8% (post-test). With an N-Gain Score of 0.52, this media is proven effective and feasible to use as an additional learning resource. Recommendations for future research include developing content for other topics, testing in different conditions, and improving interactive features.

Keywords: Augmented, Media, Numerical

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INTRODUCTION

The use of augmented reality (AR) in education has shown potential to improve primary school students' numeracy skills. Studies have shown that augmented reality (AR)-based learning media are effective in improving students' understanding of mathematical concepts (Syahriyani, 2023; Haekyung, 2023; Akhyar, 2023; Awal, 2023). AR applications allow students to view and interact with mathematical concepts in a more interesting and immersive way, which increases their interest and understanding of the subject. AR applications not only increase students' interest in mathematics but also help them connect interesting concepts with each other. The incorporation of AR into educational content has also been found to be beneficial for encouraging students to learn and master various skills. Ultimately, this enhances students' learning experience and their overall academic performance.

Although Augmented Reality (AR) technology shows great potential in education, most of the existing research focuses more on improving understanding of mathematical concepts in general, without paying specific attention to numeracy literacy which includes basic abilities such as counting, understanding numbers, and using numbers in the context of everyday life. There is a need for more focused research on how AR can be used to improve numeracy literacy at the primary level. Based on observations at PKBM Quins Level Ibtidaiyah, it was found that teachers have used augmented reality media but only focus on understanding the material in learning, so it lacks contextual problems of everyday life. So it is necessary to develop augmented reality-based learning media based on numeracy literacy.

Some research results on Augmented Reality Based Learning and numeracy literacy show that the integration of AR technology in educational settings has been recognised as a practical and successful approach to improving numeracy skills, as evidenced by positive feedback from students and teachers about the effectiveness and usefulness of AR-based learning materials. Numeracy literacy plays an important role in various aspects of life, including education, work, and society Numeracy literacy improves learning outcomes in school, especially in mathematics, by increasing students' ability to manage numbers and symbols effectively, leading to better problem-solving skills in everyday life (Syahriani, 2023). Overall, numeracy literacy is a foundational skill that empowers individuals to confidently navigate numerical information and make informed decisions across multiple life domains (Fathonah,2023).

RESEARCH METHOD

This research and development will use the Research and Development (R&D) research method to create products, namely Augmented Reality learning media, and conduct feasibility tests. This research and development will use the Research and Development (R&D) research method to make products, namely Augmented Reality learning media, and conduct feasibility tests. For the development of this media used ADDIE development model, Analyze, Design, Development, Implementation, and Evaluate (Lee and Owens, 2004). The basic reason for this interactive learning media development model using the Lee and Owens development model is because this model is devoted to developing multimedia (Lee & Owens, 20004).

This model consists of five stages, one of which is analysis, which is concerned with analysing the working conditions and environment so that we can find a product that suits our problem. The planning of the necessary and required products is known as design. Product manufacturing and testing is part of development. The use of the product is part of the development process, and evaluation is part of the process of assessing the operation steps and

products that have been made whether they are qualified or not (Fitri,2019). The Lee and Owens development steps, namely: (1) Assessment/Analysis which is divided into two parts, namely needs analysis and front-end analysis; (2) Design; (3) Development; (4) Implementation; (5) Evaluation. The development procedure is shown in Figure 1 as follows.

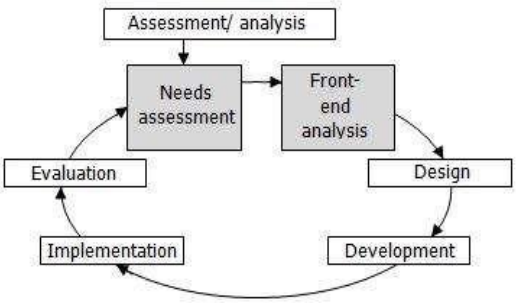

Figure 1 Development Procedure
(William W. Lee & Diana L. Owens, 2004)

In accordance with the type of research, the types of data used in media development research are quantitative and qualitative data. Quantitative data is obtained from the validation questionnaire scores of experts and field practitioners (teachers), student response questionnaires, blackbox testing questionnaires and pre-test and post-test assessment results. Meanwhile, qualitative data was obtained from the results of interviews and criticisms and suggestions from media validators. In this study, there are three types of data analysis techniques used, namely: (1) validity analysis obtained from the questionnaire validation scores of material experts, media experts, and field practitioners (classroom teachers) with a range of questionnaire assessment scores between 1 to 5. The scores were analysed using the Likert scale in table 1 and then processed with the validity formula.

Tabel 1 Skala Likert

No	Skor	Keterangan
1	Skor 1	Very inappropriate, very inappropriate, very unclear, very uninteresting, very uneasy.
2	Skor 2	Less precise, less appropriate, less clear, less easy.
2	Skor 2	Less precise, less appropriate, less clear, less easy.
3	Skor 3	Quite appropriate, quite appropriate, quite clear, quite interesting, quite easy.
4	Skor 4	Precise, appropriate, clear, interesting, easy.
5	Skor 5	Very precise, very appropriate, very clear, very interesting, very easy.

Formula for Percentage of Validity:

$$p = \frac{\sum X}{\sum X_1} \times 100\%$$

Description: p = percentage of validity value, ∑X = number of expert answers in one aspect, ∑X1 = maximum number of answers in one aspect, 100% = constant (Sugandi & Abdur Rasyid, 2019).

After knowing the validation score value, then the results are described by looking at the validation criteria in table 2 below.

Tabel 2 Kriteria Kevalidan

No	Tingkat Pencapaian	Kualifikasi	Keterangan
1	81% - 100%	Sangat Baik	Sangat Valid
2	61% - 80%	Baik	Valid
3	41% - 60%	Cukup Baik	Cukup Valid
4	21% - 40%	Kurang Baik	Kurang Valid
5	0% - 20%	Sangat Kurang Baik	Tidak Valid

(Sumber: Almira Eka Damayanti, dkk, 2018)

(2) Practicality analysis was obtained from the data of blackbox testing results conducted on a small group trial of 5 android users. The data obtained was then analysed using the Guttman scale in table 3. The variables in the questionnaire were measured from two categories made in the form of a checklist with a score of 1 for the answer "Yes" and a score of 0 for the answer "No".

Tabel 3 Skala Guttman

No	Skor	Keterangan
1	Skor 1	Setuju / Ya
2	Skor 0	Tidak Setuju / Tidak

(Sumber: Sugiyono, 2019)

Practicality Percentage Formula:

$$p = \frac{\sum X}{\sum X_1} \times 100\%$$

Description: p = percentage of practicality value, ∑X = number of answers from all respondents in one aspect, ∑X_1 = number of maximum answers in one aspect, 100% = constant (Sugandi & Abdur Rasyid, 2019).

After knowing the practicality score value, then the results are described by looking at the practicality criteria in table 4 below.

Tabel 4 Kriteria Kepraktisan

No	Tingkat Pencapaian	Kualifikasi	Keterangan
1	81% - 100%	Sangat Kuat	Sangat Praktis
2	61% - 80%	Kuat	Praktis
3	41% - 60%	Cukup	Cukup Praktis
4	21% - 40%	Lemah	Kurang Praktis
5	0% - 20%	Sangat Lemah	Tidak Praktis

(Sumber: Almira Eka Damayanti, 2018)

(4) analysis of effectiveness obtained from student numeracy literacy data by conducting pre-test and post-test in large group trial activities conducted on 42 fifth grade students of MI Darussalam Brenggolo. The calculation formula for numeracy literacy skills is as follows.

$$S = \frac{T}{T_t} \times 100\%$$

Notes: S = numeracy literacy score of each student, T = total score obtained, Tt = total maximum score, 100% = constant (Ariska, Darmadi, & Murtafi'ah, 2018).

Then, to calculate the difference in the level of significance between the pre-test and post-test evaluation results using the N-Gain Score test which aims to measure students' numeracy literacy skills between before and after using interactive learning media with the following formula.

$$N - Gain = \frac{Skor\ Posttest - Skor\ Pretest}{Skor\ Maksimal - Skor\ Pretest}$$

From the formula that has been presented, the criteria for the level of numeracy literacy improvement can be seen in table 5 as follows.

Tabel 5 Kriteria N-Gain Score

N- Gain Score	Kriteria
N-Gain > 0,7	Tinggi
0,3 ≤ N-Gain ≤ 0,7	Sedang
N-Gain < 0,3	Rendah

(Sumber: Majdi, Subali, & Sugianto, 2018

RESULTS AND DISCUSSION

The results of media development products that have been developed by researchers are presented in the following figure.

Figure 1 For Scanner

Figure 2 For Scanner

Figure 3 Ilustration Picture

Figure 4 Ilustration Picture

The steps taken by researchers in developing interactive learning media are as follows.

1. **Analisys**

   Preliminary analysis and needs analysis are the two categories of analysis stage procedures. The process of needs analysis involves evaluating the current state of the industry, the students, and the sources of information that will be used to develop new products. Research in field studies has identified the following issues: (1) students require accessible learning materials; (2) students require supportive learning materials that can aid in learning both independently and with guidance; (3) students struggle to understand geometry material due to the abundance of submaterials; (4) there are no interactive learning materials available for mathematics subjects, particularly for geometry material. (5) and pupils require more enjoyable and varied learning opportunities. The researchers developed interactive learning media mathematics based on these data results.

2. **Design**

   The design stage is the beginning of the process of creating this educational media product. It involves activities to ascertain the requirements for media development, ascertaining the format of the produced media material, creating materials and solving building space issues in elementary schools, creating storyboards and flowcharts of the media created using the Asembler application, and gathering assessment tools to ascertain the validity of the produced media.

3. **Devolepment**

   The media development stage is the stage that researchers do to assemble all components such as materials, images, animations, music, and others into interactive learning media products. To make it happen, researchers need the following. In developing assembler edu-based augmented reality (AR) media, researchers need several important things. The following are the main elements needed:

   a. Basic Knowledge of AR and Assembler Edu: Augmented Reality Technology: Basic understanding of how AR works, including hardware (e.g., cameras, sensors), software, and rendering techniques. Assembler Edu: In-depth knowledge of the assembler edu platform, including how to integrate it with AR technology.
   b. Hardware: Computers and Mobile Devices: Specifications sufficient to run AR development applications, Cameras and Sensors: High-quality cameras and additional sensors (such as motion or depth sensors) to detect the environment and physical objects. AR Device: AR headsets or mobile devices that support AR technology (e.g., smartphones with ARCore or ARKit).

c. Software: AR development platform: Software development kits (SDKs) such as Unity with Vuforia, ARCore (for Android), or ARKit (for iOS). Edu Assembler Tool: Software or platform used to create and manage assembler-based educational content.
d. Assembler Edu tool: Software or platform used to create and manage assembler-based educational content.
e. Internet Network: A stable internet connection for downloading and updating AR content. d. Internet Network: A stable internet connection for downloading and updating AR content. Learning Management System (LMS): To integrate AR media in a wider learning environment.
f. By combining all these elements, researchers can develop assembler edu-based AR media effectively and efficiently, and ensure that it can provide an innovative and useful learning experience for users.

4. Implementation

Testing learning media products is done during the implementation stage in order to determine whether or not they are appropriate for use. A group of experts—material experts, media experts, and field practitioners—who were chosen during the design phase execute this step in order to verify the media. The media was tested on an expert team, and the findings of that trial were then revised to make the product even better before it was made available to students. In addition, researchers carried out large- and small-group trials. The following is a description of the data analysis findings regarding the product's efficacy, viability, and validity.

The results of the material expert validation obtained an average percentage of 92% with very good / very valid criteria, this is in accordance with the results of Krismadinata's research (2019) obtained high valid results, this proves that the content contained in interactive media is valid, practical and effective so it can be concluded that the numeracy literacy material on the media is suitable for use. Material expert validators also conveyed several things that need to be improved on the media that have been developed, including: the need for refinement of learning indicators, the need for adjustments to student and teacher animations that are in accordance with student characters, the need for a variety of numeracy literacy questions that are in accordance with the student environment.

Two validators also performed validation with media experts. This evaluation of media validation is based on the programming and display elements of educational materials and uses a validation questionnaire sheet with 26 questions. Using valid validation criteria and the percentage of the two aspects, it can be concluded that this interactive learning medium is appropriate for use. The average percentage of validity obtained was 88%. Expert validators in the media also pointed out a number of things in the media that need to be improved, including the addition of animated images and changing the background color in each section.

The PKBM Quins class teacher served as one of the field expert validators who conducted the field practitioner validation. In addition to validation from media and material experts, this field practitioner assessment takes into account aspects of appearance, ease of use, presentation, and media benefits. A validation questionnaire sheet with 20 items is used for this validation activity. With very very valid criteria, the average validity percentage of AR learning media is 92.5%. Thus, it can be said that

this educational material is appropriate for use. In order to improve the media, field practitioners also communicated a number of things, one of which being the requirement for more HOTS question material.

Blackbox testing activities in small group trials by seven different types and types of Android users yielded a practicality analysis. After researchers made changes to the media in response to critiques and recommendations from knowledgeable validators, this test was carried out. This test is intended to ascertain whether the learning media software's functionality is operational. The outcomes of the blackbox testing demonstrate that media functionality has a 100% success rate. Thus, it can be said that the media created can operate error-free and run smoothly.

The large group trial's pre- and post-test evaluation activities yielded an effectiveness analysis. The fifth grade students at PKBM Quins administered this test using their individual Android devices. It is known that in the pre-test results, there were three students with a maximum score of 78 who scored ≥75 based on the analysis of the pre- and post-test evaluation results. In contrast, 36 students with a maximum score of 100 were among the post-test results' students who scored ≥75. The value of numeracy literacy completeness must be determined by performing the following traditional calculation between the pre- and post-tests. Prior to utilizing interactive learning materials (pre-test), the percentage of numeracy literacy score completeness was 6.15%. Following the use of interactive learning materials, the percentage of complete numeracy literacy scores (post-test) is 79.8%. According to the calculations, students' classical pre-test and post-test scores for numeracy literacy are 7.14% and 73.8%, respectively.

Afterwards, the N-Gain Score test is used to determine the significance level. Based on the computed results, the N-Gain Score of 0.52 falls within the moderate criteria range of values, which is $0.3 \leq$ n-gain ≤ 0.7. According to the findings of Umbara and Nuraeni's research (2019), augmented reality learning media with asmbler edu is deemed feasible to use and succeeds in increasing the literacy of students. This indicates that there is an increase in students' numeracy literacy after using interactive learning media that has been developed in the moderate category. It's clear from the thorough explanation provided that learning media can significantly raise students' numeracy literacy.

5. **Evaluation**

Data from the trials is gathered for the evaluation stage, including validation from media and material experts as well as field practitioners, in order to make necessary modifications and follow up. Large group and small group trials are additional sources of information used in product evaluation in addition to specialists and field practitioners. The evaluation data's outcomes are used to decide which educational materials have been created and are suitable for use as supplementary resources when teaching geometry in mathematics classes.

CONCLUSION

The development of augmented reality (AR)-based learning media and assembler edu involves several stages. First, needs analysis identifies problems such as the lack of interactive learning materials and students' difficulties in understanding geometry. Next, media design is done by determining the format, creating storyboards, and flowcharts using assembler

applications. In the development stage, components such as materials, images, animations and music are combined into an interactive product. Implementation involves testing by material experts, media, and field practitioners as well as small and large group tests. Evaluation of data from the trials showed the media was effective in improving students' numeracy literacy and feasible to use as an additional learning resource. Subsequent investigations may concentrate on creating augmented reality educational resources for subjects other than geometry, like algebra or statistics, in order to expand the advantages of this format to diverse facets of the mathematics syllabus.

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.

CONFLICTS OF INTEREST

The author(s) declare no conflict of interest

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