Education Management in the Development of Contextual Problems Using Mobile Augmented Reality to Support Mechanical Engineering Students Creativity in Learning Mathematics

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There are still many mechanical engineering students who are passive in learning activities. The aim of this research is to create Mobile Augmented Reality to provide contextual problems to mechanical engineering students. So, students can imagine and be active in learning. The method used is 4D development (Define, Design, Develop, and Disseminate). Apart from that, it uses quantitative research to influence the use of mobile augmented reality. Next is qualitative research to analyze the use of mobile augmented reality. The conclusion of this research states that there is a significant influence on the activeness and creativity of mechanical engineering students after developing and using mobile augmented reality in mathematics learning activities.

Keywords: augmented reality, contextual problems, creative thinking

INTRODUCTION

At this time, educators have a great opportunity to involve their students in developing learning technology. This learning technology becomes a tool that allows participation in complex problem-solving tasks (Czerkawski & Berti, 2021). Solving problems, of course, requires an understanding of the problem itself. Therefore, it is necessary to have technology as a tool to help visualize things more realistically so that they are easier to understand.

Augmented reality allows humans to interact with 3D visual objects and physical objects around them. The ability to change two-dimensional images into three dimensions and visualize them more realistically is one of the factors that contribute to the ability to understand related problems (Nurhayati et al., 2019). So, understanding a problem becomes easier by visualizing it more realistically with the help of augmented reality. One, of the reasons for a person's inability to understand a problem well is the lack of real context in the problem. A person's inability to imagine and visualize problems is a factor in someone not being able to understand the problem well (Umam et al., 2017).

Technological developments have succeeded in making technology increasingly varied using computers, tablets, and mobile phones (Fatayan et al., 2023). Technology has provided extensive facilities and opportunities to help the interaction process in mathematics learning. The combination of augmented reality technology with mathematics learning creates a new application to increase the effectiveness and attractiveness of learning in real life. This technology allows three-dimensional virtual objects to be brought into the real world so students can directly interact with these objects (Fernández-López, 2022).

When students succeed in visualizing the problem, they will quickly understand the problem they are facing so that the problem can be solved well. Students can discover how contextual problems can be solved more entirely. Simplification of how to handle a problem is based on students' ability to integrate understanding of mathematical concepts well. Augmented reality tries to help align understanding and problem-solving abilities (Lee et al., 2021).

The existence of augmented technology can encourage students to interact more with problems. Student interest increases with the help of appropriate visualization. High student curiosity causes students' interest in seeing mathematical problems to be more natural and better (Tien & Namasivayam, 2023). Augmented reality is popular in education even though it is not a new technology. Augmented reality is a combination of learning media between print and computer technology (Bower et al., 2014). Augmented reality is an optical technology that combines virtual and real worlds in real time.

Visualization in technology plays a role in providing added value both from a cognitive and affective perspective. Augmented reality can facilitate and support the visualization of objects (Vilca et al., 2023). With augmented reality, the visualization can be seen more clearly so that students can understand the material better. Not only limited to imagining the material abstractly, students can also see the material being taught to be more concrete, and clear. Augmented reality has made understanding mathematical material and concepts easier (Visscher & White, 2020).

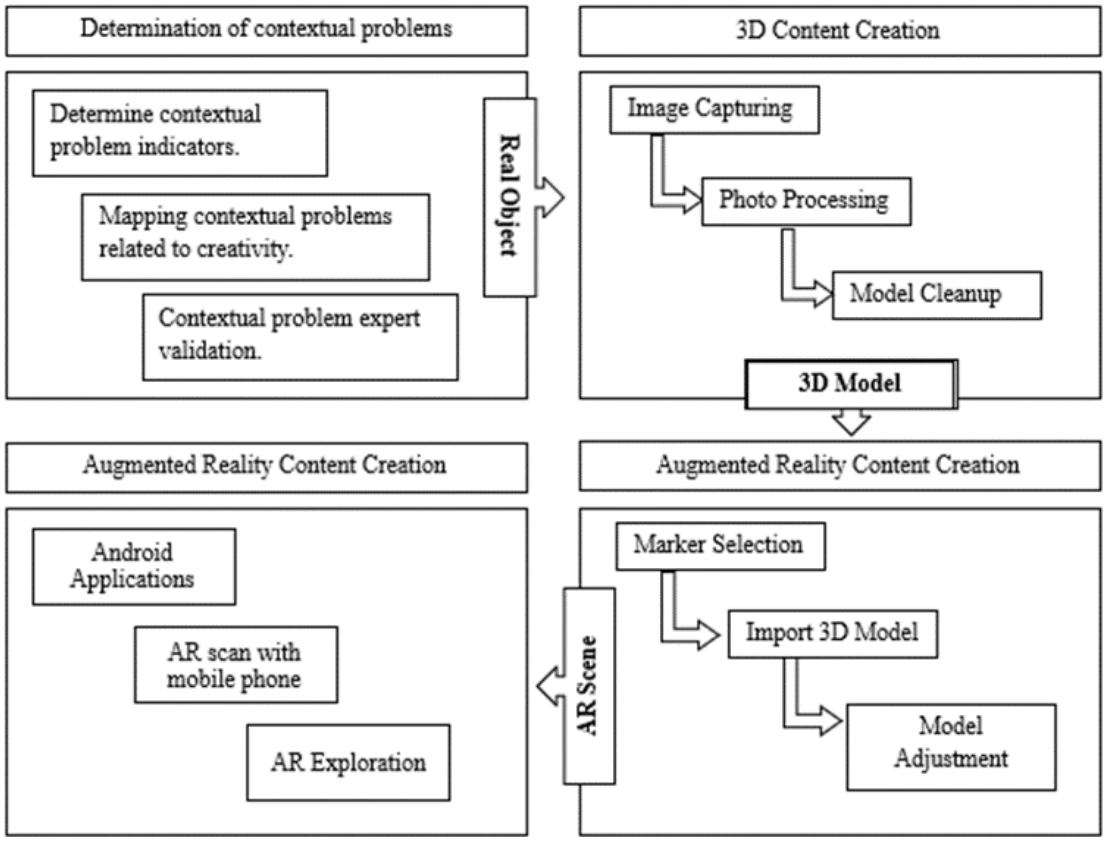
The visualization displayed in augmented technology provides space for someone to increase their opportunities to explore subject matter in more detail and absolute terms. Visualization in augmented reality can be displayed by rotating 360 degrees; in other words, the visualization can be seen from all sides. Augmented reality encourages students to be more active and productive in asking questions or discussing activities. They can argue according to the point of view displayed through augmented reality. Apart from being able to provide arguments, students can also find solutions to problems more independently. This fact proves that augmented reality encourages students to be more creative.

METHOD

Through the help of augmented technology, this research allows students to understand contextually based mathematical problems. This integration of mathematics with technology can be categorized as development research because it goes through various stages that must be passed, including expert testing and augmented technology-based problem development (Smit et al., 2022).

In the development stage of augmented reality, research adopted Borg research. The stages of augmented reality development have been carried out through four process stages: contextual problem determination, 3D Content Creation, AR Content Creation, and AR implementation.

FIGURE 1
STAGE OF DEVELOPMENT OF AUGMENTED REALITY IN MATHEMATICS LEARNING



Research Model

In this study, researchers used the research and development (R&D) method with the 4D development model (Define, Design, Develop, and Disseminate). This method was chosen to produce a technological product that is feasible and effective in improving learning in the Merdeka curriculum based on the Pancasila student profile strengthening project (P5). So, research and development are longitudinal; that is, research carried out in stages can be multi-year (Sugiyono 2017:297).

In this study, there were four stages: first, define the stages that define the contents of the product to be made. At this stage, it must adapt to the characteristics of the subject and elementary school students. Second, the design at this stage is carried out by designing the product to be made. Third, the development stage creates a product that several participants can test to determine whether the product is valid or appropriate for research. Fourth, disseminate the stages that researchers can use to obtain research results by disseminating the product they have created to participants.

RESULTS AND DISCUSSION

The research uses purposive sampling. Purposive sampling aims to ensure that subjects are directly involved in mathematics learning activities that use augmented reality. The sample for this research is students of the mechanical engineering study program in Geometry material using augmented reality. The demographics of research subjects can be explained as follows.

TABLE 1
DEMOGRAPHIC INFORMATION

Indicator		Frequency
Gender	Male	52
	Female	38
Age Range	12 – 13	23
	13 – 14	35
	Above 15	32
Mathematical Learning Achievement	Low	26
	Middle	35
	High	39

Data Collections and Instrument

Research data was obtained through various techniques, including interviews, surveys, questionnaires, and daily journals. Interviews were conducted with two students with good communication and two experts, a material expert and a learning media expert (Fatimah et al., 2019). After experiencing the mathematics learning process using augmented reality, surveys were given to students for at least six meeting sessions. The requirement of a minimum of 6 meeting sessions considers the more, aspects of experience students gain so that they can make a more practical contribution.

Analysis Data

Quantitative research data was obtained from the results of validation assessments by media experts, material experts, and student responses, which were filled in on distributed sheets. Qualitative data in the form of comments from students and experts is used as a data source to revise augmented reality developed to produce better development products. The measurement instrument for this research uses a Likert scale to measure the extent of expert and student opinions regarding the augmented that has been developed, which can be seen in Table 1. as follows.

TABLE 2
LIKERT SCALE FOR ASSESSMENT

Category	Related Score	How to relate the average score (X) to the given category
Very Good	5	$X > 4.21$
Good	4	$3.40 < X \leq 4.21$
Acceptable	3	$2.60 < X \leq 3.40$
Poor/less valid	2	$1.79 < X \leq 2.60$
Very poor/Invalid	1	$X \leq 1.79$

By using the research categories specified in Table 2. Data recapitulation can be categorized more specifically. After development, the application was tested on mechanical engineering study program students. Then, the trial results will be measured statistically through pre-test, post-test, and t-test, considering the students' mathematical creative aspects.

DISCUSSION

In this research, the 4D (Define, Design, Develop, and Disseminate) concept is used as a stage in developing augmented reality applications based on contextual problems. There is an 4D development

process, which consists of 4 stages: Define, Design, Development, and Disseminate (Czerkawski & Berti, 2021). An explanation of the four stages of development will be explained as follows.

Define

At the analysis stage, researchers analyzed based on several aspects such as environmental aspects, curriculum aspects, and aspects of material difficulties faced by students. The data analysis shows that in developing mathematics materials, students experienced obstacles in simulating natural forms in campus learning (Duma et al., 2023). Students need an actual display so that students can adapt quickly to the context of the problem. When carrying out learning, students need contextual problems, making it easier for them to carry out simulations related to mathematics learning material.

Design

The results of the analysis carried out by the research team regarding learning objectives, student difficulties, and the difficulty of mathematics learning material were used as the primary basis for carrying out the design stage (Visscher & White, 2020). The analysis results show that students' difficulties in simulating mathematics learning material can be solved by implementing augmented reality so that students can easily simulate problems more realistically (Maarif et al., 2022). This design stage consists of determining learning objectives, determining contextual problems that will be used, and designing the application of augmented reality to contextual problems and assessments to evaluate student abilities.

Development

In the augmented reality development stage, the research team adjusted the interface stages used by students. The team adjusts the design by adjusting it during the development stages. The team included an Assemblr EDU link and an interactive quiz by adding 3600 rotations, and several evaluations were applied to assessing students' abilities and understanding in augmented reality development (Naseem et al., 2022). Before carrying out the development stages, the research team asked for help from media and mathematics learning materials experts to evaluate three aspects: college students' interface, interactive learning, and practical practices.

Experts explain that developing learning applications requires views from media experts and mathematics material experts so that the applications developed are better and more effective when used. Experts' validated applications will then be tested on a small scale. The results of student responses will be taken into consideration for carrying out development revisions. The data shows the following results.

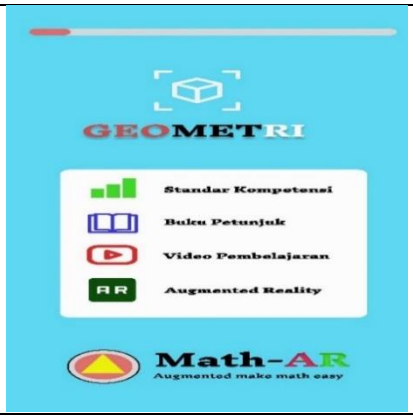
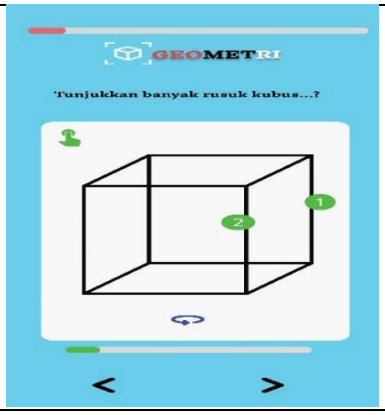
TABLE 3
STUDENTS RESPONSES ON 3 ASPECTS

Statement	Average Score of Trial Class	
	Small Class	Large Class
Students' Interface Aspects		
The application is easy to interact with.	4.5	4.5
The app encourages me to interact with friends.	4.5	4.5
I want to repeat it.	4.5	4.5
Average Score of Students' Interface Aspects	13.5	13.5
Learning Interactive Aspects		
I can learn more interactively.	4.5	4.5
Learning materials are more interactive.	4.5	4.5
The quiz is more interactive.	4.5	4.5
Average Score of Learning Interactive Aspects	13.5	13.5

Statement	Average Score of Trial Class	
	Small Class	Large Class
Effectiveness Aspects		
The material provided is easy to understand.	4.5	4.5
Students are motivated to learn.	4.5	4.5
Quizzes and exams are more effective.	4.5	4.5
Average Score of Practical Practices Aspects	13.5	13.5
Students' Interface Aspects		

Data on the interactive aspect tends to be low, so researchers improve the interaction aspect by providing more interactive quizzes by developing a click feature on the aspect being tested. The addition of this feature allows students to have more interaction with the understanding being measured. The results of this development show quite significant results from student responses, the majority of which strongly agree. Interface design developed in augmented reality-based mathematics learning on contextual problems.

FIGURE 2
EXAMPLE OF AN IMAGE WITH MOBILE AUGMENTED REALITY

<table>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Menu</td><td>Mathematical Content</td></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Augmented Reality</td><td>Quiz Developed</td></tr>
</table>

Data on the interactive aspect tends to be low, so researchers improve the interaction aspect by providing more interactive quizzes and developing a click feature on the tested aspect. Adding this feature allows students to interact more with the understanding being measured. The results of this development show significant results from student responses, most of which strongly agree. Interface design developed in augmented reality-based mathematics learning on contextual problems.

Disseminate

In implementing learning with augmented reality, students feel delighted with the assistance of technology. The existence of augmented reality mathematics learning for mechanical engineering study program students becomes more natural and easier to imagine in the way students think. When learning mathematics using augmented reality, students majoring in mechanical engineering felt delighted because they could find a way to solve a problem contextually (Toheri et al., 2020). The results of this implementation process can be seen from the results of the pre-test, post-test, and t-test in the following table.

TABLE 4
PRE-TEST, POST-TEST, AND T-TEST

Class	n	Pre-test	Post-test	T-test
Class A	45	M= 59.828, SD= 7.06	M=75.069, SD= 7.19	t= 1.67, p < 19.17
Class B	46	M= 72.069, SD= 9.58	M=83.103, SD= 10.48	t= 1.67, p < 35.54
Class C	42	M= 51.882, SD= 6.15	M= 60.165, SD= 6.25	t= 1.67, p < 9.35

Analysis of the data in the table shows that all schools A, B, and C have relatively similar abilities with slight differences in scores in the pre-test scores. This shows that there are similar characteristics between the three schools. After receiving adequate treatment with augmented reality, the post-test scores showed statistical significance between schools A and B. However, there was no significance between schools A and C, which were treated with augmented reality. The t-test shows statistically that there is a statistical difference between the before and after tests with the three classes with Cronch Alpha.

Based on the results of the evaluation that has been carried out, two things need to be corrected. First, the interaction between students and teachers is less attractive because they only get one worksheet, so students feel they are not privileged to study in groups. This may be anticipated by providing sufficient worksheets and technology to serve augmented learning more specific to student needs (Estrada et al., 2022).

CONCLUSION

The Augmented technology that has been developed has succeeded in supporting students majoring in mechanical engineering to become more creative in learning mathematics and solving real problems. Students can easily understand the problem better and re-visualize the problem with a version of the student's imagination. This encourages students to find more straightforward solutions to mathematical problems.

This ability to simplify a problem solution can encourage students to be able to find more than one way to solve it. This shows that the augmented reality that has been developed has succeeded in developing students' mathematical creativity as a whole. These results are supported by statistical data contained in data analysis.

Research on augmented reality needs to be developed with various models that can be visualized more realistically. Future research needs to pay attention to how the mathematics learning process integrated with Augmented reality requires more adequate learning instruments so that the structure of mathematics learning becomes more focused.

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