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Mobile-Based Realistic Mathematics Learning Design to Improve Students' Reasoning Ability and Problem-Solving Ability

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Abstract

Mathematical reasoning and problem-solving skills have become a very necessary need at this time. Students who do not have mathematical reasoning and problem-solving skills will have difficulty adapting to current technological advances. The purpose of this study is to design mobile-based mathematics learning to improve students' mathematical reasoning and problem-solving skills. The subjects of this study were junior high school students. The research method developed was ADDIE (Analysis, Design, Development, Implementation, Evaluation). The results of the study showed that improving students' mathematical reasoning skills had a very positive impact on students' mathematical problem-solving skills. These results provide additional contributions and references for mathematics teachers who want to add knowledge related to improving the quality of mathematics learning in the classroom.

Keywords

Mobile Learning, Mathematical Reasoning, Mathematical Problem Solving

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MOBILE-BASED REALISTIC MATHEMATICS LEARNING DESIGN TO IMPROVE STUDENTS' REASONING ABILITY AND PROBLEM-SOLVING ABILITY

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Abstract

Mathematical reasoning and problem-solving skills have become a very necessary need at this time. Students who do not have mathematical reasoning and problem-solving skills will have difficulty adapting to current technological advances. The purpose of this study is to design mobile-based mathematics learning to improve students' mathematical reasoning and problem-solving skills. The subjects of this study were junior high school students. The research method developed was ADDIE (Analysis, Design, Development, Implementation, Evaluation). The results of the study showed that improving students' mathematical reasoning skills had a very positive impact on students' mathematical problem-solving skills. These results provide additional contributions and references for mathematics teachers who want to add knowledge related to improving the quality of mathematics learning in the classroom.

Keywords: Mobile Learning, Mathematical Reasoning, Mathematical Problem Solving

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INTRODUCTION

The rapid development of mobile-based technology has now become an inseparable part of the mathematics learning process in the classroom. Teachers use many mobile-based applications in the mathematics learning process (Ferdiani et al., 2021; Luluk, 2019). This is a form of effort presented by teachers to support the creation of higher quality mathematics learning. Teachers always try to present an innovation by integrating mobile-based mathematics learning and the ability to teach students face-to-face at the same time (Alifah & Utami, 2022; Boekaerts et al., 1995). Realistic mobile-based mathematics learning allows students to access all material information and explanations more flexibly and interactively (Anne & Mangulabnan, 2013; Susanti & Hartono, 2019). Therefore, this study has a very important position in understanding how this mobile-based mathematics learning design can have a positive impact on the development of students' abilities. Although the use of mobile technology has been widely discussed, its application in the context of realistic mathematics learning that focuses on problem-solving and mathematical reasoning skills of junior high school students has not been widely studied. Facts on the ground show that many junior high school students still have difficulty in understanding mathematical concepts more comprehensively and tend to be less skilled in applying their knowledge to solve real problems (Arsyad & Irawati, 2016; Dooren et al., 2013; Hadi & Rulviana, 2018). This shows the need for a more interactive and adaptive realistic mathematics learning method, which can provide opportunities for students to explore mathematical concepts that can be applied to help solve real problems (Barbieri & Booth, 2020; Yi & Na, 2020). The

main challenge is how this research can design an effective and fun mobile platform to help students improve their mathematical reasoning and problem-solving skills (Ferdiani et al., 2021; Nyroos et al., 2015). This study aims to design and develop a mobile-based mathematics learning model that can improve students' mathematical reasoning and problem-solving abilities (Barbieri & Booth, 2020; Ndiung et al., 2021; Purwanto, 2020). Before the platform design is made, this study needs to understand the needs and various obstacles faced by students in realistic mathematics learning. A good understanding of the needs of students and teachers will greatly assist researchers in the process of developing this mobile-based mathematics learning. This study also needs to understand the technical obstacles that are often encountered by students in learning independently or in groups. With an in-depth analysis of the needs and technical obstacles faced, it is hoped that the development of mobile-based realistic mathematics learning can provide many opportunities for students to learn more interactively and independently so that they are able to understand mathematical concepts more deeply and applicative.

RESEARCH METHOD

This study chose a development design with the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model (Mamolo, 2019). The analysis begins with the needs of students, teachers, mathematical problem-solving abilities, and students' mathematical reasoning abilities. The next stage is designing which describes the stages of developing realistic mathematics learning that will be developed. The design is adjusted to the needs analysis and research objectives that have been set to improve students' mathematical reasoning and problem-solving abilities. The development stage is carried out by changing the front end of the figma application that has been created so that it can display something more realistic. The implementation stage is carried out together with teachers in the experimental class using the application that has been developed. The evaluation stage is an important element in the process of developing realistic mathematics learning where the use of the application is evaluated in terms of substance and application.

This research was conducted in the odd semester of 2023-2024 in 3 high schools. Each school has 6 classes, 3 of which are experimental classes and 3 control classes. The number of students consists of 214 people, of which there are 45 female students and 157 male students. The analysis of the research data will be explained in detail with the stages of ADDIE development, namely analysis, design, development, implementation, and evaluation. The stages of data analysis of mathematical reasoning and problem-solving abilities use a rubric that has been validated by experts in Mathematics Education and Technology Education. Experts will be asked to give a value with a range between 1 and 5 for each aspect assessed. The combined value between experts will be averaged including not feasible

(average <4.0), feasible (4.0 average value 4.5, and very feasible (average value > 4.5).

To evaluate the impact on mathematical reasoning and problem-solving abilities, two t-tests were conducted where the first t-test was to measure students' mathematical reasoning abilities and the second t-test was to measure students' mathematical problem-solving abilities.

RESULTS AND DISCUSSION

Analysis

The analysis stage begins by identifying two aspects, namely the aspect of student needs and the aspect of the material to be taught. The aspect of student needs begins by identifying what students want so that the realistic mathematics learning process becomes more enjoyable and of higher quality (Bintoro et al., 2021; Ferdiani et al., 2021). In collecting this analysis, researchers conducted semi-structured interviews to be able to explore the conditions that students actually want to get in the learning process. This semi-structured interview makes it easier for researchers to dig up all information from students more comprehensively, making it easier to design learning that is suitable for students. Based on the results of the interview, several things were obtained, including students wanting active interaction between teachers and students. The interaction between teachers and students is built through a more conducive learning environment process by building students' self-confidence and motivation to learn. In addition, students have a desire to have the motivation to be able to solve different mathematical problems because the majority of students feel that the problems given are not the same as those taught. This reflects the need for students to improve their mathematical reasoning and problem-solving abilities. After identifying the interview results, the researcher then compiled the stages that he wanted to build in achieving the main objectives of realistic mathematics learning in this context, namely improving mathematical reasoning skills and mathematical problem-solving skills. The researcher started by using indicators of students' mathematical reasoning skills, namely submitting hypotheses, manipulating mathematics, compiling evidence equipped with logical reasons, and concluding problems. Problem-solving skills were compiled using Polya indicators, namely understanding the problem, planning problem solving, solving problems, and reviewing the results of the work that had been obtained. The researcher tried to elaborate on problem-solving skills and mathematical reasoning skills by compiling the stages of the learning process. The researcher started by looking for life problems that were very close to students but related to the material to be taught. This problem-collecting stage is a very fundamental aspect because it is the entry point in compiling the desired learning process (Alim et al., 2016; Pramoda Wardhani & Oktiningrum, 2022). All the problems that have been collected are then modified according to the needs to be achieved while still paying attention to the indicators that have been set. The modified math problems were

then read by several teachers and practitioners to provide input so that they could be used more effectively and efficiently.

Design

The analysis results are used to design mobile-based learning. The analysis results greatly help the design team to translate the learning stages into more real and appropriate ones. In designing, there are 3 stages carried out by the research team, including the readability of the analysis results, the platform design on figma, and the revision of the design results. At the readability stage, the analysis results begin by reading carefully and understanding all stages of the learning process that will be included in the platform. The design team is given 1 week to read aspects that need confirmation and those that need further explanation. The readability of the learning design is very important because the design will adjust and improve the quality of interaction through figma. After getting the same understanding between the designer and the research team. The design team begins by determining the color of the plate used so that all stages of the design use the appropriate collaboration color. This is very important considering that color has a significant impact on building students' moods to learn. A well-designed application design will make a positive contribution to the quality of learning and student satisfaction. The design uses figma to make it easier for developers to implement it into code. In providing a sufficient overview, researchers have prepared various examples of mathematics learning designs.

Development

The development of a mobile-based platform begins with determining the color of the plate to be used in the development. The figma design is then converted into codes to be developed into an application. In this development, researchers also integrated short videos, pre-test and post-test value analysis. After this application has functioned well, researchers do not immediately provide it to students and teachers in the mathematics learning process.

Table 1 Hasil Validasi Media

No	Aspects	Average Values	Kriteria
1	Device Engineering	4,66	Very Worthy
2	Visual Display	4,78	Very Worthy

The assessment of media experts illustrates that the development of realistic mathematics learning meets the minimum criteria standards set. The ease of the realistic mathematics learning process with this application is expected to meet the research needs used in improving students' mathematical reasoning and problem-solving abilities.

Table 2 Validasi Pakar Matematika

No	Aspect	Average Values	Criteria
1	Learning Design	4,31	Worthy

2	Software engineering	4,57	Very Worthy
3	Visual Display	4,58	Very Worthy
4	Functions for mathematical reasoning and mathematical problem-solving abilities	4,55	Very Worthy

Mathematics education experts provide quite significant input in learning design by changing several learning steps. Experts ask for learning design to be given short videos that can invite students to improve their mathematical reasoning and problem-solving abilities. Meanwhile, technology learning media experts provide suggestions related to the ease of interaction between students by adding the joined feature. The advice from these experts provides quite significant input in helping the process of developing mobile-based mathematics learning.

Implementation

In the implementation of this research, it received a very good response from teachers and students. This development succeeded in inviting students to consciously improve their problem-solving and mathematical reasoning skills simultaneously. Learning becomes more active, and many activities encourage students to think deeper so that the existence of teachers in the classroom changes into facilitators who facilitate students in the process of learning mathematics.

In measuring the extent of the impact that can be given by the results of this development. Implementation of learning in the classroom is carried out by measuring the extent to which students can improve their mathematical reasoning skills. Many experimental classes increased significantly as can be seen in table 3 below.

Table 3 Results of T-Test Scores for Mathematical Reasoning Ability

Class	Students Number	Average	Sig.	Keterangan
Eksperimen	85	88,56	0,0025	Sig. < 0,05
Kontrol	85	72,25		

The results of mathematics learning on mathematical problem solving abilities also increased significantly, which can be seen in the following table.

Table 4 Results of T-Test Scores for Mathematical Problem Solving Ability

Class	Students Number	Average	Sig.	Keterangan
Eksperimen	85	88,45	0,0045	Sig. < 0,05
Kontrol	85	73,25		

Respons guru dalam pembelajaran yang memfokuskan pada kemampuan penalaran matematis dan kemampuan pemecahan masalah matematis. Respons positif guru dalam kemudahan penggunaan aplikasi sangat bermanfaat.

Evaluation

In evaluating the extent of the positive impact given to mathematics learning in the classroom. Evaluation is measured by considering the assessment aspect, and the survey aspect. The assessment aspect will provide a comprehensive picture of students' mathematical reasoning and problem-solving abilities (Luluk, 2019; Purwanto, 2020; Son et al., 2020). Students in the experimental class were very enthusiastic about undergoing mathematics learning in the classroom. This student enthusiasm is also reflected in the value data obtained by students.

Meanwhile, in the process of satisfaction obtained by students in mathematics learning, it will measure with a standard between very unsatisfactory and very satisfying. The majority of students gave very positive responses to mobile-based mathematics learning. This is also in line with several studies that have made a positive contribution to the mobile-based learning process. The shift in students' lives that is very close to cellphones changes students' perspectives in the learning process.

CONCLUSION

Mathematics learning design that is designed and considered in all stages will provide a very positive contribution in improving students' mathematical reasoning and problem solving abilities. This learning design is able to encourage students to be more active in learning in groups so that there is an equalization of students' reasoning with each other. Students' activeness in group discussions is seen when students make hypotheses supported by students' ability to provide logical reasons for their statements. Each student gives an opinion and strengthens points that have similarities. In the discussion, the entire group concludes the solution to the problem supported by appropriate mathematical concepts. This shows that students' mathematical reasoning abilities have increased. In solving problems, students are seen to be able to manage all information that can be used to solve problems. Students learn to make plans as well as submit hypotheses from problem solving. Students freely and actively provide responses to other students' statements by providing logical and mathematical reasons. The interaction in this learning process illustrates how students are able to improve their mathematical problem solving and mathematical reasoning abilities. The students' hypothesis supported by the right information provides reinforcement to the fact that students' problem solving, and mathematical reasoning have improved.

The limitations of time and materials delivered with this learning design are a challenge for future research. Future research also needs to design mobile-based mathematics learning in other mathematics materials. The success of this mobile-based learning process allows it to contribute to other materials. Further research also needs to consider the use of a wider range of students in order to test the effectiveness of this mobile-based learning design.



Mobile-Based Realistic Mathematics Learning Design to Improve Students' Reasoning Ability and Problem-Solving Ability

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Keywords: Mobile Learning, Mathematical Reasoning, Mathematical Problem Solving

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design a practical and fun mobile platform to help students improve their mathematical reasoning and problem-solving skills (Ferdiani et al., 2021; Nyroos et al., 2015). This study aims to design and develop a mobile-based mathematics learning model to improve students' mathematical reasoning and problem-solving abilities (Barbieri & Booth, 2020; Ndiung et al., 2021; Purwanto, 2020). Before the platform design, this study must understand students' needs and obstacles in realistic mathematics learning. A good understanding of the needs of students and teachers will greatly assist researchers in developing this mobile-based mathematics learning. This study also needs to understand the technical obstacles often encountered by students when learning independently or in groups. With an in-depth analysis of the needs and technical obstacles faced, it is hoped that the development of mobile-based realistic mathematics learning can provide many opportunities for students to learn more interactively and independently to understand mathematical concepts more profoundly and applicatively.

METHODS

This study chose a development design with the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model (Mamolo, 2019). The analysis begins with the needs of students, teachers, mathematical problem-solving abilities, and students' mathematical reasoning abilities. The next stage is designing, which describes the stages of developing realistic mathematics learning that will be created. The design is adjusted to the needs analysis and research objectives to improve students' mathematical reasoning and problem-solving abilities. The development stage is carried out by changing the front end of the Figma application that has been created so that it can display something more realistic. The implementation stage is carried out together with teachers in the experimental class using the application that has been developed. The evaluation stage is an essential element in developing realistic mathematics learning, where the use of the application is evaluated in terms of substance and application.

This research was conducted in the odd semester of 2023-2024 in 3 high schools. Each school has six classes, 3 of which are experimental and three control classes. The number of students consists of 214 people, of which there are 45 female students and 157 male students. The research data analysis will be explained in detail in terms of the stages of ADDIE development: analysis, design, development, implementation, and evaluation. The stages of data analysis of mathematical reasoning and problem-solving abilities use a rubric that experts in Mathematics Education and Technology Education have validated. Experts will be asked to give a value ranging between 1 and 5 for each aspect assessed. The combined value between experts will be averaged, including not feasible (average <4.0), feasible (4.0 average value 4.5, and very feasible (average value > 4.5).

Two t-tests were conducted to evaluate the impact on mathematical reasoning and problem-solving abilities. The first test measured students' mathematical reasoning abilities and the second measured students' mathematical problem-solving abilities.

RESULTS & DISCUSSION

Analysis

The analysis stage begins by identifying two aspects, namely, the aspect of student needs and the aspect of the material to be taught. Students' needs start by identifying what they want to make the realistic mathematics learning process more enjoyable and of higher

quality (Bintoro et al., 2021; Ferdiani et al., 2021). In collecting this analysis, researchers conducted semi-structured interviews to explore the conditions students want in the learning process. This semi-structured interview makes it easier for researchers to dig up all information from students more comprehensively, making it easier to design learning suitable for students. Based on the interview results, several things were obtained, including students wanting active interaction between teachers and students. The interaction between teachers and students is built through a more conducive learning environment by building students' self-confidence and motivation to learn. In addition, students desire to be motivated to solve different mathematical problems because most students feel that the given issues are not the same as those taught. This reflects the need for students to improve their mathematical reasoning and problem-solving abilities. After identifying the interview results, the researcher compiled the stages he wanted to build to achieve the main objectives of realistic mathematics learning in this context, namely improving mathematical reasoning and problem-solving skills. The researcher started by using indicators of students' mathematical reasoning skills, namely submitting hypotheses, manipulating mathematics, compiling evidence equipped with logical reasons, and concluding problems. Problem-solving skills were compiled using Polya indicators, namely understanding the problem, planning problem-solving, solving problems, and reviewing the results of the work that had been obtained. The researcher tried to elaborate on problem-solving and mathematical reasoning skills by compiling the stages of the learning process. The researcher started by looking for life problems that were very close to students but related to the material to be taught. This problem-collecting stage is fundamental because it is the entry point in compiling the desired learning process (Alim et al., 2016; Pramoda Wardhani & Oktiningrum, 2022). All the problems collected are then modified according to the needs to be achieved while still paying attention to the indicators that have been set. Several teachers and practitioners then read the modified math problems to provide input to be used more effectively and efficiently.

Design

The analysis results are used to design mobile-based learning. The analysis results greatly help the design team translate the learning stages into more real and appropriate ones. In design, the research team has three stages, including the readability of the analysis results, the platform design on Figma, and the revision of the design results. At the readability stage, the analysis results begin by reading carefully and understanding all stages of the learning process that will be included in the platform. The design team is given 1 week to read aspects that need confirmation and those that need further explanation. The readability of the learning design is essential because the design will adjust and improve the quality of interaction through Figma after getting the same understanding between the designer and the research team. The design team begins by determining the plate color used so that all design stages use the appropriate collaboration color. This is very important, considering that color significantly impacts building students' moods to learn. A well-designed application design will positively contribute to the quality of learning and student satisfaction. The design uses Figma to make it easier for developers to implement it in the code. Researchers have prepared various examples of mathematics learning designs to provide a sufficient overview.

Development

The development of a mobile-based platform begins with determining the color of the plate to be used. The Figma design is then converted into codes to be developed into an

application. Researchers also integrated short videos and pre-test and post-test value analysis in this development. After this application has functioned well, researchers do not immediately provide it to students and teachers in the mathematics learning process.

Table 1. Media validation results

No	Aspects	Average Values	Criteria
1	Device Engineering	4,66	Very Worthy
2	Visual Display	4,78	Very Worthy

The assessment of media experts illustrates that the development of realistic mathematics learning meets the minimum criteria standards set. This application's ease of the realistic mathematics learning process is expected to meet the research needs to improve students' mathematical reasoning and problem-solving abilities.

Table 2. Validation of mathematicians

No	Aspect	Average Values	Criteria
1	Learning Design	4,31	Worthy
2	Software engineering	4,57	Very Worthy
3	Visual Display	4,58	Very Worthy
4	Functions for mathematical reasoning and mathematical problem-solving abilities	4,55	Very Worthy

Mathematics education experts provide significant input in learning design by changing several learning steps. Experts ask that learning design be given short videos inviting students to improve their mathematical reasoning and problem-solving abilities. Meanwhile, technology learning media experts provide suggestions for the ease of student interaction by adding the joined feature. These experts' advice provides significant input in helping the development of mobile-based mathematics learning.

Implementation

In implementing this research, I received an excellent response from teachers and students. This development invited students to consciously improve their problem-solving and mathematical reasoning skills simultaneously. Learning becomes more active, and many activities encourage students to think deeper so that the existence of teachers in the classroom changes into facilitators who facilitate students in the process of learning mathematics.

In measuring the extent of the impact this development's results can have. Implementation of learning in the classroom is carried out by measuring the extent to which students can improve their mathematical reasoning skills. Many experimental classes increased significantly, as shown in Table 3 below.

Table 3 Results of T-Test Scores for Mathematical Reasoning Ability

Class	Students Number	Average	Sig.	Keterangan
Eksperiment	85	88,56	0,0025	Sig. < 0,05
Control	85	72,25		

The results of mathematics learning on mathematical problem-solving abilities also increased significantly, as seen in the table 4.

Table 4 Results of T-Test Scores for Mathematical Problem-Solving Ability

Class	Students Number	Average	Sig.	Keterangan
Eksperiment	85	88,45	0,0045	Sig. < 0,05
Control	85	73,25		

Teachers' responses in learning that focus on mathematical reasoning and problem-solving skills are very beneficial. Teachers' positive response to the application's ease of use is also constructive.

Evaluation

Evaluating the extent of the positive impact of mathematics learning in the classroom is measured by considering the assessment and survey aspects. The assessment will provide a comprehensive picture of students' mathematical reasoning and problem-solving abilities (Luluk, 2019; Purwanto, 2020; Son et al., 2020). Students in the experimental class were very enthusiastic about undergoing mathematics learning in the classroom. This student enthusiasm is also reflected in the value data obtained by students.

Meanwhile, student satisfaction in mathematics learning will be measured with a standard between very unsatisfactory and very satisfying. The majority of students gave very positive responses to mobile-based mathematics learning. This also aligns with several studies that have positively contributed to the mobile-based learning process. The shift in students' lives, which are very close to cell phones, has changed students' perspectives on learning.

CONCLUSION

Mathematics learning design that is designed and considered in all stages will improve students' mathematical reasoning and problem-solving abilities. This learning design encourages students to be more active in learning in groups to equalize students' reasoning with each other. Students' activeness in group discussions is seen when students make hypotheses supported by students' ability to provide logical reasons for their statements. Each student gives an opinion and strengthens points that have similarities. In the discussion, the entire group concludes the solution to the problem supported by appropriate mathematical concepts. This shows that students' mathematical reasoning abilities have increased. In solving problems, students are seen to be able to manage all information that can be used to solve problems. Students learn to make plans and submit hypotheses through problem-solving. Students freely and actively respond to other students' statements by providing logical and mathematical reasons. The interaction in this learning process illustrates how students can improve their mathematical problem-solving and reasoning abilities. The student's hypothesis, supported by the correct information, reinforces that students' problem-solving and mathematical reasoning have improved—the limitations of time and materials delivered with this learning design challenge future research. Future research must also design this mobile-based mathematics learning in other mathematics materials. The success of this mobile-based learning process allows it to contribute to other materials. Further research also needs to consider using a more comprehensive range of students to test the effectiveness of this mobile-based learning design.

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