24 (4), 2023, 890-900

Jurnal Pendidikan MIPA

e-ISSN: 2685-5488 | p-ISSN: 1411-2531

http://jurnal.fkip.unila.ac.id/index.php/jpmipa/

Development of STEM -Based Learning Media using Android Platform to Improve Students' Problem Solving Abilities

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Abstract: This research aims to develop Android-based learning media using a STEM approach to enhance students' problem-solving abilities. The learning media was developed using the 4D model and tested on 192 eighth-grade students from six junior high schools in Yogyakarta. The research results indicate that the developed learning media fulfills aspects of validity, practicality, and effectiveness. Validity was confirmed through assessments by subject matter experts and media experts, scoring 82 and 73.5, respectively, falling into the categories of very good and good. Practicality was established through small-scale and large-scale tests, scoring 80.27 and 76.34, respectively, categorized as good in both instances. Effectiveness was determined through effectiveness tests, including one-sample t-test and mean different test. The one-sample t-test results indicated an improvement in students' problem-solving abilities with an average increase of 21.2769 in the control class and 42.5423 in the experimental class. The conclusion drawn from this research is that Android-based learning media using a STEM approach is effective in enhancing students' problem-solving abilities.

Keywords: learning media, STEM, mobile application.

Abstrak: *Penelitian ini bertujuan untuk mengembangkan media pembelajaran berbasis android dengan pendekatan STEM untuk meningkatkan kemampuan pemecahan masalah siswa. Media pembelajaran dikembangkan dengan model 4D untuk diuji coba kepada 192 siswa kelas 8 dari 6 SMP di Yogyakarta. Hasil dari penelitian menunjukkan bahwa media pembelajaran yang dibuat memenuhi aspek valid, praktis, dan efektif. Aspek valid diperoleh melalui penilaian ahli materi dan ahli media dengan nilai 82 dan 73,5 serta masuk pada kategori sangat baik dan baik. Aspek praktis diperoleh melalui uji skala kecil dan uji skala besar dengan nilai 80,27 dan 76,34 serta masuk kategori baik dan baik. Aspek efektif diperoleh melalui uji efektivitas yang meliputi one sample t-test dan mean different test. Berdasarkan one sample t-test diperoleh hasil bahwa terdapat peningkatan kemampuan pemecahan masalah siswa dengan peningkatan rata-rata sebesar 21,2769 pada kelas control dan 42,5423 pada kelas eksperimen. Kesimpulan dari penelitian ini adalah media pembelajaran berbasis android dengan pendekatan STEM efektif untuk meningkatkan kemampuan pemecahan masalah siswa.*

Kata kunci: *android, media pembelajaran, STEM, 4D.*

▪ INTRODUCTION

Mathematics learning today is experiencing quite significant developments and is evolutionary, accumulative and continuous. In the past period, mathematics learning activities were carried out conventionally and did not prioritize collaboration with other scientific disciplines. Ideal mathematics learning should be supported by various scientific disciplines so that it can solve everyday problems both formally and contextually (Simanjuntak, Simangunsong, Tiofanny, & Naibaho, 2021). This support can be realized through a STEM approach which has the characteristics and goals of collaboration with several scientific disciplines and focuses on designing solutions to

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DOI: http://dx.doi.org/10.23960/jpmipa/v24i4.pp890-900
Received: 14 November 2023
Accepted: 25 December 2023
Published: 27 December 2023

problems that occur in everyday life. Apart from that, the STEM approach is also a step to guide science by combining several strategies that provide cross-sector learning (Anwari, et al., 2015). The STEM approach is here to help students learn mathematics so that students can focus more on the process of discovery rather than the final result. Through STEM, students learn to solve problems, become innovators, creators and collaborators because these conditions are very much needed in facing the challenges of an increasingly complex era (Gustiani, Widodo, & Suwarma, 2017).

One form of STEM implementation that can be applied to junior high school mathematics learning is learning activities with the help of learning media. At this time, the learning media used is no longer presented in physical form, but is developed in the form of Android-based software. Developing technology contains many breakthroughs, one of which is in learning activities with the aim of helping teachers teach and students learn more flexibly (Astra, Nasbey, & Nugraha, 2015; Chinetha, Joann, & Shalini, 2015). This Android-based learning media was developed using a 4D model by Thiagarajan with the syntax Define, Design, Development, Dissemination. The Define stage is the process of determining the material that will be used, the learning problems that will be solved, and the students' abilities that will be measured through the media created. The Design stage is the process of designing Android-based learning materials using a STEM approach, designing a plan for learning activities to be carried out, and designing a learning media prototype. The Development Stage is the process of developing the product, expert validation testing, and small and large group trials. The Dissemination stage is the process of disseminating the learning media created. This dissemination is carried out during learning activities (Hudha, Aji, & Huda, 2018; Pardimin & Widodo, 2017)

The learning media developed based on Android with a STEM approach aims to increase student learning activities and make it easier for students to understand the mathematics material provided, and train students to achieve optimal learning outcomes (Verawati, Agustito, Pusporini, Utami, & Widodo, 2022). The material presented through this learning media is Pythagorean material presented in the form of contextual problems. The purpose of presenting contextual problems is so that students can read and analyze problems so they can find the right solution (Angraini, Stephani, & Ain, 2021). This research aims to develop Android-based learning media products with a STEM approach so that they can help students improve their mathematical problem solving abilities in terms of valid, practical and effective aspects.

▪ METHOD

Participants

This research was conducted at 6 private junior high schools in Yogyakarta taken from 13 existing private junior high schools. The selection of schools is carried out randomly using a lottery system. The subjects of this research were 192 grade 8 students at the school. Based on the results of the lottery, the sample of schools used in the research was Kanisius Gayam Middle School, Kanisius Pakem Middle School, Joannes Bosco Middle School, Maria Immaculata Marsudirini Middle School, Stella Duce 2 Middle School, and Pangudi Luhur 1 Middle School.

Research Design and Procedures

This research is development research with stages carried out including: Preliminary study in the form of field observations and teacher interviews to decide on using appropriate materials, Creation of Android-based learning media using a STEM approach. Making this learning media requires the iSpring Suite software application to create learning media and website2apk to transform learning media in Android form, Material validation tests and product validation tests for validators. Mathematics teachers at each school become material expert validators in order to obtain agreement in accordance with the research objectives and learning objectives to be achieved. Apart from that, there are colleagues who are experts in the field of learning media who are appointed as media expert validators as expert judgment in carrying out the assessment. Small-scale trials and large-scale trials on students as research subjects were also carried out in order to obtain optimal results, Implementation of learning media in classroom learning activities during 3 meetings with a pretest given beforehand and a posttest afterward.

The development research design was carried out using the 4D model which emphasizes a comprehensive development cycle approach, starting from identifying needs to implementing and using learning materials (Thiagarajan, Semmel, & Semmel, 1974). Through the 4D model with the syntax Define, Design, Development and Dissemination, the development of learning media can be carried out systematically and ensure that the resulting material meets the desired learning objectives, namely improving students' problem solving abilities.

Figure 1. 4D Diagram

The process of learning activities carried out with the help of the learning media developed has the aim that students can have good and structured problem solving skills so that they are able to solve the mathematical problems given. This learning process encourages students to hone their problem solving skills which include understanding the problem given, establishing a plan to solve the problem given, implementing the problem solving plan that has been designed, verifying the results of solving the problem carried out (Hanim, Kurniati, Oktavianingtyas, Susanto, & Jatmiko, 2023; Ilham, Syarifuddin, & Silviana, 2021).

Instruments

This research involves test and non-test instruments as data collection materials. The test instruments used are pretest and posttest questions. There are 4 test questions given to students to measure students' problem solving abilities which include understanding the problem given, establishing a plan to solve the problem given,

implementing the problem solving plan that has been designed, verifying the results of the problem solving carried out. This instrument was developed by researchers together with mathematics subject teachers in these 6 schools. The validity and reliability of this instrument is carried out through expert judgment to provide a professional and objective view. Through the considerations given, the questions used in the pretest and posttest can truly measure students' problem solving abilities. The non-test instrument used is in the form of a questionnaire and is then given to material experts, media experts, and students as a response to the learning activities carried out. There are several items in the questionnaire that must be filled in by the relevant sources/respondents, namely A total of 9 items that must be filled in by material experts including 3 items of learning elements and 6 items of material content elements, A total of 10 items that must be filled in by media expert includes 6 items of appearance elements and 4 items of accessibility elements, A total of 13 items that must be filled in by students include 6 items of interest in the subject, 4 items of material elements, and 3 items of language elements. The instrument used in this research was adapted from the BNSP Bulletin which has been validated by the BNSP team and obtained results Score 4.4 on material expert validity with very valid criteria, Score 4.65 on media expert validity with very valid criteria, Score 1 on content validity with very high criteria and an average questionnaire score of 4.26 with good criteria. Based on these scores and criteria, the instrument is suitable for use in this research (Tim Penyusun, 2021).

Data Analysis

This research has criteria for the learning media being developed. There are valid, practical and effective classification standards that are used to assess whether learning media can be said to be successfully developed and suitable for use in classroom learning activities. Apart from that, the learning media developed is said to be successful if it is able to improve students' problem solving abilities. Data on the valid aspect is obtained from the validation results provided through the assessment of material experts and media experts. Data on practical aspects was obtained from the results of small-scale trials and large-scale trials based on learning media users, namely students. The valid and practical criteria obtained from the validation results are in the minimum good category. Data on the effective aspect was obtained through student test results which were compared via pretest and posttest. The results of this test will measure 4 problem solving indicators which include understanding the problem given, establishing a plan to solve the problem given, implementing the problem solving plan that has been designed, verifying the results of the problem solving carried out.

Table 1. Validity and practicality criteria classification

No	Score	Criteria
1.	$\bar{x} > \bar{x_i} + 1.8sb_i$	Very good
2.	$\bar{x_i} + 0.6sb_i < \bar{x} < \bar{x_i} + 1.8sb_i$	Good
3.	$\bar{x_i} - 0.6sb_i < \bar{x} < \bar{x_i} + 0.6sb_i$	Enough
4.	$\bar{x_i} - 1.8sb_i < \bar{x} < \bar{x_i} - 1.6sb_i$	Less
5.	$\bar{x} < \bar{x_i} - 1.8sb_i$	Very less

The effectiveness test carried out in this research used the normality test and homogeneity test. The learning media developed is declared practical if: the normality

test results have a significance value of more than 0.05 and the data comes from a normally distributed population, the homogeneity test results have a significance value of more than 0.05. Meanwhile, another test used is the one sample t-test with the hypothesis:

H_0: There is no effect of using Android-based learning media with a STEM approach to improve students' problem solving abilities.

H_1: There is an effect of using Android-based learning media with a STEM approach to improve students' problem solving abilities.

▪ RESULT AND DISSCUSSION

The results of this research are development research using the 4D model which is one of the instructional design models. This model has been used to develop curricula in various fields (Hariyanto, Ita, Wiwik, & Rindawati, 2022). The product produced in this research is learning media with the name "Sobat Pytha" which is an appropriate learning tool both theoretically and empirically because it can train students to solve problems (Badriyah, Poedjiastoeti, & Yuliani, 2021). Buddy Pytha has several learning components and materials that students must master through the learning process. Buddy Pytha has certain characteristics, is specifically designed, and designed according to students' conditions, so that it is hoped that it can meet students' needs in learning activities (Suhono & Sari, 2020). There is a stage of analyzing student learning needs, especially because learning activities are still in the post-pandemic stage. There are several conditions that are used to adjust learning activities after the pandemic, one of which is the presentation of Android-based learning material so that it can be accessed via each student's gadget, considering that during the pandemic everyone cannot be separated from using gadgets.

Table 2. summary of android-based learning media development activities using STEM approach

Steps	Activities
Define	Identify learning media that is appropriate to student goals, learning objectives, learning material content, learning environment, and learning approaches used.
Design	Designing a learning media concept that is different from usual and made in detail.
Development	Develop the required learning media according to the design that has been made and create instruments to measure the performance of the learning media developed.
Dissemination	Disseminate the learning media developed to students and teachers so that they can be used in learning activities.

The initial step is to define the material used in the creation and development of Sobat Pytha, namely determining the material that will be used, namely Pythagoras, the problems in learning that will be solved in learning activities, namely contextual problems related to Pythagorean material, and student abilities that will be measured through learning media. What is developed is students' mathematical problem solving abilities. This stage contains an analysis of the student's condition, an analysis of the materials to be used, and an analysis of the assignments to be given which are discussed together with the mathematics subject teachers of each school. Learning activities are carried out using

Android-based learning media with a STEM approach. This design includes learning objectives, learning activity scenarios, learning tools used, teaching materials delivered, and learning evaluation tools. The integration of science and technology has a very important role in creating the needs of today's society, therefore STEM is very suitable to be applied in this learning activity (Suwarma & Kumano, 2019).

The next stage is designing Pythagorean teaching materials that are in accordance with the STEM approach, designing a learning activity plan that will be carried out over 3 meetings, designing a learning media prototype that will be made starting from selecting the media used, namely Android-based so that it is easy to use and disseminated to students and presented in form of application that can be installed on each gadget (Singh, 2014). This design stage consists of what content will be presented in the learning media that is developed for teachers to know so that it matches the characteristics of students and achieves learning objectives. In the end, it was agreed that the Android-based learning media created were story games. Making Sobat Pytha learning media aims to improve students' problem solving abilities, therefore it is necessary to develop solutions to achieve goals (Firman, Rustaman, & Suwarma, 2015; Kalelioğlu & Gülbahar, 2014)

The learning media development stage is carried out to create a learning media design that will be used in learning activities. The learning media created is then validated by each mathematics teacher in the form of a material expert validation test and colleagues in the form of a media expert validation test. Learning media were also tested in small groups on 10 students in each school to obtain trial results. Product validation is carried out to ensure that learning media is valid and measurable (valid and practical) so that it is suitable for use in learning activities. Validation was carried out in two parts, namely validation of material experts from mathematics teachers in each school and validation of media experts from colleagues who are experts in Android-based learning media with a STEM approach. The learning media created contains structured learning activities starting from the competencies to be achieved, learning materials, examples of mathematical problems, contextual practice questions, and learning evaluation tests, so that students can think critically and creatively so that they have mathematical problem solving abilities (Moma , 2015; Bybee, 2013).

Table 3. Summary of suggestions and input from validators

Validator	Suggestions and Inputs
Validator 1	As a special medium, it would be good if it was given a name, that's why the name "*Sobat Pytha*" emerged with the philosophy that this learning media is a student's friend in learning Pythagoras.
Validator 2	Adding open-ended practice questions helps students to be able to solve problems not just in one way or find one answer. Apart from that, questions that guide students to solve mathematical problems are made more interesting, coherent and structured so that students can have mathematical construction skills in solving problems.
Validator 3	There needs to be instructions for students in interesting language so that students can follow instructions well.
Validator 4	There are contextual questions so that students are able to imagine and solve the problems given.

Validator 5	Practice questions that have been filled in by students can be connected to the teacher's e-mail so that the teacher can correct them and make the practice questions a form of assessment.
Validator 6	Unnecessary images, sounds and button symbols can be reduced so that students are not distracted by these things but focus more on the material being studied.

The material expert validation score obtained was 82 in the very good category and the media expert validation score obtained was 73.5 in the good category. The suggestions and input given by media expert validators are the color, space and scale components that need to be considered because today's gadget models are diverse. This aims to prevent overlapping content when installed and opened on gadgets with low resolution. The results of validation by material and media experts state that Android-based learning media with a STEM approach is valid for use. One of the challenges faced when developing Android-based learning media is compiling a story board, where the suitability of buttons, learning media content, layout, and attached trinkets such as sound, effects and moving images can function well according to the design. made (Qohar, Susiswo, Nasution, & Adem, 2019).

This practicality test was carried out by asking students to install Buddy Pytha on their respective gadgets and try it until the end. In the small scale test, 10 students were randomly selected from each school so that 60 students were obtained as respondents. Meanwhile, in the large-scale test, all research subjects were required to use Sobat Pytha, resulting in 192 student respondents. The practicality test results in the small scale test and large scale test obtained an average of 80.27 and 76.34 so they are in the good category. The results of this practicality test state that Android-based learning media with a STEM approach is practical to use. This practical nature encourages the use of learning media so that it can be used by more and more students and teachers in an effort to support learning activities in schools. Learning media, in fact, is not the only learning tool but helps teachers and students in achieving learning objectives specifically designed for the material (Fredagsvik, 2023).

The effectiveness test of Android-based learning media was analyzed based on the results of the pretest and posttest carried out by students. The test used is analysis using the normality test and homogeneity test. Based on these two tests, it shows that the data obtained is normal and homogeneous. The next test is an effectiveness test using a one sample t-test. This test shows that Ho is rejected, so there is an influence of using Android-based learning media with a STEM approach to improve students' problem solving abilities. The average increase in scores in the control class was 21.2769 while in the experimental class it was 42.5423. The results of the effectiveness test stated that the learning media created could improve students' problem solving abilities. Based on the three test results that have been carried out, learning media is said to be suitable for use because it meets valid, practical and effective aspects (Putri, Hasratuddin, & Syahputra, 2019).

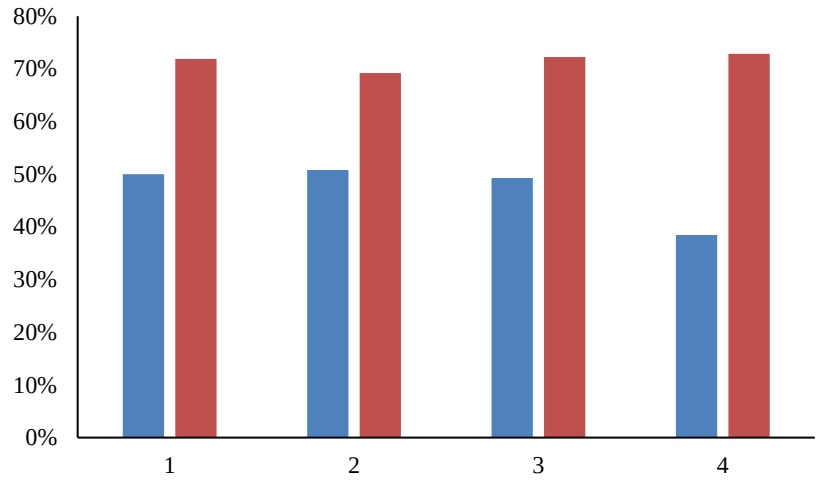

Figure 2. N-gain score for each pretest and posttest questions in both class

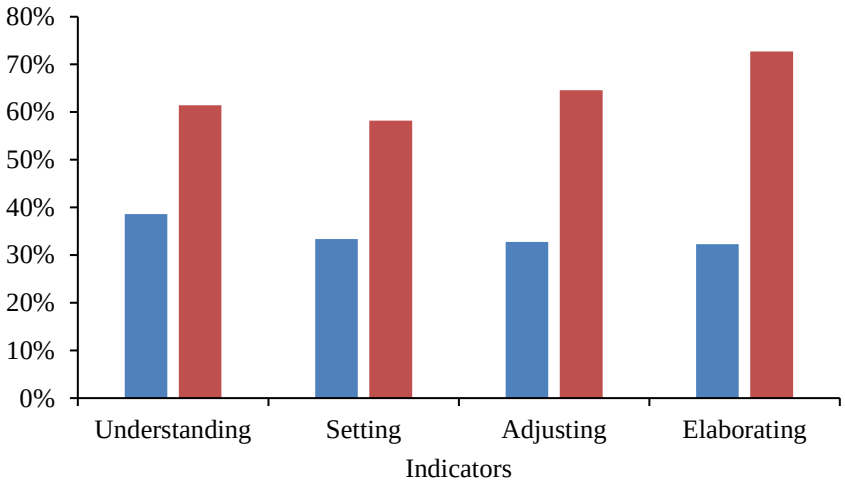

Figure 3. N-gain score for problem solving skills' indicators in both class

The final stage, namely dissemination, is carried out by distributing learning media to students in the form of an Android application. Buddy Pytha can be implemented in learning activities so as to facilitate students to achieve the learning goals designed by the teacher, improve learning achievement and students' mathematical problem solving abilities. This stage refers to the application of a STEM approach in creating learning media (Barret, Moran, & Woods, 2014; English & King, 2015; Michaluk, Stoiko, Stewart, & Stewart, 2018). Apart from that, the dissemination of Sobat Pytha can enrich the treasures of Android-based learning media being developed, so that more students and teachers will use it in learning activities, providing inspiration to many educators, teachers and learning media developers to further develop other learning media that can facilitate teachers and students and achieve certain learning goals (Papadakis, 2020).

▪ CONCLUSION

Learning media was developed using an Android-based 4D (Define, Design, Development, Dissemination) model with a STEM approach aimed at improving students' problem solving abilities. Learning media meets valid aspects based on material experts in the very good category and media experts in the good category. Learning media meets practical aspects based on the results of small-scale tests and large-scale tests in the good category. Learning media meets the effective criteria based on effectiveness test results which state that learning media can improve students' problem-solving abilities. The learning media specifically has the name Sobat Pytha with the aim of being students' friends in learning Pythagoras.

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