Solid geometry educational game based on student's mathematical understanding

S A Pramuditya\textsuperscript{1,}, A Rozak\textsuperscript{2} and D Rukmana\textsuperscript{1}

\textsuperscript{1} Department of Mathematics Education, Universitas Swadaya Gunung Djati, Cirebon, Indonesia
\textsuperscript{2} Department of Indonesian Education, Universitas Swadaya Gunung Djati, Cirebon, Indonesia

*amamisurya@fkip-unswagati.ac.id

Abstract. The low ability of students in solid geometry material and the lack of use of digital media make students less active and creative in the learning process. One way to solve this problem is to develop valid learning media. It can be used as a supplement by students. The aim of this study is to develop learning media in the form of android-based educational games. This research is a development research, and uses the ADDIE model. This learning media was tested for validity by three validators, and the implementation was tested in one class consisting of 23 students. Based on the validation test obtained a percentage of 94.79% and its implementation has very practical results with a percentage of 97.71%. The percentage is based on the data of the results of the pretest and posttest results, obtained by students in solid geometry material — the ability of mathematical understanding increase in the medium category. From these results it can be concluded that the media based android education game can be used in the learning process in the solid material and easy to use for students.

1. Introduction

Now, technology has an important influence on the world, including education. Technology in education is used as a tool in the learning process. The younger generation who have the expertise to access digital media have not yet compensated for their ability to use digital media for the sake of obtaining self-development information [1]. This is also not supported by the increase in material or information presented in digital media that is very diverse in type, relevance, and validation by Hagel [1] even though technology media has an important influence on aspects of education, for example, Mobile, PC, tablet, computer, and internet. Many learning media can be used, one of the media that can be used is a mathematics learning application. In this era, technological advances also help the 2013 curriculum learning system as an example of the emergence of E-Report.

The learning media used can enhance students' learning process in understanding learning which is expected to improve learning outcomes [2]. One of the learning media that can be used is a game with android application. Why is the game? At this time the game becomes one of the features or technology that is very popular among children, adolescents and even adults. Therefore the game can be utilized in the learning process. The newest technology used in helping learning process is a mathematical educational game [3]. Mathematical educational games are inserted the content of mathematics learning in the form of questions and material. There are several types of games that develop, such as arcade,
RPG, action, sport, etc. [4]. One of the benefits of this technology is the existence of Android-based smartphones. Android is an operating system for devices mobile Linux-based that includes operating systems, middleware and applications. Android provides an open platform for developers to create their applications [5].

In the process of learning mathematics, there is one goal in the learning process, one of the goals is to improve student understanding ability. Mathematical understanding is defined as an ability that relates to mathematical notations and symbols that are relevant to the loading of mathematical ideas and combines them into a series of logical reasoning [6]. So in the development game of this mathematics education will be used based on mathematical understanding so that the purpose of one of the mathematics learning can be achieved.

2. Method
The method is research and development; the media is an educational game. In developing game, a development model is used with the ADDIE model. This model is an approach that helps instructional designers, content developers, or even teachers to create an efficient and effective teaching design. Elements made by following the ADDIE model can be used in any environment online or face to face. Also, this systematic process is represented in the ADDIE acronym, which stands for an important component in the instructional design process of making analysis, design, development, implementation, and evaluation [7]. Each phase in the ADDIE model relates and interacts with each other.

ADDIE is one of the concepts used to design learning systems. One component of the learning system that can be designed using ADDIE is learning media. ADDIE phases include Analysis, Design, Development, Implementation, and Evaluation [8].

2.1. Analysis phase
The analysis phase is the phase of the information collected can be used as material design of the game is to identify problems in the form of a needs analysis software and developed the concept of ideas on educational games presented in the storyboard. At this phase, the researcher will interview the respondent to find out the problems that occur during the field, especially in the subjects of solid geometry.

2.2. Design phase
Based on the analysis, the second phase is the design phase of products which includes the step of formats and media selection, preliminary design phase of the game and the preparation of the content in game that eventually the whole may be contained in android application.

2.3. Development phase
Development of assisted learning media android application was developed using Role-Playing Game (RPG) software that can be used on android. At this phase, media validation is also carried out. To find out the learning media that are made valid or not, the validator learning media is validated. The validator consists of one lecturer, one math teacher, and one colleague. The data obtained from the validator is analyzed based on each expert.
2.4. **Implementation phase**

The implementation phase is phase beta testing (user or student). This phase can be done if the results of alpha testing (media experts and material experts) are appropriate or valid. While testing is beta carried out by students as users. Beta testing is conducted to determine the user's assessment of the practicality of educational games and to test students' completeness and an increase in understanding or not in learning to use learning media game educational. Testing is done by using a sample of 1 class. Students are given the opportunity to use games that have been developed. This research was conducted at 8th grade Junior High School with 23 students. To test the students' learning completeness, the t-test is used while to find out whether there is an increase in the learning process used normalized gain test.

The t-test, as well as the z test can be applied to test the hypotheses in the one treatment study. T-test is done to find out the average results of research that has been done in meeting these criteria or not. In this case, the descriptive average is 60%.

Normalized Gain Test is used for knowing the general picture of improving learning outcomes between before and after learning. The amount before and after is calculated using normalized gain and gain category (g) developed by Hake [9].

2.5. **Evaluation phase**

The evaluation phase is the process of improvements made by researchers at each ADDI phases and suggestions received by researchers in each phase.

3. **Results and discussion**

3.1. **Analysis phase**

In the analysis phase, direct interviews were conducted with the teacher and students to find out the characteristics of students' learning needs [8]. This is done in addition to knowing the characteristics of student needs but is done to find out the needs of products in the community. This product is also prepared as a medium or supplement in the learning process to help students, especially in the material to build a solid geometry. The analysis phase was interviewed directly with the teacher and students, and the questionnaire was distributed to the public through the google form. From the results of teacher interviews, the results showed that students still have difficulty in learning solid geometry, the most difficult problem faced is the desire of students who lack interest in learning mathematics because the teaching aids used are only teaching aids available at school.

3.2. **Design phase**

At this phase of manufacture map (map) as well as events that are synchronized to the scenario [10]. In the design phase, scenario creation, map creation, creation of the main character, entering the game questions and testing the game are made. In the design phase of the media, the game was educational made by RPG Maker MV software. This educational has been completed with the name "Math the Online" and containing 11 maps, 7 phases, one main character and 30 questions in the game. At this phase, the question has been validated using construct validation so that the questions that have been made can be used and included in the game.

3.3. **Development phase**

Development phase is covering the manufacture of products, expert validation, and practicality [4]. So after the game is finished, at this phase the results of the game are explained and then display the results of a media validation.

At this phase, the game is made by using a Personal Computer (PC), where the entire file in the previous phase is made in a single form in the form of a game whose purpose is changed into a format (.apk) so that it can be operated on an Android smartphone.

The validation media of "Math The Online" is carried out by three people, namely one lecturer as a media expert, one teacher as an expert in material building solid geometry and one colleague. The
following results of media validation that have been carried out from each aspect of the indicators of each expert are shown in Table 1.

| Validator 1 | Relevance | Systematic | Suitability | Design | Compatibility |
|-------------|-----------|------------|-------------|--------|---------------|
| 75          | 87.5      | 100        | 86.1        | 75     |

| Validator 2 | Relevance | Systematic | Suitability | Design | Compatibility |
|-------------|-----------|------------|-------------|--------|---------------|
| 100         | 87.5      | 100        | 100         | 100    |

| Validator 3 | Relevance | Systematic | Suitability | Design | Compatibility |
|-------------|-----------|------------|-------------|--------|---------------|
| 100         | 100       | 100        | 100         | 100    |

3.4. Implementation phase
This phase is about changing our plan into action. To pass this phase, we must consider three main steps, which train the instructor, prepare students, and regulate the learning environment [6].

The subject of the research on the user practicality test was conducted on 1 class of students as many as 23 students. The following are the results of the user's consistency test on each aspect of each student presented in table 2.

| Table 2. Practically validation on each aspect (%) |
|-----------------------------------------------|
| Convenience | Term | Content | Satisfy |
|-------------|------|---------|---------|
| 98.91       | 94.57| 98.75   | 100.00  |

The normality test is carried out to find out the sample data that has been tested to a sample from a normal or not population. To test the normality of the data used pretest and posttest data using the Shapiro-Wilk test assisted by SPSS 22.

| Table 3. Normality test results. |
|----------------------------------|
| Kolmogorov-Smirnov*       | Shapiro-Wilk |
| Statistic | df | Sig. | Statistic | df | Sig. |
| Pretest    | .134 | 23 | .200* | .962 | 23 | .510 |
| Posttest   | .206 | 23 | .013 | .928 | 23 | .099 |

*. This is a lower bound of the true significance
a. Lilliefors significance correction

Based on the output above, the significance value Shapiro-Wilk for pretest and posttest is greater than 0.05, so it can be concluded that the variables are normally distributed. Furthermore, the posttest data will be tested by t-test with known average posttest score of 79.13, the standard deviation of 8.614, KKM value of 65 and number of students 23.

| Table 4. Statistic test. |
|--------------------------|
| Test | Value |
| t-count | 7.8677 |
| α=0.01,t-table= | 2.5083 |
| α=0.01,t-table= | 1.7171 |

From table 5, for α = 0.01 and α = 0.05, t-count > t-table so the average posttest value Mathematics at 8th grade Junior High School is at least 65. From these results, students complete their learning in solid geometry.

In the implementation phase to see whether there is an improvement in the learning process, it is used result pretest and posttest before and after using educational game media. The results of these improvements can be seen in figure 1.
Figure 1. Results of graphs of comparison of pretest and posttest.

Figure 1 shows that all students experienced an increase in learning seen from the values and graphs above which are based on the pretest and posttest scores. With the acquisition of the normalized gain test results obtained a high interpretation of 10 students and for medium interpretation as many as 13 students. For the range of gain the interpretation of high is 0.705882 - 0.9 and for the medium range of interpretation is 0.588 - 0.692. The average increase in students' understanding ability shows moderate interpretation. Here is the result of the gain test obtained in figure 2.

Figure 2. Results of the gain test.

The gain test in Figure 2 was found that there was an increase in students' understanding after using educational game media on the material of solid geometry based on the data of pretest and posttest scores.

3.5. Evaluation phase

The last phase on ADDIE development model is an evaluation; the purpose is to assess the quality of products and processes. Evaluation is carried out at each phase. An evaluation intended to improve the media at each phase. The phases of improvement carried out by the researcher during the ADDI process taking place in this study and obtain suggestions from each phase [7].

In the analysis phase, the researcher improves teacher interview guidelines to improve student interview guidelines, improve questionnaire interview guidelines on the google form and get suggestions for online questionnaires. Google forms are multiplied to strengthen the analysis of product integrity.

At the design phase, researchers improve the language used in the media, improve the language of the questions used in the media and get the advice given to the size of the media to try as small as possible.

At the development phase researchers refined the media that had been deployed but there were damages or bugs, improved by paying attention to the process deployment. It because there was an error in the supporting application namely the application crosswalk, fixing the media validation
questionnaire, after media validation corrected the problems in the media that did not match the answer is, after the media validation improves by adding instructions to the media used, after media validation fixes the damage or bugs that are still in the media and gets the advice given by validation. Check the questions in the media with the answers used to add the questions which contain in daily life and the flow of questions in the media used by the student's learning resources (Books).

In the implementation phase the researcher gives the practicality questionnaire, then got the suggestion that for students in the classroom the students were given a longer time in the teaching and learning process by using the media and adding meeting time in using the media.

4. Conclusions and implications
The learning media development process used is the ADDIE model. The steps in the study are as follows: 1) Analysis: a phase that includes analysis of product needs in student learning. 2) Design: a phase that includes selecting products in formats and media, making storyboards, and making questions. 3) Development: the phase that includes product development and product validation. 4) Implementation: a phase that includes the application of products in the learning process to test practicality and test the completeness of student learning and test for an increase in understanding in using the educational game media. 5) Evaluation: mentions the phases of improvements made by researchers at each phase and suggestions received by researchers from each phase carried out. The game "Math the Online" made by researchers has very high validity criteria obtained from validator 1 of 85.94%, validator 2 of 98.44% and validator 3 of 100% with an average preset of 94.79% of the total percentage of each validator. Several educational game studies with subjects of senior and junior high school students obtained media validation results above 90% [3,5,8]. And based on the results of Pramuditya's research [3,5,8] said that the results of practical for senior high school students were 85% and junior high school students were 80%.

Based on the results of the implementation of the game "Math the Online", the percentage results were obtained with an average for students' practicality of 97.71% so that the media game which was used was very practical as a medium of mathematics learning. By using statistic test, results that students complete learning in the solid geometry material. Using normalized gain test data, the results of the pretest and posttest scores obtained that students experienced an increase after using the media. So it can be concluded that the educational game media is very practical, can complete the learning completeness of students and can improve students' understanding ability in learning in the solid geometry material.

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