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The Development of Educational Game as Instructional Media to Facilitate Students' Capabilities in Mathematical Problem Solving

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Abstract: This study aims to produce a valid and practical educational game that can facilitate students' mathematical problem solving ability. This study is a development research using Borg & Gall model which has been modified. Subjects were technology and subject matter experts as validators and 8th grade students of State Junior High School 21 Pekanbaru for practically test and the object of this study are educational game and students' mathematical problem solving ability. The data were obtained through a validation process by validators, practicalities by students, and effectivity by students' mathematical problem solving ability test in the form of post-test. Data collection instruments are in the forms of validation sheets, practicalities questionnaire sheets and post-test for mathematical problem solving ability. The data were analyzed with descriptive analysis techniques. The educational game development results have been tested with validity degree of 84.1% (very valid), practicality degree of 85.42% (very practical) and effectivity degree of 80% (effective). From these results, it was identified that the educational game that developed was very valid, very practical and effective to facilitate students' mathematical problem solving ability

1. Introduction

Mathematics learning has become one of the most researched fields in education. This is caused by so many strategies, methods, media, and learning sources that can be used in its practices. Mathematics has a wide variety of its contents so that different strategies and media are needed in its lessons. Mathematics also has many different abilities that needed for its learning, like understanding, communications, problem solving, and many more.

From those abilities, problem solving is one of the most important, because, as Halmos (1980) said, "I do believe that problems are the heart of mathematics[1]". It means that almost all mathematics learning is about to find and solve problems. Therefore, problem solving ability is very much needed by students in mathematics learning.

Problem solving also needed for a meaningful learning. Brownel (1953) said that learning happen trough meaningfulness and understanding[2]. Wertheimer (1959) further explained that the meaningfulness of learning can occur due to the discovery of various way of solving a problem[3].

Students also can be benefited from having this ability, as Hudoyo (2005) said that problem solving is an essential part in mathematics learning because (1) students become skilled at selecting relevant



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5 information, then analyzing it and finally researching the results; (2) intellectual satisfaction that will arise from within is an intrinsic problem for students; and (3) students' intellectual potential increases and students learn how to make discovery through the process of discovery[4].

Problem solving itself, as the process of finding answers to problems, either in classes or situations in real life[5], has some steps. Polya summarizes those steps as understanding the problem, devising a plan, carrying out the plan, and looking back[6] while Anisa explains the four steps of solving problems in mathematics as (1) read and understand the language and the problem of the story; (2) presenting the problems in mathematical model; (3) planning the calculations of the mathematical models, and (4) solving the calculations of non-routine questions [7]-[10].

As mentioned above, the ability to solve mathematical problems is very much needed by students, as most mathematics learning will be problem solving. However, based on interviews with one of the mathematics teachers at State Junior High School 21 Pekanbaru and the tests that have been done, most students still did not have the required skills for problem solving, such as identify the elements that are known, formulate mathematics' problems and apply strategies to solve problems from a story based problem.

Most students think that mathematics is a difficult and tedious lesson, so they are less interested in learn it that causes their low mathematical problem solving ability. Mathematics learning that held at State Junior High School 21 Pekanbaru is using supporting books from the library, teaching materials in the form of student worksheets, and has used instructional media in the form of power point, video, and interactive CD learning, but still cannot facilitate students' mathematical problem solving ability.

Teachers are required to always innovate in providing learning resources for students; one of them is instructional media. This means teachers should always develop the instructional media in accordance with the needs of students and the development of science and technology.

The instructional media developed not only must be in accordance with the needs of students, but also must be able to attract students so that the developed media can be applied to the fullest. Based on observation and interview to find what is liked by the students, authors found that most students really liked game.

Game, especially digital game is not a strange word in this world. Nowadays, people are stimulated by the use of game for entertainment and playing facility[10] that could become an extremely time consuming thing, especially to children, that can spend until 13 hours playing game in a week [11].

Based on students' interest of game, it can be used in education field as a media to help students to learn better. An educational and constructive aspect of the game is that individuals want to progress in the game and modify the way of playing. It seems that progress and desire to winning in game motivate the passive students to think [12], Nekah said. Cheng also stated that a very important reason why game has a positive effect on learning is because game provides live experience of user involvement[13].

The using of educational game is a form of Game Based Learning (GBL), a method of learning that use digital game as a medium to reach the learning objectives. In GBL, students are actively doing experiences, understanding the game, and resolving the problems that exist in it [14], Groff said. Based on that, game actually helping students to practice their problem solving ability, even when they did not realized it.

Game is a way to facilitate student's mathematical problem solving ability. Suherman stated that educational games containing mathematical values can improve their conceptual understanding, comprehension and consolidation skills, improve the ability to find and solve problems, and others[15].

McLaren support this with a research that stated that students become more enjoyable in learning and have better understanding, thus can solve problems better after using educational game[16].

This is also supported by Şimşek in his research that students' interests toward mathematics increased, they started to like mathematics, they would like to reserve more time for mathematics and they would like to have advanced level information about mathematics. Besides, an increase of

academic success regarding the objectives, which is a cognitive quality, has been noted thanks to the three dimensional Mathematics Robot they developed[17].

Moreover, Craig’s research results stated that there was a positive impact on the students understanding of coordinates and translations after using the game that they developed[18] that also helped them to improve their problem solving ability.

Randel’s research results on 1991 stated that the usage of game is very useful on subjects that related with mathematics, physics, and language ability[19]. It means that game, especially educational game, could help students to improve their mathematical problem solving ability. The link between meaningfulness of learning and various ways of solving that found by students is accommodated through various mathematical games.

Based on those, authors will conduct a research to develop an educational game that valid, practical, and effective to facilitate students’ mathematical problem solving ability. The problem of this research is how are the validity, practicality, and effectivity of the educational game that developed to facilitate students’ mathematical problem solving ability.

2. Methods

This research used research and development (*R & D*) method. Research and development is a process or steps to develop new products, or to improve the existing products. This research was conducted at State Junior High School 21 Pekanbaru for 8th grade students with purposive sampling. The study was developed using a modified Borg & Gall model (researching and gathering information, planning, developing initial product forms, initial field testing, major product revisions, primary field testing, product operating revisions, final product revisions). The procedures involved are needs analysis, product development, validity, revision 1, user-limited testing, revision 2, user group test, revision 3, and final products.

The data analyses used are the qualitative and quantitative descriptive questionnaires. The descriptive qualitative analysis is used to analyze data from technology experts and subject matter expert, and the comments of the revised educational game. The descriptive quantitative analyses are:

$$\text{Validity} = \frac{\sum \text{obtained score}}{\sum \text{score criteria}} \times 100\%$$

$$\text{Practicality} = \frac{\sum \text{obtained score}}{\sum \text{score criteria}} \times 100\%$$

The level of validity and practicality can be seen in the following table:

Table 1. Level of validity / practicality of educational games[19]

Ideal percentage (%)	Categories
0-20	Not Valid/ Not Practical
21-40	Less Valid / Less Practical
41-60	Enough Valid/ Enough Practical
61-80	Valid / Practical
81-100	Very Valid / Very Practical

As for effectivity, students’ score are categorized based on Minimum Mastery Criteria (MMC), which

are 75 for mathematics at State Junior High School 21 Pekanbaru.

$$\text{Effectivity} = \frac{\sum \text{students who meet the MMC}}{\sum \text{students who take post test}} \times 100\%$$

The level of effectivity can be seen from the following table:

Table 2. Level of Effectivity of Educational Game to Facilitate Student Mathematical Problem Solving Ability[20]

Effectivity level	Categories
81% - 100%	Very Effective
61% - 80%	Effective
41% - 60%	Enough Effective
21% - 40%	Less Effective
< 20%	Not Effective

3. Result and Discussion

Development The procedures of educational game development begin with needs analysis, where we found that there are students with low ability to solve mathematical problems. The next step is product development that used Adobe Flash Professional CC 2015. In developing the product, the focuses are to make an interesting interface (opening, menu, exercise, key answer, and Score) and storyboard that can facilitate Mathematical problem solving ability of 8th grade students, especially in circle.

Furthermore, validation is done by technology and subject matter experts. The validation results from technology experts can be seen in the following table:

Table 3. Validation Results of Educational Game Developed from Technology Experts

Variables of validity	Validity score	Criteria
Feasibility of Appearance	81.83%	Very Valid
Feasibility of Presentation	72.88%	Very Valid
Language	82.9%	Valid
Average Score	79.2%	Valid

The results of data analysis showed that the educational game that developed is valid in technology side and can be used for practicality test after small revisions.

The validation results from subject matter experts can be seen in the following table:

Table 4. Validation Results of Educational Game Developed from Subject Matter Experts

Variables of validity	Validity score	Criteria
Feasibility of Contents	87%	Very Valid
Language	88%	Very Valid
Problem Solving	92%	Very Valid
Average Score	89%	Very Valid

The results of data analysis showed that the educational game that developed is very valid in subject matter side and can be used for practicality test after small revisions.

The next step is revision 1, which authors did based from comments by technology and subject matter experts. Then, practicality test phase I was conducted with small group tester consisting of seven students. The results are presented below.

Table 5. Practicality of Educational Game Developed from Small Group Tester.

Variables of practicality	Practicality score	Criteria
Feasibility of Performance	95.6%	Very Practical
Feasibility of Presentation	97.3%	Very Practical
Average Score	96.67%	Very Practical

From the data above, it showed that the educational game that developed is very practical for small group using and can be used for large group test after small revisions.

The next step is revision 2, which authors did based from comments by students from small group tester.

Then, practicality test phase II was conducted with large group tester consisting of 20 students. The results are presented below.

Table 6. Practicality of Educational Game Developed from Large Group Tester.

Variables of practicality	Practicality score	Criteria
Feasibility of Performance	88.6%	Very Practical
Feasibility of Presentation	82.24%	Very Practical
Average Score	85.42%	Very Practical

From the data above, it showed that the educational game that developed is very practical for large group using and based of the questionnaires, there is no need for revision 3. So the final product is the educational game that used for large group practicality test.

Finally, to know the effectivity of the educational game that developed to facilitate students' mathematical problem solving ability after using the developed educational game, post-test was conducted with problem solving based questions to large group tester.

The result of the post-test was 16 of 20 students that take the post-test meet the Minimum Mastery Criteria (MMC) or have scored at least 75. It means that the effectivity score of the educational game that developed is 80%, with effective criteria.

From the results above, it can be seen that each step in the educational game's development procedure is related to each other. From the need analysis where we found out the problem, the product development where the educational game was made based on the problem that found from need analysis, the validation process where the developed educational game are evaluated by the experts, revision 1 where the developed educational game are revised based on validation comments, practicality test using the revised educational game with small group tester, revision 2 where the developed educational game are revised based on small group students' comments, practicality test using the revised educational game with large group tester, and finally post-test to see students' mathematical problem solving ability after using the developed educational game that conducted to large group tester.

The developed educational game has a good grade, based on all the tests that conducted. It has 79.2% validity by technology experts (valid), 89% validity by subject matter experts (very valid), and 84.1% validity by average (very valid). It means that based on content and technology used, this game can be used for mathematics learning.

It also has 96.67% practicality by small group tester (very practical) and 85.42% practicality by large group tester (very practical) that also become the final practicality score. It means that this game is interesting and students can use it easily. It also means that the mathematical contents in it can be understood easily.

After the using of the developed educational game, 80% students' mathematical problem solving ability score can meet the Minimum Mastery Criteria (MMC). It means that most students can solve the mathematics problems given after using this game. It also means the developed educational game is effective to facilitate students' mathematical problem solving ability

4. Conclusion

Educational game is one of instructional media that can be used in mathematics learning. Its capacity to facilitate students' mathematical abilities has been questioned many times before. Based on this research, the educational game that developed with Adobe Flash Professional CC 2015 is very valid with 84.1% validity, very practical with 85.42% practicality, and effective with 80% effectivity to facilitate students' mathematical problem solving ability.

For future study, researchers could improve the game levels and problem solving based questions that used, so that students could play the game based on their ability without feeling overwhelmed or bored.

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