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Educational Game Design to Improve Reasoning Skills

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Abstract

Mathematical reasoning is a modern learning media that is suitable for improving mathematical thinking. Problem Based Learning is one learning model that can help enhance reasoning. This article aims to design multimedia learning in the form of educational games to enhance students' mathematical reasoning. This research is a type of development research using the Multimedia Development Life Cycle model. The procedure includes six stages, namely concept, design, collecting materials, assembly, testing, and distribution while this research is limited to the design stage. The subjects of the study consisted of teachers and students' class 8 of SMP Muhammadiyah 1 Kalasan. The research instruments were observation guides, interview guidelines, and documentation sheets. Observation guidelines are used to retrieve student characteristics data while interview guidelines are used to determine the characteristics of students from the teacher's perspective during the learning process and documentation sheet to get data on curriculum implementation that runs at school. Data were analyzed using qualitative techniques. This research resulted in the design of educational games that were under the needs analysis of students. This educational game is designed to improve students' mathematical reasoning. This research can be extended to collecting, assembly, testing and distribution materials.

Keywords: *Educational Game, mathematical reasoning, multimedia, problem-based learning*

INTRODUCTION

At present, schools and educational institutions are intensifying to improve the quality and quality of learning, including through modern learning approaches and methods. So, teachers like teachers also need to be more efficient in maximizing their potential so that their time and energy do not run out to deliver the material. Teachers need to improve themselves in various aspects, especially in improving the quality and quality of students to be able to compete in the current era. Because now the teacher no longer only teaches students to use formulas but begins to explore high-level thinking, this is under the skill needs of the 21st century.

The National Council of Teacher of Mathematics (NCTM, 2000) stated five necessary mathematical abilities, namely problem solving, reasoning and proof, communication, connections, and representations. Mathematical reasoning is the main part of several sections that aim to describe mathematical thinking and allow students to use all other mathematical skills (Sumpter & Hedefalk, 2015). Mathematical reasoning is imaginative, so it is necessary to use several explanations to compile real experiences and turn them into abstract thinking models (English, 2013).

In observations made by researchers at one of the junior high schools in Indonesia, precisely at SMP Muhammadiyah 1 Kalasan, Yogyakarta in mathematics learning, the reasoning of class 8 students was still in a low category. Some indicators of reasoning appear to have not been reached during the learning process just as it has not been able to relate the facts to propose allegations to conclude. Quite a lot of students go through most of the procedures or steps in working on math problems so that mistakes often occur in answering the problem description.

To overcome the problems, a lot of media and multimedia are developed in helping the learning process. But in its implementation, the majority is only limited to displaying reading material in electronic form, so it is still monotonous, and this is not much different from a textbook. Nonetheless, electronic technology is an essential tool for teaching, learning and doing mathematics. When technology tools are used, students can focus on decision making, reflection, reasoning, and problem solving (Kramarski & Zeichner, 2001). Other researchers, such as Steen (1999) also say that computers provide an amazing tool for educators to produce and validate patterns that can help students learn mathematically. Therefore, researchers will develop multimedia that can make students go directly to problem solving in mathematics.

Multimedia learning can combine text, images, audio, music, animation, in units that support each other to achieve learning goals. So that multimedia-based educational games can motivate learning (Mozelius, 2014; Sin et al., 2014; Woo, 2014). Produce pleasure and facilitate the learning process. Educational games are expected to be following the characteristics of class 8 students at SMP Muhammadiyah 1 Kalasan were more than 60% of students like games to improve mathematical reasoning.

Meanwhile, the right learning model to improve student reasoning is Problem Based Learning (PBL) (Okubo et al., 2012; Lalonde, 2013; Aldarmahi, 2016; Wosinski et al., 2018). The problem-based curriculum gives students guided experience in learning through complex real-world problem solving. PBL is designed with several important goals (Padmavathy & Mareesh, 2013) so PBL is one of the suitable learning models to be used to help improve mathematical reasoning. This article aims to analyze and design suitable learning needs in the form of multimedia learning to enhance students' mathematical reasoning.

METHOD

This development research methodology uses the MDLC (Multimedia Development Life Cycle) model as used by previous researchers in making adventure games (Hartono et al., 2016; Sutopo & Pamungkas, 2017; Zhao et al., 2017; Khair & Hariyanti, 2018) Multimedia development consists of 6 stages namely concept, design, collecting materials, assembly, testing, and distribution. These six stages do not have to be sequential in practice. These stages can exchange positions. Even so, the concept must indeed be the first thing to do. This research is limited to product design based on the needs analysis in the form of student character and curriculum analysis as seen in Figure 1.

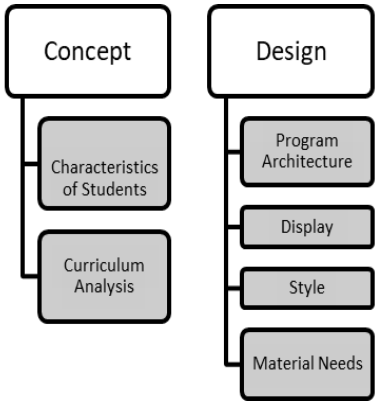

Figure 1. Research flow

The research subjects consisted of two mathematics teachers and ten students who were randomly selected from SMP Muhammadiyah 1 Kalasan grade 8. The research instruments were observation guidelines, interview guidelines, and documentation sheets. Student characteristics data were taken using observation guidelines. Student characteristics are also taken using interview guidelines from the teacher's point of view during the learning process. Meanwhile, to get data on curriculum implementation that runs in schools using documentation sheets. Departing from the needs analysis, on this occasion, the researcher made an appropriate flowchart and storyboard.
Data were analyzed using qualitative techniques to create educational game designs according to students' needs. While for design validation, qualitative data will be converted into quantitative data with Likert scale provisions. The scores obtained will be averaged and classified according to Table 1.

Table 1. Ideal assessment category criteria

Score Range Quantitative	Qualitative Categories
$\bar{X} > 4{,}2$	Very good
$3{,}4 < \bar{X} \leq 4{,}2$	Good
$2{,}6 < \bar{X} \leq 3{,}4$	Enough
$1{,}8 < \bar{X} \leq 2{,}6$	Less
$\bar{X} \leq 1{,}8$	Very less

The average can be calculated by the formula: $\bar{X} = \frac{\sum_{i=1}^{n} xi}{n}$

Where:

$\bar{X}$: Average score
$\sum_{i=1}^{n} xi$: Total score
n : Total statements

Educational game design that will be validated can be declared feasible if getting an average score of more than 3.4 or the minimum is in the good category.

RESULT AND DISCUSSION

Based on the analytical needs in mathematics learning, students of SMP Muhammadiyah 1 Kalasan grade 8 still need to improve reasoning with 3D shape material on basic competencies: solving problems related to surface area and volume of 3D shapes (cubes, beams, prisms, and pyramid), and the combination. PBL learning model uses educational games aimed at motivating students and enthusiasm for confidence using mathematical concepts. So that it can work on mathematics, express its opinion, think logically to obtain a hypothesis until it can make a relevant conclusion. On this occasion, the researchers will design multimedia-based games using PBL models with the aim of improving mathematical reasoning.

This game is designed for 8th-grade mathematics subjects in the even semester with basic competencies: solving problems related to surface area and volume of building flat side spaces (cubes, beams, prime and pyramid), and combinations. The duration of this game takes 3 hours of lessons.

In addition, in making this game design the researcher will consider the reasoning indicators used by previous researchers with the technical guidelines of the Director General of Basic Education and Education Regulation No. 506 / C / PP / 2004, namely: (1) Ability to present mathematical statements verbally, in writing, pictures and diagrams, (2) Ability to submit suspicions, (3) Ability to do mathematical manipulation, (4) Ability to compile evidence, give reasons / proof of the correctness of the solution, (5) ability to draw conclusions from statements, (6) examine validity of an argument, (7) find patterns or traits of mathematical symptoms to make generalizations (Rizqi & Surya, 2017). So, by considering these indicators, researchers will design the educational game as follows.

The main characters in this game use names that are familiar with the student environment, namely Beta, a name typical of one of the tribes in Indonesia. The selection of characters is based on tribal clothing that is still very traditional from eastern Indonesia, which blends with nature according to the theme and background of the game in a remote village in the middle of the forest. So the students are expected to be entertained and motivated to play it.

The first step in the making is to prepare all the supporting files that will be used in making the game on Macromedia Flash. These assets are like Beta characters, friend characters, background, sound or sound, buttons, material and practice questions. Then make the stage design good at each change of appearance. The part that makes this multimedia life is an animation that will be displayed in games such as animated characters running, throwing arrows, and other animation needed. The next step which is the main focus is to insert the material and questions according to PBL steps in the game so that students can issue the ability to reason.

The PBL step in this game that refers to Hmelo-Silver (2004) which focuses on learning experiences uses meaningful processes of investigation, explanation, and resolution of problems. At the beginning of learning, students work in groups on a small scale while the teacher continues to guide the course of education, including in running and playing educational games. In the game students will be presented with a problem scenario and students will be asked to analyze the problem by identifying the facts. If students understand the question well, they can provide hypotheses about solutions that might occur. From this process, there will be self-awareness about lack of knowledge, especially when pressing the help button in the game. By collaborating new knowledge obtained from the educational game section, students can evaluate the hypothesis to get the right solution. The PBL cycle can be seen in Figure 2.

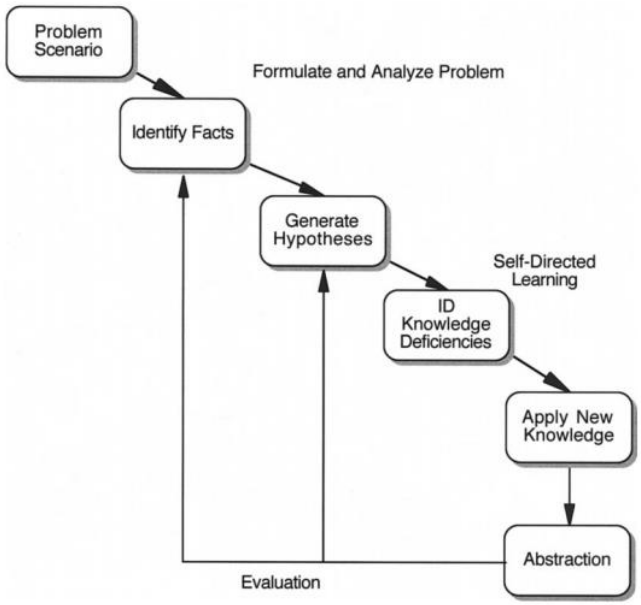

Figure 2. The Problem Based Learning cycle.

This educational game has four main menus, each of which will be displayed when students click the "Enter" button. These menus are Play, About, Help, Quit. The explanation for each menu can be seen in Table 2.

Table 2. Educational game menu

Menu	**Description**
Play	To start the game
About	To find out the identity of the game and the game maker
Help	To find out the instructions for using the game
Quit	To exit the game / application

As for the story or plot of this game talks about the main character named Beta who is looking for treasure inherited from his grandfather. Beta is the character of the native people of eastern Indonesia with clothes that are thick with their customs. The initial display design can be made as attractive as possible so that students are more motivated to press the enter button as shown in Figure 3.

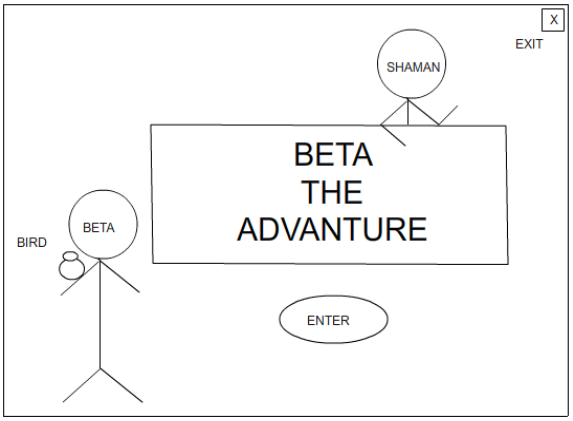

Figure 3. Initial display

In the initial display of multimedia Beta characters and other characters appear beside the game title, and there are two buttons namely enter the game and exit the application. This adventure game explores looking for treasure and is located in the forest area. After pressing the enter button, a narrative about who the Beta will appear along with the biodata about other characters can be seen in Figure 4.

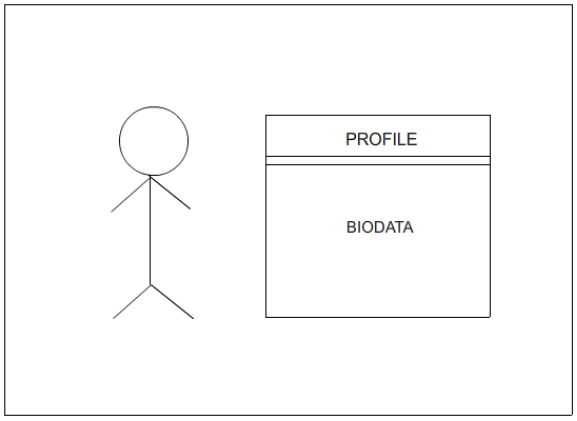

Figure 4. Profile of game characters

Beta does an adventure accompanied by a smart bird. The bird will play a significant role in guiding Beta on its long journey. Included in explaining the contents of the map which is a broad picture of the flow of adventure that will be explored. The design of adventure paths can be seen in Figure 5

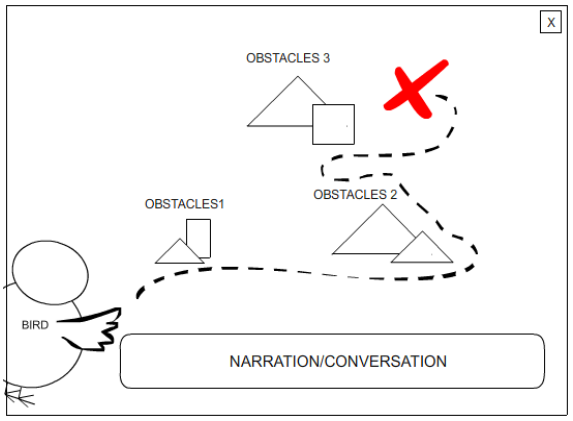

Figure 5. Overview of adventure flow

At the beginning of the Beta adventure, he was directed to learn 3D shape material with his classmates. This is intended to equip students with knowledge before embarking on an adventure to solve various cases. The content provided contains formulas relating to surface area and volume of 3D shapes (cubes, beams, prime and pyramid), and their combinations. The display design of this material can be seen in Figure 6. In the delivery of this material, there will be a conversation between Beta and his friend so as not to be monotonous. Including guessing games (true/false) as a matter of exercise.

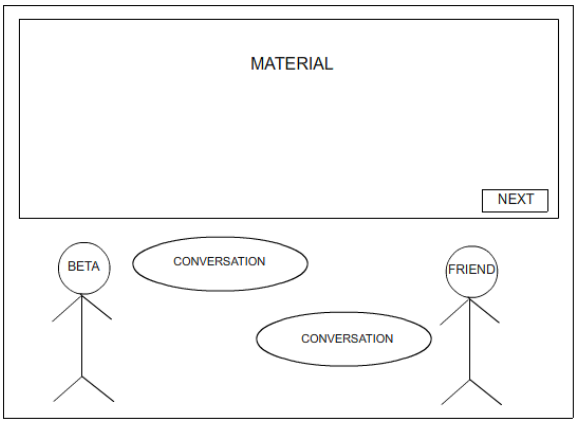

Figure 6. Display material

In searching for treasure, Beta will be faced with various problems related to 3D shape material whether it's when he uses the item or when he is in a 3D shape room. With illustrations of real issues, it is expected that his reasoning will be more focused starting from analyzing cases to making conclusions. As stated by Hmelo-Silver (2004) that to obtain knowledge and reasoning strategies, the use of video-based stories will present challenges to students so that it is profitable. First, this provides an opportunity for students to apply their knowledge together for relevant problems. Second, videos support understanding ongoing problems because problems often require 15-20 steps for solutions.

In addition to smart bird characters who always accompany him, there is a shaman whose role is to help when it is urgent and functions as a help button in the game. Shamans will provide Beta assistance especially in resolving cases. This shaman will only offer limited support so that students can make more effort in completing the mission. Shamans will give instructions in the form of a formula that appears just seconds. Then by considering several other known clues in the story, students will look for several alternative solutions by conducting an analysis, so that they can determine the most appropriate way to solve the problem. The design features of a shaman's character when helping to solve Beta cases can be seen in Figure 7.

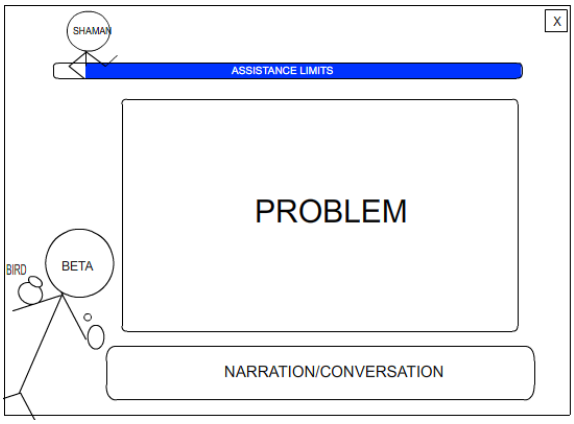

Figure 7. Help feature in resolving cases.

The help button (shaman) will be in the top left corner. Each aid is limited to just a few seconds according to the difficulty of the case. But the help of the shaman will not provide raw answers but only small instructions. So, students need to think and discuss to match the information obtained.

Case in the first obstacle is that students must help Beta to make three bookshelves without a lid. Whereas wood (plywood) is available is very limited, so Beta must know precisely how wide plywood is needed to make it. To solve these problems, students first need to know the correct rack surface formula. In this section, there will be a game to choose webs from the right form of bookshelves according to the students' ideas. Then students can calculate the surface area of the bookshelf by involving the number of boxes in the previous nets. When he has found the answer in the form of surface area for one cube from a bookshelf, then students can determine the area of plywood needed to make the whole shelf.

Each obstacle will be given a different case. The farther the obstacle, the higher the difficulty level in the case. Throughout the challenges, all students remain in the guidance and direction of the teacher. However, in 1 special case, which is the last 1 case, students will be released to solve it independently. In this section can be a direct benchmark in testing student understanding. At the same time, it will be a motivation about who will be the fastest in completing this game and get treasure according to the narration in the game. Meanwhile, to know the achievement of students' reasoning abilities in working on each question in more detail, the teacher can check his work in full that is obtained in writing.

The design of this educational game has been validated by two mathematics teachers, namely Noor Aini, S.Pd. who teaches at SMP Muhammadiyah 1 Kalasan and Maryati, S.Pd. who teaches at SMP Muhammadiyah 1 Tepus. Both validators are mathematics teachers from the junior high school level in Yogyakarta, Indonesia. Following are the comments of the assessment of the validators and revisions which are summarized in Table 3.

Table 3. Comments and revision

Comments	Follow-Up
Information and knowledge to help students formulate hypotheses have not been described in detail	Provide a detailed design of information and knowledge to help students formulate hypotheses
No storyline directs students to find the formulation of conclusions	Provide a storyline that can lead students to find their conclusions in the case

Meanwhile, the acquisition of educational game design validation scores can be seen in Table 4.

Table 4. Obtaining a design validation score

Assessors	Average Score	Criteria for Quantitative Data
1. Noor Aini, S.Pd.	3.90	Good
2. Maryati, S.Pd.	3.80	Good
Average	**3.85**	**Good**

From the results of the validation, both show that this educational game design gets an average score of 3.85 from a scale of five. So that it is in the "Good" category based on the criteria in Table 1 and this educational game design is declared fit for use.

CONCLUSION

Based on the needs analysis that researchers have done, students of SMP Muhammadiyah 1 Kalasan grade 8 still need to improve reasoning on 3D shape material with the characteristics of learning as a game. So, in this study, it was concluded that the design and manufacture of game applications were designed using the Problem Based Learning model and were built using Macromedia Flash. Macromedia flash is a pretty good program with complete tools that have made this animation processing program chosen. The application can also be played by a computer or laptop anytime and anywhere without using the software. Also, the most important thing about making this design is that the teacher uses this design to create educational games to improve students' mathematical reasoning.

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