Developing math games media using scratch language

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Abstract. Problems faced by students on mathematical problems always occur due to process errors because for those with enough knowledge to memorize formulas, then their job is only to insert numbers in formulas, and in fact, even when they use them they are not able to develop reasonable process stages. The purpose of this media learning, the existence of a strong positive influence they can understand mathematics, able to tune in concepts and be able to evaluate if there are steps in the wrong process then they correct mistakes. This study aims to develop the potential of prospective teachers or students to create ICT-based interactive media in mathematical games, using the ADDIE model of Analysis, Design, Development, Implementation, and Evaluation to see and guide students in making better products. From the results of the study that there is a positive influence when using media based on the average class at pretest 70.74 and post-test 82.69 with paired t-test with a significant value of 0.000 <0.05. and there is also an increase in the ability to solve the context of mathematical problems using the scratch program language based on a decrease in the indicators of student difficulties.

1. Introduction

Difficulties of students in understanding a sub-subject matter often become an obstacle in the learning process in the next material [1-2]. One reason for this is that during the teaching and learning process most teachers still use the lecture and question and answer method [3]. This means that the learning process is still centered on the teacher and students have not played an active role in learning because it is only limited to question and answer. Furthermore[4] states that learning that tends to be centered and sourced from the teacher does not teach students to construct lessons and result in mathematics being passive. Therefore, we need a way of teaching that is more centered on students so that students can construct their lessons given by the teacher. Regarding teaching that constructs students' knowledge, Freudenthal [5] states that students should not get the concept of a lesson directly but through the activity of constructing mathematical concepts. Also, [6] states that students' experiences in daily life are related to mathematical concepts. There are still many teachers who have not fully used technology-based learning media, especially computers, even though students often interact with computers daily, but have not maximized their ability to use computers [7].

Teacher learning methods are still conventional and have not been able to create or develop interactive learning media. Students use computers mostly just for playing games. Many programs can be used for learning media, including PowerPoint, Flash, Prezi, and Scratch [8]. The Powerpoint and Flash programs are already popular with Mathematics Teachers because they can display media that depict abstract and micro material. The flash program excels in complex and attractive motion depictions, while for the ease of the manufacturing process, the PowerPoint program is preferred by many teachers because it is easier to display images and easier to operate. In line with technological developments, learning media using the Scratch program began to be developed. Scratch is an application for making games and learning simulations without having to struggle with the
programming language. This complicated programming language is replaced by buttons that are easy to apply easily using the concept of programming blocks that can be click drag and drop. Researchers use the scratch application in learning mathematics.

The purpose of using the scratch application is so that students can understand the material in a whole and meaningful manner so that students are expected to become more enthusiastic, creative, and able to work together with their groups. With this scratch application program in the learning process of mathematics subjects, students will become more enthusiastic and active in the learning process, think creatively, and be able to work with groups. The Scratch program has advantages, which can produce learning media equivalent to the quality of Flash programs, but the process of making the media is equivalent to making media using a PowerPoint program. Currently learning mathematics using Scratch-based media has not been done much, but in physics learning research conducted by [9] on gas kinetic material that is included in the abstract and micro matter, it was successfully concluded that the Scratch program turned out to help mathematics to understand physics concepts better, and mathematics are interested in learning with Scratch-based two-dimensional animation.

Research conducted by [10] shows that of 41 students, 76.5% agreed that learning using the Scratch program was fun. So, Scratch media can help math in understanding abstract/micro material better and the learning process is more fun Scratch Application Program is a type of Open Source Software, desktop-based Freeware, web-based application that can be used free of charge. Scratch program is an educational application programming language that was created as an instrument of learning and educational purposes, not as a tool for making real applications. However, the advantage of some of these selected educational applications is that they can be used to make real and reliable applications, because some of these applications are real application makers, but quickly and easily. Scratch itself is an MIT Media Lab project from the Massachusetts Institute of Technology. The scratch project has been supported with funding from the National Science Foundation, Intel Foundation, Microsoft, Mac Arthur Foundation, LEGO Foundation, Google, Dell, Inversoft, and MIT Media Lab.

Scratch can support the teacher to analyze the activities of students' thinking patterns in understanding students about the scope of mathematics so that students can make strategies of new ideas that arise so as to help students understand mathematical concepts [11]. This goal, directing prospective teachers or students to focus on developing students' computational thinking from understanding to solving problems so students can learn mathematics with fun [12].

2. Method
The research method used is the research using the ADDIE model [13-15] which consists of 1) analysis containing the results of observation of students' basic knowledge about mathematical concepts, interviewing the difficulties of students using initial software, analyzing the results of initial student work on introducing software; 2) design Stage, making strategies and arranging learning steps based on the outline that occurs in the difficulty of students forming a flowchart; 3) development Phase, provides an outline of the stages and provides drawings in the form of samples that have been prepared; 4) Implementation phase, the task given by students to create media from scratch related to mathematics; 5) evaluation stage, which consists of analysis-mentoring students and mastery of making media and open questionnaires about the input from students after learning. Research subjects were conducted on 42 students in the Innovative Education Learning course at one of the universities in Cimahi when the research was conducted for 6 months. For the research steps in the figure 1.
To assess mathematical media using the Scratch program language, there are several media value categories in table 1 [16].

| Percentage | Valid rate    | Interpretation                  |
|------------|--------------|---------------------------------|
| 76 – 100   | Valid        | Worthy / No need to be fixed    |
| 50 - 75    | Valid Enough | Worthy / Sedikit diperbaiki     |
| 26 - 50    | Less Valid   | Decent but needs improvement.   |
| <26        | Invalid      | Not feasible and repaired       |

3. Result and Discussion
The results obtained from the beginning and end in making mathematical game media using the initial language of the program, where at the beginning of making the initial game media, students are given a stimulus of the initial knowledge base from explaining the components in the initial software to how it works when running the program which has become a media, students are then allowed to be given the task of making media. And in the final result, students are given a special set of steps from the outlines based on the difficulty of the students at the time of making media at the beginning.

| Tabel 2. Results Media Values |
|------------------------------|
| No  | Scratch learning | Average | Deviation |
|-----|-------------------|---------|-----------|
| 1   | Early Learning    | 70,74   | 4,42      |
| 2   | End of Learning   | 82,69   | 4,49      |

Table 2 explains that the average grade of the initial learning class is 70.74 and after learning 82.69 means there is an increase in the results of the media assessment, where the initial learning outcomes are included in the sufficient category while the final learning assessment is in a good category, while the grading assessment is the same as the good beginning and the end of learning can be seen from the
value deviation between the beginning and end of learning. Likewise, that there is an influence at the beginning and after learning can be shown from the significant value of the Wilcoxon test (2-tail) equal to 0.0000 < 0.05, previously tested Shapiro-Wilk normality where the significant value for the beginning of learning 0.002 and significant value for the final learning value of 0.03, both of them are less than 0.05.

Before conducting research, to obtain data on mastery of scratch programs, there are some points that students measure about the program. Previously, students had already known and studied program languages.

### Table 3. Scratch Mastery Program

| No | Mastery                     | Percentage | Information                                                                 |
|----|-----------------------------|------------|-----------------------------------------------------------------------------|
| 1  | Logic language              | 66.67%     | Students are already familiar with the implications, conjunctions, and disjunctions, not yet regulating functions, reverse functions, repetition functions. |
| 2  | Math functions              | 85.71%     | Students are familiar with mathematical functions in the form of symbols, but 6 students have difficulty using it. |
| 3  | Algorithm Understanding     | 33.33%     | 18 students had difficulty locating a language program correctly.            |
| 4  | Associate images with material | 21.43%  | 31 Students always find it difficult to think creatively in creating picture stories that interact with one another. |
| 5  | Animated images in the media | 38.09%     | 26 students interested in taking animated pictures who choose images that don't need much to get pictures |

Table 3 explains after observation and interviews, students have mastered the language of logic and mathematics functions, from this result students are given basic knowledge about the attributes contained at the beginning which mainly explain the menu language of each block in Scratch. And given an example of basic mathematical media at the beginning as an initial stimulus so students can come up with different new ideas in creating more interactive media.

**Figure 2. Media about Prime Numbers**

Figure 2 explains that the two pictures of animals discuss each other about prime numbers, students create concepts that are directly on the material prime numbers without any further explanation, some Early languages compose the creation of prime numbers about the functions of the mathematical module well. For repetition, material uses repeating animation on animal pictures, and there is a response from all images.
Figure 3. Rectangular Media Medium

Figure 3 explains students making a rectangular wide media, on the display there is only one mathematical function that is the multiplication operation to determine the multiplication value only, not using animated images and many questions that are directly intended for users to enter the length and width as variables.

Figure 4. Media Operating Numbers

Figure 4 explains about making a number operation media with the accuracy of the number operations of addition, improvement, multiplication is right to control the division when numbers are divided by zero then an error occurs, students do not use the use if you want to improve the operation.

The learning outcomes of all experiments using media-making are preliminary, some important findings are a factor in the difficulties of students when using block language.

| Table 4. Student Constraints in Using Block Language Before Learning |
|---------------------------------------------------------------|
| No | Obstacles            | Total | Percentage | Information                                                                 |
|----|----------------------|-------|------------|-----------------------------------------------------------------------------|
| 1  | Logic language       | 18    | 42.86%     | Do not use it because do not yet understand if others are indifferent changes. |
|    |                      | 12    | 28.57%     | Uses logic functions but cannot be executed.                                |
|    |                      | 2     | 4.76%      | Using a logic function but a condition error occurred.                      |
| 2  | Use of turn functions| 32    | 76.19%     | Students do not use the function repeat, forever, and repeat until.          |
|    |                      | 7     | 16.67%     | Students try to use but become mistakes (Errors)                            |
| 3  | Mastery of Text      | 2     | 4.76%      | Students have worked but cannot display the text.                           |
| 4  | Image placement      | 0     | 0%         |                                                                              |
| 5  | Animated Image       | 39    | 98.86%     | Static images due to difficulties in the relationship of the repetition function and the costume function |
Table 4 explains the conversations encountered when students conduct experiments making mathematical media using block language and the placement of initial attributes that need to be conveyed namely 1) the workings of the function if then, if other, and if there are more branches, use analogy verification; 2) how it works, the benefits of using and examples of repeat use, forever, and repeat until; 3) Apply block language according to the intended use.

| No | Obstacles                          | Total | Percentage | Information                                                                 |
|----|------------------------------------|-------|------------|-----------------------------------------------------------------------------|
| 6  | Mathematical Function              | 0     | 0%         | -                                                                           |
| 7  | Image linkages with Mathematics    | 42    | 100        | Mathematics is still in the form of abstract which explains it by using communication between two objects |

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Figure 5 explains the strategy of making Scratch media using a sample of media about the Smallest Multiples Allocation that was made according to a plan that involved drawings that would explain the mathematical material. To run the drawings when the two numbers are input until the results are obtained, a scenario or story has been made from the engineering notes in the form of block language applications in scratch, 3 program languages are very important to convey to students, namely 1) Using if-else functions to change the value of tens associated with mathematical functions, namely modulo, operations for, times, less, and rounds or rounding numbers. The if-else function, this is the basic language of the if branch function, because students are led to an understanding of two true and false statements; 2) Using the branched if function, the language of this program is the development of the if-else function, students will be faced with many conditions consisting of many different message senders, to the two lights where the first lamp will light according to a multiple of the first number and the second light will light up according to the multiples of the two turns each other until both lights are on; 3) Using the repeat function is added a time function as an animation generator on all attributes so that the media will be more interactive and interesting.

All the explanations presented to students, the study conducted an overall evaluation by asking questions that were not understood by students by asking directly. The results of student statements regarding students’ lack of understanding of the language of the program can be seen in table 5.
Table 5. Student Statement about the Scratch Program Language

| No | Program language section | Statement and question |
|----|--------------------------|------------------------|
| 1  | if-else function         | There are no obstacles |
| 2  | if branched function     | How to put lots of if blocks |
| 3  | Repeat function          | Distinguish if outside and inside the function. |
|    |                          | Why should you add time or wait for blocks |
|    |                          | Distinguish repeat function and function forever as a new finding to visit. |

Table 5 explains the students' questions that were discussed, related to, and focused on the workings of the media related to students' problems after learning the block language from 3 language programs. After they agreed and discussed, the researchers gave the task again to make media software related to mathematics.

Table 6. Analysis of Student Constraints in Using Block Language After Learning from the Results of Making.

| No | Obstacles               | Total | Percentage | Information                                                                 |
|----|-------------------------|-------|------------|-----------------------------------------------------------------------------|
| 1  | Logic language          | 3     | 7,14%      | 1 The student misplaced the block if it was switched while running the program, 2 Student placed the wrong broadcast inside if it branched out. 92.86% there are no obstacles |
| 2  | Use of the turning function | 1    | 2.38%      | 1 Student mistakes using broadcast in a repeat that collides with each other in bringing up the story. 97.62% there are no obstacles |
| 3  | Mastery of Text         | 0     | 0%         | there are no obstacles                                                       |
| 4  | Image placement         | 0     | 0%         | there are no obstacles                                                       |
| 5  | Animated Image          | 0     | 0%         | there are no obstacles                                                       |
| 6  | Mathematical Function   | 0     | 0%         | there are no obstacles                                                       |
| 7  | Image linkages with Mathematics | 0  | 0%         | there are no obstacles                                                       |

Table 6 explains the analysis of student difficulties and input from students when they make a mistake, namely how to block according to the storyline or scenario to create media, namely drawing and writing designs before making media, then compiling an algorithm that drives a program using block language.
Figure 6. Results of Student Development Media.

Figure 6 explains one of the results of media development after learning and discussion, students can already learn how to place objects and divide tasks according to scenarios that have been made. 1) The first step, determine the numerator and denominator using mathematical functions; 2) the second step, determine the type that will be explained whether the shape of a circle or rectangle, students have mastered if otherwise; 3) Third step, fix the picture of the cat and think of a circle or rectangle that is thought to be asking for a butterfly and run it, the student approves the function if otherwise, repeat, and wait; 4) automatically the beetle image will add asiran to fields related to fractions, the findings of which have been prepared here by the broadcasting function student, that is, the function that connects objects independently.

Figure 7. Development of Mathematical Media with Different Materials

Figure 7 explains an example of the results of the making of mathematical media, namely a game to determine the unit of length using a ladder, media to explain the area of a triangle, a media game to determine Pythagoras, and the media explain the basic logarithmic functions. From the results obtained, several new findings can be seen in the creative requirements of students to calculate messages that use
exponentials, making storylines that have sufficient advantages to provide explanations, making new drawings using the pen function, motion animation using the glide function. The development of mathematical concepts using Scratch software makes students more active and interactive [17, 18] and creates teacher initiatives to make math games more interesting [19, 20].

4. Conclusion
Beginning software is software that offers media users who use very easy language programs suitable for prospective teachers or students who wish to learn in the classroom more interactive and interesting. 7 outlines need to be considered to create media from scratch, namely logic language, turning function, handheld text, placement drawing, animated drawing, mathematical function and arrangement, and mathematical images. Also, students have to use a simple block programming language that is a function if otherwise, if it is branched, repeat, wait, and forever as an important factor in making media.

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