**DEVELOPMENT OF AUDIO-VISUAL MEDIA TO IMPROVE OPEN UNIVERSITY STUDENTS’ ABILITY TO SOLVE MATHEMATICAL PROBLEMS**

**Abstract.**

Problem solving is main goal of students learn mathematics because through it the students acquire productive thinking which is critical and creative thinking. The research aimed to develop audio-visual media improved the ability of UT students in solving mathematical problems which met valid, effective, and practical citeria. This research was classified as developmental research. The subjects were undergraduate students of PGSD UPBJJ UT Jember, Surabaya, and Malang who taked Mathematics course. The development of this media used Plomp stages which were initial investigation, design, realization/construction, test, evaluation and revision, and implementation. The instruments were tutorial kits, audio visual media, expert assessment sheets, tutor activity observation sheets, and four mathematical problems. Each student’ssolution was scored using holistic rubric with scale 0 - 4. Therefore, the maximum score of each student is 16. The result of the research showed the students’ scoresas before and after the implementation of visual media were 7.51 and 11.9 respectively. The statistical test results showed the normal gain increase more than 0.5 significantly with a 95% confidence level.

**Keywords**: audio-visual, media, mathematical problems, problem solving, mathematics tutorial

**INTRODUCTION**

The National Council of Teachers of Mathematics (NCTM) in Principles and Standards for School Mathematics (NCTM, 2000: 52) states: "solving problem is not only a goal of learning mathematics, students should acquire ways of thinking, habits of persistence and curiosity, and confidence in unfamiliar situations ..."(National Council of Teachers of Mathematics, 2000). Furthermore, students who study mathematics but lack of the ability to solve problems, then their understanding of the benefits and usefulness of ideas, knowledge, and mathematical skills will be limited (Watters & Logan, 2004).

In addition, students can acquire high-order thinking skills through learning to solve math problems (Adams & Hamm, 2010; King, Goodson, & Rohani, 2016). The ability is divided into two, namely critical and creativethinking. Critical thinking is thinking that is directed to solving math problems. Creative thinking is the highest ability directed to find other ways or answers from mathematical problems (Krulik, Rudnick, & Milou, 2003). Based on these definitions, the two capabilities are directly related to math problems.

The math problem itself can be interpreted as question where the way to solve it is not immediately visible to students (Polya, 1973). An example of a mathematical problem is "A number consists of three numbers. The third number is equal to 16. The number of tens plus the unit number is equal to eight more than the unit number. If the number of hundreds and unit numbers are converted to the same number. Determine the number ". Problems are different from routine exercises.

Routine questions can be solved by applying some mathematical formulas or procedures directly to obtain an answer (Hudojo, 2005; Posamenteir & Krulik, 2009). This means the student does not need to understand the problem by creating a mental image of the condition in the problem to determine the answer of the routine question. Students do not necessarily have to synthetized the previously learned concepts and procedures in developing the plan used to find the answerof routine question. Example of routine questionis "Determine the answer of SPLTV: x + y + z = 1; x -y + z = -1; x + y-z = 4".

There are different from math problem. Students perform both activities to determine the correct answer of the problem. In addition, students also need to implement the previously developed plan and look back the solution has been made (Polya, 1981). There are two different terms used in relation to problem solving which weresolution and answer. The solution is the process that students undertake in solving problem from beginning to end. The answer is something produced at the end of the process (Krulik, Rudnick, & Milou, 2003).

The importance of solving math problem is not accompanied by the facts on the schools. The research results showed that students have difficulties in solving the problem. This difficulties occured because the students did not have a meaningful understanding of the concepts that exist in the problem, had no knowledge of approaches or problem-solving strategies, or lacked knowledge formed from previous experience in solving problems. It caused the students to hesitate in making plans, using other problem solving which is in contrast to the problem being solved (pseoudoplan), incorrect in using symbols or mathematical concepts, using targets as the known, creating pseudosolutioning (the solution felt true by the students but actually wrong), unable to justify the solution has made, or not know the location of the error and how to correct it (Mairing, 2014).

Thus, one of the factors that influence the ability of students in solving math problems is their understanding of the concepts that exist in the problem. Students who have a meaningful understanding are more capability to solve problems than those that are not meaningful (Hudojo, 2005). A meaningful understanding is formed if the math concepts are associated with previous knowledge in the mind of the students. The linkage of concepts occurs when new knowledge is constructed actively and independently by students (Sutawidjaja & Afgani, 2011).

Tutors should create learning activities or tutorials that can encourage students to be actively involved and independent. Such conditions may occur if the tutorial is tailored to the student's condition, the depth of the material or concepts studied, the characteristics of the tutorial, and the availability of learning resources. Especially for tutorial activities at Open University, the role of students is very dominant where the students understand the materials of BMP (Buku Materi Pokok) and tutorial kit developed by tutor independently. Furthermore, the students reinforce this understanding in face to face tutorial activities. However, the activities are only 8 times so that students are required to use all their learning resources to construct a deep understanding.

Learning resources that can help students in self-study is a media of learning. Media itself is defined as everything that can channel the message, and can stimulate the thoughts, feelings and motivation to learn so that the creation of learning processes in students (Setiawan, Pribadi, Suroso, & Andayani, 2007). The intent is achieved if the media is interesting and easy to use. In addition, the characteristics of tutorials at the Open University that emphasize distance learning require a medium that can deliver tutor messages to students dynamically. One such medium is the audio-visual media. Audio-visual media is an intermediate medium or any form that is used to channel the message of information / material and its absorption through sight and hearing so as to build conditions that can make students able to acquire knowledge, skills, or attitudes. (Arsyad, 2002: 11).

Based on the above description, the researchers intended to develop audio-visual media that can improve the ability of open university students in solving problems in the Mathematics course. The researchers chose this audio visual media in addition to interesting, the media can also run on computers and smartphones (smartphones) so that students can learn many times, anywhere, and anytime independently. This media should be interesting because of the current tendency where students are very fond of everything related to computers and smart phones. Furthermore, this media also gave students the opportunity to learn over and over when something is still not understood. If the concept or material remains unintelligible, the student may ask the tutor in the next tutorial. Such a process can encourage students to have a deep understanding. Furthermore, this understanding can help students have the ability to solve math problems, and high-order thinking skills.

**THE INITIAL INVESTIGATION STAGE**

The researchers gave the initial problems to investigate initial ability to solve problems

**THE DESIGN STAGE**

The resereachers design tutorial kits, audio visual media, dan reseach isntruments

Initial scores of the students’ ability

Blue prints of tutorial kits, audio visual media. Research instruments

**THE REALIZATION AND CONSTRUCTION STAGE**

The res

earchers realized the blue prints

FIRST PROTOTYPE OF THE MEDIA

**THE TEST, EVALUATION, AND REVITION STAGE**

The first prototype was evaluated by three experts

SECOND PROTOTYPE OF THE MEDIA

**THE IMPLEMENTATION STAGE**

The researchers implemented the second prototype to the subjects

**AUDIO VISUAL MEDIA**

Figure 1.The Devolopment Procedure

Based on the above background, the problem formulation in this research is how to develop audio visual media that can improve the ability of open university students in solving problems in valid, effective, and practical in Mathematics course? The media was said to be valid if two of the three experts agree or strongly agree that the media have been developed in accordance with theories of constructivist learning and mathematical concepts. The three experts are UT lecturers in mathematics courses, and two experts in mathematics or mathematics education. The media was said to be effective if the media can improve students' ability in solving math problems. The media was said to be practical if all students use the media in learning, and 80% of them agree or strongly agree that the media is easy to use.
Benefits of this research were seen from the outcome of this research is audio visual media that can be used not only by researchers, but also by lecturers who teach other subjects. The use of audio-visual media is intended to create enjoyable learning and that help students to construct meaningful knowledge. Such learning can encourage the improvement of students' skills in solving mathematical problems. These improvements have a direct impact on improving the quality of learning at the Open University.

The theoretical benefits of this research are to provide a theoretical background and ground on how to develop an educational product that is useful in creating active, creative, effective and enjoyable learning. Such learning is expected to help students have a meaningful understanding. Students who have such understanding are expected to be able to learn something new independently, and be able to solve math problems.

**RESEARCH METHOD**

The purpose of this research is to develop audio-visual media that can improve the ability of UT students in solving problems in valid, effective, and practical IN Mathematics course. Thus, the output of this research was audio visual media. The media was developed using the product development stages put forward by Plomp (1997). In other words, this research produces a certain educational product which was audio visual media, so pertained in research and development.

The subjects of this research were 71 open university students of PGSD UPBJJ Surabaya in Lamongan, Mojokerto, and Madiun who take Mathematics course (code of course was PDGK 4108) during registration 2017.1. The research instruments are tutorial kits, audio visual media, expert assessment sheets, tutor activity observation sheets, questionnaire, and four math problems. Each student solution of the problems was scored using a holistic solution of problem solving on a scale of 0 - 4. They were four problems so the maximum score for each student was 16.

The development of audio visual media uses the stages of development of Plomp educational products (Plomp, 1997: 5). This development stages generally consists of four stages: (1) initial investigation, (2) design, (3) realization / construction, (4) test, evaluation and revision and (5) implementation. The stages could be seen in Figure 1.

Data analysis technique in this research was done by comparing data in each stage of development with valid, effective and practical criteria which have been predetermined, and to test hypothesis to know the improvement of students’ ability in solving math problem. The hypothesis was:

$H\_{0}: $gain normal $\leq 0.5$

$H\_{0}: $gain normal $>0.5$

where

$$G=\frac{initial score-final score}{16-initial score}$$

The conclusion withdrawn by using a two paired samplescomparison test. The test was conducted by researchers using statistical software which was Minitab 17.

**THE RESEARCH RESULTS AND DISCUSSION**

**The Research Results**

This research aimed to develop audio-visual media that can improve the ability of open university students in solving problems in valid, effective, and practical Mathematics course. The development used the Plomp stage which were (1) initial investigation, (2) design, (3) realization / construction, (4) test, evaluation and revision and (5) implementation. Description of the results of his research is based on these stages.

**The Initial Investigation Stage**

At this stage, the researcher identified the initial conditions of the students' ability to solve and the factors that cause the current condition. The initial conditions were identified by giving four initial problems.

*Initial Problems*

1. Let $g\left(x\right)=x+1$ and $gof\left(x\right)=3x^{2}+4$. Determine $f\left(0\right)$! Expalin your solution!
2. From a group of students consisting of 6 men and 4 women, a team of 3 students will be formed. What is the probability that there are two men in the team?
3. Find all numbers that satisfy $x^{2}<\left|2x-8\right|$!
4. Adi is an employee of a textile company in charge of storing data. Adi asked the head of the company to prepare data on the increase of production for five periods. After searching, Adi only found four data, that is 4%, 9%, 7% and 5%. One of the data, fifth data not found. Investigate the fifth data, if Adi only remembers that the average and median of the five data are the same!

The results showed that the average score wass 7.51 (maximum 16), if converted to a scale of 100 to 46.9 (Table 1).

Table 1. Initial Ablity of the Students in Solving Problems

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Average** | **Minimum** | **Maximum** |
| Awal | 7.51 | 1 | 16 |

The ability of students in solving problems can be classified into good, routine, and naive problem solvers (Goldstein, 2011; Muir, Beswick, & Williamson, 2008; Sternberg & Sternberg, 2012). In this study, the student was naive problem solver if the score is in every problem 0 or 1, good problem solver if get score 4 in every problem, besides belong to routine problem solver. Tutors certainly hoped the students were classified as good problem solvers. However, preliminary investigation results show that the percentage of students who were classified as good, naive, and routine problem solvers respectively were 2.8%; 95.8%; and 1.4%.

The results of interviews with tutors and students indicated that the condition occurred because the students did not have a deep understanding of concepts in the Mathematics course, and the students had no experience in solving previous math problems. Both of these affect the ability of students in solving mathematical problems (Mairing, 2017).

**The Design Stage**

Based on previous results, researchers designed audio visual media that integrated with the tutorial kits. The tutorial kits consisted of the Tutorial Activity Plan (TAP), the Tutorial Activity Unit (TAU) and the Evaluation Plan (EP) and the student worksheet (SW). RE consists of Tasks 1, 2 and 3. Each task contained the math problems. The audio-visual media emphasizeda deep understanding of the concepts in the Mathematics course, and gave students experience in solving problems. The media was designed in eight tutorials with the following details.

Table 2. Desain Media Audio Visual

|  |  |  |
| --- | --- | --- |
| **Tutorial** | **Concpets** | **The tutorial aims** |
| 1 | Math problems, and Problem Solving | The students could explain an importance of solving problems as the main goal of students in learning mathematics, and Polya phases of solving problems. |
| 2 | 1. Logics
2. Set, relation and function
 | The students could explain logics, set, relation, and function concepts. |
| 3 | Task 1 | The students could solve problems |
| 4 | a. Linear equation and inequality b. Qudratic equations, and non-quadratic equations | The students could explain linear equation. inequality, udratic equations, and non-quadratic equations |
| 5 | Task 2 | The students could solve problems |
| 6 | a. Probabilityb. Social Arithmetics | The students could explain probability and social arithmetics |
| 7 | Task 3 | The students could solve problems |
| 8 | a. Transformationb. Congruent | The students could explain transformation, and congcruent |

Furthermore, the researchers designed a data collection instrument consisting of an expert appraisal sheet, a tutor activity observation sheet, a student questionnaire, and a final test containing four mathematical problems which were similar to the initial test differing only in the numbers.

*Final Problems*

1. Let $g\left(x\right)=2x-4$ and $gof\left(x\right)=3x^{2}-11$. Determine $f\left(0\right)$! Expalin your solution!
2. From a group of students consisting of 8 men and 6 women, a team of 3 students will be formed. What is the probability that there are two men in the team?
3. Find all numbers that satisfy $x^{2}<\left|3x-18\right|$!
4. Adi is an employee of a textile company in charge of storing data. Adi asked the head of the company to prepare data on the increase of production for five periods. After searching, Adi only found four data, that is 4%, 10%, 6% and 8%. One of the data, fifth data not found. Investigate the fifth data, if Adi only remembers that the average and median of the five data are the same!

**The Realization Stage**

At this stage, the researchers were realizing tutorial kits, audio-visual media, and pre-designed research instruments. The tutorial kits consisted of eight meetings. The media were studied by students before the 1st, 2nd, 4th, 6th and 8th tutorials. Thus, there were five media developed in this study. The result of this stage is a first prototype of audio-visual media.

**The Test, Evaluation and Revision Stage**

At this stage, the first prototype was evaluated by three experts which were mathematics expert, mathematics education expert, and tutor. The result was the three experts agree or strongly agree that the media was in accordance with learning theories, and mathematical concepts. Furthermore, the three experts stated that the first prototype was feasible to use with some suggestions. The researchers revised the first prototype based on the suggestions from the three experts into a second prototype of audio-visual media. The second prototype was used in the implementation stage. Thus, audio visual media has met the criteria of validity.

**The Implementation Stage**

The second prototype was implemented on the subjects of research. The subjects studied independently the materials in the media before the 2nd, 4th, 6th and 8th tutorials. At the time of tutorial, the tutor and the subjects discussed materials that have not understood, or mathematical problems that students could not solve yet. The tutor facilitated the students to have a deep understanding and experience in solving math problems.
During the discussion to solve mathematical problems, the tutor guided students to solve problems using the Polya stages which were understand the problem, develop plans, implement the plans, and look back a solution. The tutor did the activities by asking metacognitive questions at each stage.

At the eight tutorial, the researcher gave a student questionnaire and final test consisting of 4 math problems similar to the initial test. The aim of the test was to know the improvement of students' ability to solve problems after learning by using audio-visual media. The questionnaire results show that all students use the media in learning, and 80% of them agreed or strongly agreed that the media was easy to use. Thus, audio visual media has met the criteria of practicality.

The final test result showed that the average score of students' ability was 11.59, if converted to a 100 scale of 72.5. Furthermore, there had been an increase of a number of the good problem solvers from the initial test to the final test with an increase percentage of 21.1% - 1.4% = 19.7% (Table 3).

Table 3. Scores of Students’ Ability

|  |  |  |
| --- | --- | --- |
|  | **Statistics** | **Problem Solvers** |
|  | **Average** | **Minimum** | **Maximum** | **Naive** | **Routine** | **Good** |
| Initial | 7,51 | 1 | 16 | 2.8% | 95.8% | 1.4% |
| Final | 11.90 | 6 | 16 | 0% | 83.1% | 21.1% |

The hypothesis test was performed using two-sample comparison test. First, the initial and the final scores of each student were changed to normal gain. The average of normal gain was 0.56. Second, the researchers tested the normality of the normal gain using a Kolmogorov Smirnov test. The result using Minitab 17 was $p-value <0.01 <0.05 = α$. The result of the normal gain spread was not normal, so the researchers used a nonparametric test Wilcoxon. The result using Minitab 17 was

**Wilcoxon Signed Rank Test: Gain Normal**

Test of median = 0,5000 versus median > 0,5000

 N for Wilcoxon Estimated

 N Test Statistic P Median

Gain Normal 71 61 1261,5 0,012 0,5714

The result was $p-value = 0.012 <0.05 = α$ so the increase of normal gain more than 0.5 significantly with a 95% confidence level. Thus, the use of audio-visual media could improve students' ability in solving mathematical problems.

**Discussion**

The ability of students to solving math problems was influenced by students' understanding of the concepts existed in the problems, understanding of the problem being solved, prior experience in problem solving, understanding of approaches and problem-solving strategies, student attitudes toward math, and student confidence (Mairing, Budayasa, & Juniati, 2012; Pimta, Tayruakham, & Nuangchalerm, 2009). The results of this study emphasized on the use of audio-visual media in order to encourage the students had a deep understanding of the concepts related to the problems that contained in the students’ worksheets, and task 1, 2 and 3. Such understanding helps students in solving math problems.

Furthermore, tutorial activities in this research were based on the use of the problems in the class. The tutor facilitated discussions to solve the problems contained in students’ worksheets both in group and class discussions. The tutor also guided the students to solve the problems by asking questions on each stage of Polya. Furthermore, the tutor asked the students to determine different answers, and other ways of solving the problems. The aimed to improve students' ability to solve problems. Such tutorial activities affect these abilities (Ho & Hedberg, 2005; Muir, Beswick, & Williamson, 2008).

**CONCLUSIONS AND SUGGESTIONS**

Math problem solving is main goal of students in learning mathematics because students acquired high-order thinking skills and positive attitudes by learning to solve some problems. Tutorials that emphasized the use of the problems, and audio-visual media could improve students' ability to solve math problems. The results of this research indicated that the average score of the ability increased from before (initial) and after using the media (final). The average of initial and final score were respectively 7.51 and 11.9 (maximum score was 16). There was increasing of 58.5%. The increasing was in line with the results of hypothesis testing showed that the normal gain of the scores increase was more than 0.5 significantly with a 95% confidence level. Thus, the use of the audio-visual media integrated with tutorials based on math problems could improve students' ability to solve math problems.

The results of this research can be used as an example for other tutorials in developing audio-visual media for other subjects. The tutors who develop the media should integrate audio-visual media with problem-based tutorials. The tutors should guide students in solving problems by asking some metacognitive questions in each Polya’s stage. The tutors should also encourage students to develop different answers, and other ways of solving problems. Such activities can improve the ability to solve math problems.

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