ATLANTIS PRESS

Advances in Social Science, Education and Humanities Research, volume 326

3rd International Conference on Current Issues in Education (ICCIE 2018)

Augmented Reality Module to Improve Mathematical Communication: Is it Necessary for Elementary Students?

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***Abstract*—Mathematical communication is one of the basic math skills. It can be developed on a math lesson with all the learning resources that students and teachers have. Module based Augmented Reality (AR) is one alternative learning resources that can help students and teacher during the learning process. The purpose of this study is to know the importance of the AR module to improve mathematical communication of elementary students. This study uses a survey with questionnaire distribution and interview session. The data were collected from the elementary schools in Kulon Progo District, Yogyakarta with total respondents of 1000. The findings revealed that total percentage of the students' level in Mathematical communication was 40,3% (low category) and the level of students' Mathematical communication on each aspect was 48,68% (low category). The teacher did not have the learning resources to develop mathematical communication. In fact, the students are very interested in the gadget. It will be beneficial to develop an AR module by involving gadget to improve the students' Mathematical communication.**

Keywords—augmented reality, elementary student; module, mathematical communication

I. INTRODUCTION

Mathematics is one of the compulsory subjects which it is very important. Wasserman considers Mathematics as a subject that should be given big attention [1]. Math should facilitate students' Mathematical skills to help them in their daily life and in the future. The purpose of the mathematics course is that students have the ability to communicate ideas with symbols, tables, diagrams, or other media to clarify the situation or problem. It is also in accordance with the standards of mathematics education set by the National Council of Teachers of Mathematics[2]. In the NCTM in 2000, the process standards to be achieved are mathematical communication, mathematical reasoning, mathematical problem solving, mathematical connections, and mathematical representations. It is known that one of the mathematical skills that need to be developed is mathematical communication.

Young children should use math language to express mathematical ideas [3,4,2,5,6]. The students need the skill to express their own mind by language to solve the problem. The teachers must create a link between mathematics and language [5,7]. Similar opinions about mathematical communication are also expressed by Schoen, Bean, and Ziebarth [8]. They define mathematical communication as the students 'ability to explain an algorithm and a unique way of solving problems. Here is the students 'ability to construct and explain real-world phenomena in graphs, sentences, equations, and tables or students' ability to give conjecture about the pictures of geometry.

Unfortunately, Mathematical communication did not develop well by the teacher. They give little attention to this point and make students had less Mathematical communication. The students find it difficult to understand the symbol/ picture and they cannot express the meaning of the picture, diagram or other media. Most of the students cannot solve the problem that involves symbols, picture, and diagram. They tend to prefer the exercise of Math without the diagram.

The success in the process of learning either Math or other subjects affected by many factors. In the case of Elementary school students, they are at level operational concrete according to Piaget's theory. In this level, the students need concrete objects to understand the concepts of the lessons. Therefore, the selection of the right media is crucial to help students learn the subject matter that is abstract. Learning media can be in the form of hardware and software. Sanjaya, W. [9], suggests that the hardware includes OHP, radio or television while the software involves books, printed materials such as learning modules. The module is a complete learning resource and compiled systematically as learning materials. The module can be used as an easy reference for students. Research results Crimmins & Rupprecht [10] indicates that the module as fun learning materials. The module can also improve understanding of the materials effectively. Prastowo [11] suggests that a minimal module structure contains seven items namely title, lesson learned (student or teacher instructions), competency, supporting information, exercises, instructions or worksheet, and evaluation. The modules can be combined with the development of technology, such as Augmented Reality (AR).

AR is one of the new technology that can combine between the real world and digital technology. Johnson, Levine, Smith, & Amp; Stone (Patrick, 2010: 91) argues that AR is mixing or adding virtual-information data, wealth media, and even the direct action – anything that can be seen in the real world to increase information with our senses. In other words, AR helps the user to obtain information from their senses. Similar to Johnson opinion, Julie Carmigniani and Borko mention the aims of AR is to simplify the user by bringing the virtual information into the real world, as a live video. It is also to increase of perception and user interaction to the real world. The learning module based AR was aimed to help students to receive information through combining virtual data with the real world. Thus, students can experience clearer instead of reading or seeing them.

This research supported Marry E Brenner study [12] on the examination of mathematical communication in two algebra classes. This study contrasted with the other classroom in which students engaged in extensive mathematical communication in small and large group formats. The paper discusses how small groups facilitate the development of communicative competence and the potential value of computers for stimulating discussion.

Next research comes from Qohar [13], Qohar develops the mathematical communication skills in learning mathematics through discussion. It describes the mathematical communication and the way to enhance mathematical communication skills. It emphasizes the development of mathematical communication skills with the application of the learning model such as reciprocal teaching approach. It changes the paradigm of learning, from the old paradigm where the teacher as a learning center into a new paradigm in which students become the center of learning, and teacher as a motivator and facilitator.

II. METHOD

This study uses survey research. It refers to a survey expressed by Rea and Parker [14] as follows: (1) identification of the study focus and method, (2) the research schedule and budget, (3) the information establishment , (4) the sampling frame, (5) the determination of sample size and selection, (6) the design of the survey instrument, (7) the pretest of survey instrument (8) the selection of interview model, (9) the survey implementation, (10) the categorization and codification of the completed questionnaires and entry data, and data analysis (11) and final report.

This research had taken place in the primary school in Kulon Progo, Yogyakarta. This research was started from May until June 2017. The population of this research was all students of the fourth grade in the primary school in Galur. A sampling technique that used is non-probability sampling, especially purposive sampling. The specified sample was twenty-eight students of X school, twenty-nine students of Y schools and thirty students of Z school. Total number of students who became respondents amounted to 100 students. The selection of three schools X, Y and Z with the consideration that the three primary schools were those had employed the 2013 curriculum.

The data were collected by questionnaire and interview. The main data were taken by the questionnaire with the range of 1-4 and interview. The obtained data were analyzed and interpreted. Here is the guidelines to that used in this research.

TABLE I. QUESTIONNAIRE GUIDELINES

Aspects	Indicators	Items
Written Texts	The students' ability to explain the concept, ideas, or situation by their own language clearly and logical	1,2,3,4,5,6
Drawing	The students' ability to draw the diagram and table completely and properly.	7,8,9,10,11
Mathematical expression	The students' ability to make algebra or mathematics model then solve it correctly	12,13,14,15

The data in this questionnaire was analyzed with the percentage. The percentage of students' response was obtained from the formula s follow.

$$\frac{\text{value of expectation score}}{\text{value of expectation}} \text{x } 100\%$$

The obtained results were compared with this category below.

TABLE II. INTERPRETATION OF QUESTIONNAIRE PERCENTAGE

Percentage	Category
$76\% < x \leq 100\%$	Very high
$51\% < x \leq 76\%$	High
$26\% < x \leq 51\%$	Low
$0\% < x \leq 26\%$	Very low

III. RESULTS AND DISCUSSION

In this section, the results of this work are presented. The results from the questionnaire found that

TABLE III. QUESTIONNAIRE RESULTS

Elementary School	Percentage	Category
Elementary School X	47%	Low
Elementary School Y	50%	Low
Elementary School Z	24%	Very low
Total	40,3%	Low

Based on the table above, it was shown that mathematical communication is low. The school of X and Y were in the range of 26%-51% which was indicated the low category. The Z school was in the

range of 0%-26% that was showed very low. Overall, the level of the students' Mathematical communication in Kulon Progo Yogyakarta was in 40.3% which can be categorized in the low category.

TABLE IV. PERCENTAGE OF EVERY ASPECT OF STUDENT MATHEMATICAL COMMUNICATION

Aspects	Percentage	Category
Written Texts	49%	Low
Drawing	46.80%	Low
Mathematical expression	50,25%	Low
Total	48,68%	Low

The percentage of the students' mathematical communication in Kulon Progo showed that the percentage written aspect was 49%, the percentage of drawing aspect was 48.80%, and the Mathematical expression aspect was 50.25% respectively. Overall, the percentage was in the low category, i.e. 48.68%. The percentage of questionnaire results from elementary school X, Y, Z were 47%, 50 %, 24 % respectively with the total of 40.3% and it includes in the low category.

This research was also supported by interview data with each classroom teachers from those three schools. The teacher from the X school said that (1) the students did not have resources to support the development of Mathematical communication, (2) Teaches mostly spend his teaching by writing on the board, (3) the students find it difficult to communicate the idea and to solve the math problem, (4) the students were very interested in the gadget.

The teachers from the Y school mentioned that (1) the students had learning resources but the teacher never used it. (2) the teacher tried to practice some learning media but the students seem not really interested. (3) many students can express easily their idea to solve the problem. (4) the students were very interested with gadget.

The teacher from the Z school stated that (1) the students did not have learning resources was which interesting and supporting to improve mathematical communication, (2) the teachers always made sure that the students paid attention to the teacher by having quiz, (3) the students found it difficult to communicate the idea to solve the math problem, (4) the students were very interested with gadget.

The percentage of the student's level on Mathematical communication in Kulon Progo showed that the percentage was in the low category, i.e. 48,68%. It needs to be improved because mathematical communication is needed by students to enhance understanding. Moreover, the students who already had the mathematical understanding demanded to be able to communicate his understanding, so that it can be understood by others. By communicating mathematical ideas, students can enhance their mathematical understanding [16].

Based on the interview, it was found that students did not have learning resources which is interesting and supporting to improve their mathematical communication. Learning resource is one of the important factors that supports the learning process. The student can use learning resources to improve their Mathematical communication. The lack of learning source can influence their study. They need learning support to improve their mathematical communication wich suitable for their interest. AR module can be a suitable choice because the students can study and enjoy learning through module combined with the gadget. The student's interest in gadget become beneficial opportunity to employ module based augmented reality during the learning process.

IV. CONCLUSION

Based on this research, it can be concluded that AR is necessary for the elementary students because they have a low category for mathematical communication with the total percentage of 40,3% (low category) and the percentage of the students' Mathematical communication on every aspect was 48,68% (low category). The teacher did not have learning resources to develop the students' mathematical communication and the students were interested in the gadget. The recommendation which can be given based on this research results is by making research to improve mathematical communication, especially the AR module which can help the teacher to improve students' mathematical communication.

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