Development of realistic mathematics education based learning device to improve students’ mathematical connection

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Abstract. Mathematics is not directly given to the students in the form of formulation, however students have to construct the knowledge by themselves through contextual problem interactively, both in formal and informal, so that students can discover the truth of the concept by themselves. One of the important components in mathematics learning is mathematical connection; however, students’ ability of mathematical connection is far from the expectation. Therefore, the development of learning device with an approach and strategy to allow mathematics as the activity of the students is of vital importance. The designed learning device by using RME approach and by adding strategy of relating, experiencing, applying, cooperating, and transferring (REACT) based on constructivism which places the students as the center of the learning. The purpose of this research is to develop RME based learning device which is valid, practical and effective to improve students’ mathematical connection of class IX Junior High School (SMP). This is a development research model by employing Plomp model which consists of three phases, namely, preliminary research phase, development and prototyping phase, and assessment phase. Preliminary research reveals that students are less interesting to learn mathematics since they have only few chances to find concept through relevant practice with their individual experience and that are suitable with students’ cognitive level.

1. Introduction

Indonesia has followed TIMSS (Trends in International Mathematics and Science Survey) and the result shows that more than 95% of Indonesian students are only able to solve the low level problem, comparing to Taiwanese students who are almost 50% of them able to reach high level reasoning ability[1]. The research result of PISA (Programme for International Student Assessment) in 2015 reveals that the mathematical ability of Indonesian students is still very low. The achievement of Indonesian students in mathematics subject is only ranked at 62th out of 70 participant countries. Meanwhile, Indonesian score is only 386 which is far behind the average score, 490[2]. Some national and international level research scales revealed that the achievement of middle high school students in Indonesia is in low level particularly toward the comprehension of mathematical concept[3].

Process and learning result are two different things but related to one another. The achievement of students is the result obtained from the learning process experienced by teacher and students[4]. The quality of learning also depending on what teacher did in the classroom to produce well prepared human resource in the future[5]. Mathematics education in Indonesia experiences positive transformation in the education curriculum as a real effort of government to develop curriculum to improve learning at school.

In fact, the quality of students’ mathematics ability has not satisfied yet. Students failed to understand the importance of learning algorithm and its formula. They tend to just memorize it without necessarily
knowing the mechanism to understand the concept first before starting to memorize it[6]. This is supported with research conducted by Arsaythamby[7] who stated that teaching and learning mathematics in Indonesia mostly focus on teacher, mechanistic, and conventional, the main instruction is to memorize facts, concepts and formulations, classroom instruction provides less chance for the students to build their own knowledge so they tend to be a passive learner and less participated in the learning process. Students are expected to be active and to explore their ideas as to look for more opportunities and to take responsibility over their learning[8]. Instead of that, most teacher focus more on learning result as required by school administration rather than on the learning process. Hence, teacher only tends to fulfill the purpose of the curriculum.

Amongst the other causes of the low level of mathematics education quality are: 1) less opportunity for the students to practice the learning in real life situation, since the instructional purpose is still dominate by remembering facts, concepts, and they produce it orally, learning the aspect of computation, and implement the formula; 2) the poor quality of mathematics textbook and the learning topics is far from the students’ daily life, even the teacher find it hard to reveal the use of the topic they taught; 3) the low level mathematics education quality in Indonesia mostly caused by most teachers still stick to the traditional teaching[9]. In the textbook, numbers of abstract concepts are introduced without paying attention to the logic, reasoning, and comprehension aspects[4]. In general, the form of mathematics learning in Indonesia is almost the same as in some African countries as summarized by Feiter & Van den Akker and Ottevanger as follow: 1) “Talk and chalk” is the favorite teaching style; 2) focus on factual knowledge; 3) only correct answer that will be accepted and proceed; 4) most of the classroom activity focus on writing without necessarily pay attention toward physical activity[9].

The above problems also encountered by the researcher during observation and interview with both teacher and students of Public Junior High School (SMP) 2 IV Koto Aur Malintang and SMPN 2 Batang Gasan in Padang Pariaman District on July to August 2018. Based on the observation result of the preliminary research, it can be concluded that students tend to be passive and only some students are actively engaged. Students encounter many difficulties in solving mathematics model problems related with real life situation. Students also experience difficulty in relating between mathematics object and concept, so that they find it hard to determine what formulation they wanted to use. This can cause problems for students in looking for the answer to the questions. They may also feel confuse in the process of working on with mathematics algorithm which requires them to look for the final answer. These problems have caused students to get bored and to easily leave the mathematics whenever they find it hard to answer it. As the consequence, most of the students just copy their peers’ answer. Moreover, students also experience difficulty to work on the variety and different questions given by the teacher.

The interview result with mathematics teacher at school revealed that teacher relies heavily on the textbook as teaching media and fail to get the students working (LKPD) on designed by the teacher himself/herself as a learning resource for the students. The book employed provides less support for the students to allow them to explore their ideas. Hence, students are merely the receiver of information delivered by teacher as indicated by the difficulties the students experienced in comprehending the language used in the text book.

Regarding to the above problems, it is important for the teacher to conduct innovation in the learning process which is the biggest part in the curriculum. Today teaching practice is no longer teacher centered learning, but student centered learning. Mathematics learning process also cannot be separated from important component in the form of learning device. The learning media used by teacher need to be effective, efficient, practical, and suitable with students’ needs. Mathematics teacher also required to employ learning approach that can enable improvement on students’ mathematics learning. One of student centered learning the approaches which allow the students to improve their mathematical ability is Realistic Mathematics Education (RME)[3].

Literature resulted from research conducted in some countries including Indonesia have showed that the theory of Realistic Mathematics Education (RME) is a promising direction to revise and to improve students’ mathematical comprehension[5]. This is supported by research result[10][9][11][12], which
stated that learning with MRE approach is really help teacher to teach mathematics to students and has proven as able to improve their mathematics ability. Devrim and Sevinç also showed their research result that students have a positive attitude toward mathematics after using RME approach[13].

RME aimed to make mathematics learning become more interesting and more meaningful for the students by introducing subject through contextual problem where the problem itself is on the students’ knowledge and experience[7]. Mathematics is not given in its final result to the students, but they need to construct their own knowledge through contextual problem solving in an interactive way, both formal and informal, so that students can find the answer themselves or by teacher facilitating them to uncover the truth.

Mathematics purpose[14], one of the main things need to be mastered by students is the ability to connect and to find out the relationship between mathematics concept to solve the problems encountered. This is called as connection ability. RME approach will support students’ ability in mathematical connection[1]. It is expected that student can again find the concept and principles of mathematics and to relate the material learned with the other contexts or the other field of study. When students are able to connect mathematics idea, their understanding toward mathematics will grow deeper and last longer[15]. This is due to students are able to connect between mathematics topic with the other learning subject and their real life situation. Through learning that emphasize on the connections of mathematics idea, not only are the students can learn mathematics but they also learn to use mathematics.

Based on the variety of references as explained above, one of the efforts implemented by teacher to solve mathematics learning problem is by providing valid, practical, and active learning device by using RME approach. Teacher will implement RME learning that will be presented in the lesson plan and supported by student worksheet. In general, student worksheet on learning acts a teaching material to minimize teacher role but encourage students to be more active, as the teaching material to facilitate students to comprehend the learning material, as a simple learning material but loaded with task to exercise, and to facilitate the teaching implementation to the student[16].

Referring to the different kind of explanations above, researchers find it interesting to conduct research in developing RME based learning device. It is expected that this development will be effective and practical for both teacher and student. The development called effective on condition that it has positive impact on both parties in the teaching and learning process. In addition, the effectiveness may bring positive impacts toward the student[9]. The development on RME based learning device will be developed by adding strategies of relating, experiencing, applying, cooperating, and transferring (REACT) to support RME approach in order to achieve the expected learning purpose.

REACT is one of the learning strategies based on constructivism. In the other words, REACT strategy is a learning strategy that can be used to activate students in building their own knowledge. In building their own knowledge, students need to interact with their environment. RME approach is developed based on the constructivism philosophy which views knowledge in mathematics as unready things to be given to the students, but rather as result of constructivism of students who are learning. Therefore, in the realistic learning, students are the center of the learning itself, meanwhile teacher focus on their roles as the motivator and as the facilitator.

2. Materials and Methods

2.1. Materials

Realistic Mathematics Education (RME) need to be connected to the real world in the form of human being activity, so that learning material should be conducted by using real life context and to appreciate students’ ideas to work on mathematics problem. Gravemeijer[17] proposed three principles related with RME, namely, (a) guided reinvention and progressive mathematization, (b) didactical phenomenology, (c) self-developed models. Furthermore, the operational principle of RME has 5 characteristics, as follow: (a) The Use of Context, (b) use models, bridging by vertical instrument, (c) Student Contribution, (d) Interactivity, (e) intertwining.
One form of the designed alternative learning can brought students into a more actively students involvement on mathematics learning through REACT (relating, experiencing, applying, cooperating, transferring) strategy. This is a learning strategy with a contextual approach first developed by Michael L Crawford in the United States of America[15]. Learning with REACT strategy involving 5 strategies in the learning process as follow: (a) relating), (b) experiencing), (c) applying, (d) cooperating, (e) transferring[18].

Connection in its relation with mathematics is called as mathematics connection. Connection in its relation with mathematics is called as mathematics connection. Mathematics connection can be interpreted both internally and externally. The purpose of the mathematics connection is to enable the students to: (a) recognize the equivalent representation of a same concept, (b) recognize the relationship of one representation procedure to the other equivalent representation procedure, (c) using and assessing some mathematics connections, (d) using and assessing connection between mathematics and other disciplines[19].

2.2. Methods
This is a research and development (R&D) study. The resulted product is Realistic Mathematics Education (RME) based learning device with REACT strategy in order to improve mathematical connection of students class IX SMP. This research employs development model as adapted from Plomp Model. This model was developed by Tjeerd Plomp. This model consists of three phases, namely, preliminary research, development or prototyping phase, and assessment phase[20].

3. Result and discussion
Preliminary Research is aimed to collect information about the existence problem and probably requires revision and innovation. Moreover, identification or analysis is conducted to develop RME based learning device. This phase is to analyze the purpose including in the limitation of learning material that will be developed. The basic steps in this phase are needs analysis, curriculum analysis, concept analysis, students’ characteristics analysis, and learning device analysis.

3.1. Needs analysis
Needs analysis is aimed to uncover the problems in learning mathematics. The activities including in this needs analysis are students’ mathematics daily test result analysis, observation result analysis, and students’ mathematical connection ability analysis. Information collection is conducted by interviewing mathematics teacher of class IX SMPN 2 Batang Gasan and SMPN 2 IV Koto Aur Malintang on August 2018. The analysis on students’ mathematics daily test result shows 30.7% out of total 26 students who were able to achieve minimum completeness criteria (KKM). Meanwhile, the result of observation analysis on learning implementation shows that students are still passive and contribute less knowledge; also their ability of mathematical connection is still low in accordance to the preliminary test conducted by researchers. Based on the collected information, it can be concluded that students are in need of new learning approach that can facilitate the improvement of students’ activity and students’ mathematical ability.

The other needs analysis can also be seen on learning device used by teachers and students. Based on the result of observation toward teacher and students, it can be seen that students are still using textbook as the learning material in the learning activity. The textbook is often called as the biggest learning material resource, example of question, example of the exercise, and some small part of working instruction for the students to allow them to find mathematics concept. The use of student worksheet in the learning activity is rare and most of it containing summary of the learning material and exercise question. LKPD or student worksheet has yet been able to facilitate students to develop their mathematical connection ability. LKPD is about the instruction on learning task related with situational interpretation toward mathematics modelling as well as to relate different mathematics concepts. The analysis result uncovers some problems in mathematics learning. Based on the problem findings, lesson
plan and student worksheet are then redesigned in order to improve students’ ability of mathematics connection of class IX.

3.2. Curriculum analysis
This stage is to analyze whether competency standards and basic competencies have been well prepared in supporting the achievement of curriculum purpose. The analysis also conducted by looking at the sequence of basic competencies in which finally to produce indicators of students’ achievement in learning. Based on the analysis result, basic competencies is in good order; however the time allocation established by school is 6 learning hours per week for two meetings. This is different from time allocation established by Permendikbud No.65 year 2013, it is 5 learning hours per week.

3.3. Concept analysis
It is aimed to determine content and learning material needed in developing learning device. Material is really important in achieving competence indicator achievement. The analysis result of the concept also describes the concept mapping and material.

3.4. Analysis of student characteristics
This stage reveals that students of class IX SMPN 2 IV Koto Aur Malintang are between 14 to 15 years old. Based on the cognitive development theory proposed by Piaget, students in this range of age are in formal operation. In this stage, students are able to think in abstract and logic. It means that, in this stage age of development, students are able to imagine the abstract things. As the result, in the thinking process, students who are in this formal operation stage age can work on answering question or solving realistic problem that require data without necessarily using concrete thing or concrete event[21]. In addition, students are able to draw conclusion and to develop their own hypothesis independently.

In order to investigate the students’ characteristics of class IX, researchers are conducting observation during learning process. The observation toward students’ characteristics revealed that most of the students find it hard to focus on teacher’s explanation in the front of the class. Moreover, students are less interested in using the textbook and tend to abandon it. Students are often experiencing boredom for them just copying the formula written in the whiteboard. Based on the result of formal operation stage, students can use realistic problem or context that they can imagine and they also can solve the problem in order to build their own knowledge. Based on this analysis, it can be concluded that RME based learning can be implemented for students of class IX SMP. It is expected that RME based learning device can be implemented for students of class IX Junior High School. Through RME approach, it is expected that passive learning may turn into an active learning and would be able to improve students’ mathematics quality learning. As stated by Arsaythamby[6] in his research which shows that RME based learning turns the students to think actively in exploring, questioning, and developing ideas and mathematics concepts. The learning device that will be developed also added up with REACT strategy in order to support the purpose of RME approach as well as to support students’ improvement on their mathematical connection ability[15].

4. Conclusion
This is a development research to produce RME based learning device enriched with REACT strategy. The process of development is employing Plomp model. This model begins with preliminary research phase in order to analyze the curriculum to see competency standards, basic competencies and indicators which are relevant with the development material, concept analysis, and student analysis. The result of preliminary research is the starting point to step into the second phase, the development or prototyping phase. Tables should be centred unless they occupy the full width of the text.

Based on the analysis of the previous preliminary research, it can be concluded that students are engage in less activity or less construct their ideas to be able to find mathematics concept. Most of the students’ activities are focusing on teacher explanation, copying teacher’s writing on the board, and to
memorize the formula. As the effect, students tend to be more passive and the learning is less meaningful since the students find it difficult to understand learning material given by the teacher. The preliminary test shows that students’ mathematical connection ability is not well developed, so that they experiencing difficulties to work on the question to find the final result. Meanwhile, the analysis of learning device used by teacher of class IX SMP N 2 IV Aur Malintang has optimal yet in order to allow improvement on students’ activity and students’ mathematical connection ability.

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