Preliminary Research of Model Eliciting Activities learning Based to Improve Junior High School Students’ Mathematical Critical Thinking Ability

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Abstract. Mathematical critical thinking ability of junior high school students in Indonesia is still low. Previous studies indicate that critical thinking ability of junior high school students is ≤ 50%. The inavailability of a helpful learning tool turns out to be the ground of lack of development on the students’ critical thinking ability at junior high schools. This condition is the foundation of conducting development research on learning tool using Model Eliciting Activities (MEAs) to improve the mathematical critical thinking of junior high school students. This research is part of the phases of plomp model development that is the preliminary research. The research is investigation study in which the activities in this introductory research are analyzing prerequisite and context (analysis of curriculum, concept and students) and review of related literature. The data are collected through questionnaires, interviews, documentation, and test of critical thinking ability. The data gained are examined descriptively. The subjects of the study are the students of SMP Negeri 8 Padang Grade VIII and the math teacher. Conclusion of this preliminary research is that it is imperative to develop MEAs based learning tool in math learning to advance critical thinking ability of junior high school students.

1. Introduction
In real life, critical thinking is the ability that every individual must possess to success and able to face various kinds of problem. Critical thinking ability is not the aptitude brought on childbirth, thus it is important to keep sharpening and improving the critical thinking ability principally at schools as formal education institutions. Every learning supervisor must provide the students with critical thinking ability as the competency that supports daily activities and be success in future [1]. Therefore, critical thinking ability is preferably to be developed beginning from early stage since the more complicated world’s demand imposes the critical thinking to be applied and developed in core curriculum and teaching-learning process to produce the students who become future leaders with qualified way of thinking[2][3]. Mathematics as one of the basic sciences integrated in schools’ curriculum play an active role to train the students to think logically, effective and lead to problem solving. Similarly, students’ mathematical skill is helpful to develop their curiosity and motivation becoming the persons attributed with creative, logic, and systematic thinking as the qualities of prospective leaders [4].

The one who is trained to think critically tend to solve the problem accurately. Critical thinking is self-management in deciding something that generates interpretation, analysis, evaluation, inference and investigation by using certain evidence, concept, method, criterion or contextual consideration as...
the basis of making the decision[5]. In addition, critical thinking is reflective and reasonable thinking ability focused on what is trusted or done [6].

The significance of critical thinking ability at school is in correspondence with findings of Program for International Student Assessment (PISA) which states that Indonesia is an under-developed country that is below the average of Organization Economic Cooperation and Development (OECD). This reveals that the ability of Indonesian students in answering the questions referring to critical skill, logic and problem-solving is still low [7]. One of the factors that influence the students’ low mathematical and critical thinking ability is that the students have lack of ability to change the story-formed question into math model; as a consequence, the students face difficulty in solving the question. This condition is affected by learning activities that unsupportive to critical thinking ability added by students’ habitual learning to listen to teacher’s explanation [8][9].

Results of preliminary research discovers the less optimum use of learning tool as well as inavailability of tool that supports training the students’ critical thinking ability have become the root of students’ low critical thinking ability that is ≤ 50%. Thus, developing learning tool using the model or learning approach centered on the students may become alternate solution to solve this problem. The resolution that the researcher offers is the development research of learning tool based with MEAs in the forms of learning plan and student’s worksheet. MEAs have been developed and used in variety of subject areas including mathematics, economics, and environment engineering [10]. MEAs approach is a reality-based approach, works in small groups and presents a model to help students build problem solving and get students to apply an understanding of the mathematical concepts which they have learned [11]. The presence of MEAs learning based is expected to resolve the low ability of junior high school students’ critical thinking and able to work out difficulties of transforming math model from story-formed questions, real problems or even higher level of problems.

MEAs approach consists of six principles: 1) the reality principle, meaning the problem should be meaningful and relevant for the students; 2) the model documentation principle, meaning the students must be able to express and to document the thinking process in their solution; 3) the model construction principle, meaning the problem must be designed to possibly create a model related to the elements, interelement operation, pattern and instruction that regulate this correlation; 4) the self-assessment principle, meaning the students must be able to assess themselves and measure the employment of their solution; 5) the construct shareability and reusability principle, meaning the solution formulated by the students should be able to be generalized or easy to be adjusted into another situation and can be useful for others; and 6) the effective prototype principle, meaning ensuring that the model being produced is as simple as possible but mathematically significant [12].

There are four steps of modeling in MEAs: 1) description, that is shaping the relationship between real life and its model; 2) manipulation, that is producing the solution related to the problem and make prediction; 3) translation (or prediction), that is changing the result gained into real situation of real life; and 4) verification, that is verifying the accuracy of result [13]. These four steps are integrated in the cycle as seen in Figure 1[13].

![Figure 1. Four steps of MEAs modeling](image-url)
imbalance between the current situation and the preferred one [14]. This first round is beneficial for the researcher to develop the product. This phase is a useful source due to the complexity of educational practices being encountered, for then becoming inspiration in developing the product [14].

Plomp model preliminary research phase is the phase of beginning investigation known as prerequisite analysis or problem analysis. Main activities in commencement investigation include users’ practical analysis (analysis of requirement and context) and basic science exploration (review of related literature) [14]. Thus, preliminary research discusses about results of investigation associated with key elements required by collecting and analyzing the information gained then followed by defining the problem and planning the next activity. Activities performed in this introductory research are learning activities observation, teacher’s interview, analysis of learning plan and student’s worksheet, students’ questionnaire, analysis of core competencies and basic competencies on learning silabus, students’ critical thinking test, and review of related literature.

This phase of preliminary research is the strong groundwork to formulate the problem and find the precise solution to the educational problem which, in this case, incorporates with the low ability of students’ critical thinking ability and the inavailability of supportive learning tool.

2. Materials and Methods
The preliminary research is conducted in February 2019 at SMP Negeri 8 Padang. The subjects of the research are thirty-two students of Grade VIII A SMP Negeri 8 Padang. The data collected is analyzed descriptively. The type of research is investigation research. This phase consists of prerequisite analysis, curriculum analysis, conceptual analysis, students’ analysis, and review of related literature.

In prerequisite analysis, the activity done is in the form of investigation on learning. This activity is carried out to identify the problems or obstacles that occur in learning process and also intends to analyse the stage of requirement on MEAs based learning tool to develop students’ critical thinking ability. The research data are collected through observation, teacher’s interview, analysis of learning plan and student’s worksheet, and test of students’ critical thinking ability.

Analysis on students is also presented to discover the students’ characteristics as students. The outcome of the analysis becomes consideration in developing learning tool particularly student’s worksheet. Students’ characteristics are exposed throughout students’ questionnaire (using Likert’s scale) and theoretical studies of Piaget’s cognitive development.

In curriculum analysis, the activity executed is the analysis of core competencies on learning silabus. The analysis is held to obtain description of characteristic of learning materials of odd semester that students of Grade VIII junior high school will learn.

The analysis of concept is made to determine the content and learning material that will be presented in learning tool and to analyze what mathematical concept that the students must achieve in learning.

After completing the prerequisite analysis and figure out the problems in the field, then review of related literature is done to study the model, method or the exact learning approach to solve the problem of low critical thinking ability of junior high school students. The review is implemented throughout books of references and national and international journals.

3. Findings and Discussion
Findings at observation points out that during learning process, there is longer portion for lecture segment. Students’ literacy ability is still low. The students dislike story-formed math question and the typical of questions that demand higher order of thinking since they are lazy to read and identify the questions given. They prefer to directly ask to the teacher about the current problem instead of reading the problem beforehand even if the estimated time for reading it has been allocated. When working on the question, smart students tend to work alone while the others like better to wait for the answer from the smart ones who have completed the task earlier. In addition, there is no student’s worksheet given by the teacher during learning process and the learning plan is of no optimum use.
Based on findings of interview with math teacher it is learnt that the students have difficulty in finishing questions that require high order thinking. Students’ communicative ability is still low and they are incapable of adjusting story-formed question into math model. Learning method mostly used is lecturing. Besides, group discussion is performed depended on the level of complexity of the material being studied. When the subject is complicated, the teacher is more comfortable to use lecturing method than group discussion. The teacher has applied Problem Basic Learning based learning plan and discovery learning, however, in its process the activities do not run as expected and in the middle of the course the teacher often returns back to conventional method. This teacher-centered learning activity causes the students’ inactive learning, easy to forget and the teacher fails to explore students’ ability especially their critical thinking ability. Moreover, the effects of convensional method are students’ laziness to think and their tendency to inquire back to the teacher of the problem being presented instead of reading the problem carefully.

Results of teacher’s interview also confirm that during the course of learning the students often find it problematic when dealing with high level of math questions (math problems that need accomplishment of more than one concept), the story-formed questions and real problems, and if given question of the same type they find it more confusing even if it has been explained previously. The basis is that the students are unsuccessful in converting the right math model to help them finishing the math problem given.

Another problem uncovered in the interview is that the teacher often uses lecturing method since it is easier and faster. The teacher comprises learning tools in the form of learning plan and student’s worksheet but sometime the tools prepared are unappropriate in its execution. In the midst of learning process, the teacher repeatedly has to teach conventionally due to time insufficiency.

Related to the use of worksheet, it is acquired that the teacher is seldom to use student’s worksheet since she often has lack of ideas in arranging student’s worksheet. Additionally, based on teacher’s experience teaching in class, the time assigned is inadequate for the students to finish the questions given in student’s worksheet. These affect the learners’ occasional use of student’s worksheet designed by the teacher herself. Currently the learners use student’s worksheet bought from publishers as the medium of exercises, which unquestionably is made without paying attention to the students’ characteristics of that school. Another information gained from result of the interview is that the teacher is unfamiliar with critical thinking ability and MEAs learning based approach that grow to be hindrance to the availability of learning tool that can solve difficulty in finishing high level of questions as the feature of critical thinking ability.

The next step in prerequisite analysis is test of critical thinking ability. It aims to inspect whether critical thinking ability is the real problem in learning, so that research finding that indicates the low ability of students of junior high schools’ critical thinking and the field obstructions related to the intricacy of dealing with high level of questions are true. Result of test in Table 1 signifies that the average of critical thinking ability of students at SMP Negeri 8 Padang are still low (≤ 50 %) in all indicators of assessment.

Derived from Table 1, it is seen that only at the indicator of validating assumption or argument that 50% of students are able to answer in maximum score. This shows the low level of critical thinking ability of junior high school students. One of the samples of verifying conceptual precision indicator and students’ answer in test of critical thinking ability are showed in Figure 2 and Figure 3. Based on students’ answer it reveals that the students do not know how to solve the questions accurately. They do not check the concept of the material carefully and only confirm the existing counting errors. These happen because they do not accomplish the question by previously composing the math model of the spots in the same horizontal line. In addition, the teacher informs that the question is too high and the students are foreign to such form of questions.
Table 1. Result of test of critical thinking ability grade VIII SMP Negeri 8 Padang

| Indicator                                         | Percentage of students’ answer per score |
|---------------------------------------------------|-----------------------------------------|
| Identifying supportive information or data         | 0% 14% 73% 13%                          |
| Verifying conceptual precision                    | 0% 7% 86% 7%                            |
| Validating assumption or argument                 | 17% 0% 13% 20% 50%                      |
| Giving alternative of prediction to completion    | 84% 3% 13%                              |
| Generalizing or summarizing from math model        | 61% 13% 3% 23%                          |

In curriculum analysis, it is attained that SMP Negeri 8 Padang has applied curriculum 2013. This stage is focused on the analysis of core competencies and basic competencies that will be clarified in the form of learning competency indicators. The indicators of learning competency are developed based on basic competencies. The verb used to develop the indicators employed Anderson Taxonomy (Revision to Bloom Taxonomy). Based on operational verb of basic competencies that is available to cognitive level C5, then operational verb of indicator is assigned to level C1 up to C5. Meanwhile, based on conceptual analysis, it is found out that the materials studied in odd semester are numerical pattern, cartesian coordinate, relation and function, linear equity and two variables linear equity.

In the analysis of students, according to Piaget’s cognitive development theory, it is discovered that students of junior high school have come into teen age in which they have their own thinking pattern in solving complex and abstract problems. Junior high school students are able to imagine alternative solution to problems along with the effects or results. This means that students of junior high school already possess critical thinking ability, therefore, the proper learning method for teenagers is no longer one-way learning but learning method that can help developing their intangible thinking outline and able to analyze the problem in search of the best solution. Results of questionnaire reflect that the
students find intricacy in accomplishing story-formed questions, high level of problems, and problems connected to real life. Also, students of junior high school prefer group discussion. Related to student’s worksheet, the students favor colorful student’s worksheet, interesting outlook inserted with pictures and stickers and using Comic San MS. These findings of students’ characteristics become researcher’s further consideration in developing the product. Results of questionnaire are presented in Table 2.

| Aspects                                                                 | Percentage of Students’ Answers |
|-------------------------------------------------------------------------|--------------------------------|
| Students have difficulty in solving story-formed questions, problems related to real life, and high level of mathematical problems. | 6% | 94% |
| In math learning, students favor learning in groups.                    | 6% | 94% |
| Students need LKPD to understand materials of math subject.             | 16% | 84% |
| Students like LKPD inserted with pictures or stickers relevant to the problems. | 13% | 87% |
| Students are fond of colorful LKPD with interesting look.               | 22% | 78% |
| Students prefer LKPD with Comic San MS writing font 12 printed on A4 paper. | 12% | 88% |
| LKPD being used so far requires revision.                               | 21% | 79% |

The last stage of this preliminary research is review of related literature. Based on review of literature, it is obtained that MEAs learning approach is suitable to use in order to help training students’ critical thinking ability. Not only as students-centered approach, the phases and steps in learning using MEAs approach can also coach the students in thinking critically. For instance, in description step, the students are required to be able to identify presented information within the problem. In addition to developing the students’ critical analysis, the students should be more cautious in selecting which information will be used and which are not, so that they are capable of converting mathematical problem into mathematical model. This activity is one of the processes in critical thinking activity. Based on previous studies, one of the processes of learning approach that generates students’ activeness and collaboration in team, potential in developing critical and creative thinking ability, and integrated in 21st century learning is by using MEAs approach [10] [12] [15]. MEAs based learning tool is also effective to advance students of junior high school’s mathematical representation [16]. Applying MEAs is valuable in helping students to develop conceptual understanding, knowledge transfer, and generalize problem-solving skills [10]. Learning with MEAs is hoped to direct the students to present mathematical ideas by translating the problems into mathematical forms either in pictures or mathematical symbols so that it can expand the students’ critical thinking [17]. MEAs is proven to be useful not only in encouraging learning process in classroom but also advantageous in students’ real life as the result of developmental research by [4]. Shows that learning with MEAs approach is started with realistic problems in order to stimulate students’ interest. This interest, then, will allow them to easily understand the problems because those problems are related to students’ daily life.

Thus, development of learning tool in the forms of learning plan and student’s worksheet in this research attends to the steps and principles of MEAs so that it is expected that class learning will be well-guided, well-planned, lively, and entertaining.
4. Conclusion

Evaluated from findings in preliminary research, it is acquired that the average critical thinking ability of students at SMP Negeri 8 Padang is still low in all assessment indicators. The roots are the students’ unfamiliarity to critical thinking questions and they encounter difficulty in solving high level of mathematical problems as well as real life problems since they are incapable of formulating the precise mathematical model. Even though developing students’ critical thinking ability is part of curriculum objectives, the teacher has never designed such learning method that is determined to increase critical thinking ability. Moreover, the teacher comes across complexity in planning the student’s worksheet due to lack of ideas in constructing mathematical problems to be given to the students. Therefore, it is strongly obliged for a learning tool that can facilitate students in solving problems with the aid of mathematical model so that the students can be more well-directed and do not get confused in accomplishing mathematical problems given. The designed learning tool should also contain high level of problems including real problems. To conclude the findings of this preliminary research, it is required a development research of MEAs based learning tool that can facilitate students in solving problems with the aid of mathematical model so that the students can be more well-directed and do not get confused in accomplishing mathematical problems given.

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