IOP Conf. Series: Journal of Physics: Conf. Series **824** (2017) 012042 doi:10.1088/1742-6596/824/1/012042

Teacher's Stimulus Helps Students Achieve Mathematics Reasoning and Problem Solving Competences

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Abstract. The students' problem-solving ability in mathematics learning still becomes a challenge for teachers, especially in primary education. The scientific approach, with its activities including observing, asking, collecting information/experimenting/trying, associating/analysing information/reasoning, communicating/presenting/ networking is expected to be able to help students to achieve their competence of reasoning and problem-solving. The Missouri Mathematics Project learning by using student worksheet and manipulative (classical and group) have helped students achieved problem-solving competence. The implementation of scientific approach in the activities of observing, experimenting, and communicating are good. However, the questioning and associating activities are still less promoted. The result of observation towards four meetings of learning by using teaching aids shows that the expected activity which did not emerge during the learning is "students ask questions from the factual thing to hypothetical thing, starting with guidance from teacher until they can do by themselves". The result of analysis towards theoretical background and research result conclude that the students' asking and thinking abilities can be developed gradually by delivering stimuli in the form of tasks which have been designed by the teacher. The task could be a problem or a clue; then the students determine things such as: "what the question?", "facts from pictures/text/graphs/tables", "find the hidden question", what's extra?", "what's missing?", "what's wrong?", alternatively, "make up the problem.

1. Introduction

Problem-solving ability still becomes a problem in mathematics learning both in primary and secondary education. Mathematics problem-solving ability is related to the students' thinking ability in the process of mathematics learning. Various studies about problem-solving ability and reasoning have been conducted, but they have not affected significantly by the practical level of mathematics learning at school. The scientific approach with its activities including observing, asking, collecting information/experimenting/trying, associating/analyzing information/reasoning, communicating/ presenting/networking is expected to be able to develop students' knowledge, thinking ability, and skill to use the knowledge through direct interaction with learning sources which have been designed by teacher [5]. Krulik and Rudnick [3] also suggest that teacher will become a choreographer who designs activities in which students could get necessary experiences to develop their mathematics power. Problem solving and reasoning are the main skills which students have to possess when they leave the school world into the real world. The students' reasoning ability will help them to solve problems and to create decisions. The current curriculum demands scientific approach be learning to achieve problem-solving competence. Meanwhile, in the meantime, the problem-solving ability or it is known in primary education as the ability to solve word problem still becomes a challenge for the teacher. The learning guide as narrated in the appendix of Minister of Education and Culture Regulation number 103/2014 states that students are subject who possess the ability to search actively, process, construct, and use knowledge. Therefore, learning has to give a chance for them to construct

knowledge within their cognitive system. Missouri Mathematics Project (MMP) is a learning model with the syntax: review, development, cooperative work, seat work, and homework. The step of review is an apperception stage. It is continued by step of development which allows the teacher to guide students such that they can construct knowledge. The use of worksheet and manipulative will help students to find concepts. In the cooperative work step, teacher guides students to discuss in a group. Then, the students will work independently in seat work step, and it ends with homework step. According to Dwiningrat [1], one of the advantages of MMP is the availability of opportunity to do exercise so that the students can be skilled in solving various types of problem. Does the MMP learning model assist with students' worksheet and manipulative help students to achieve the problem-solving competence? How does the scientific approach work?

2. Material and Methods

This research was conducted at VIIIB grade students of SMP Negeri 1 Ungaran. It was an empirical testing of manipulative in a scientific approach based learning. This testing is part of a multiyear research and development. The learning implemented in this research was scientific approach learning aided with student worksheet, task, classical manipulative for teacher's demonstration, and manipulative for individual or group of students to work in group activities. The research design is a one-shot case study. According to Sugiyono [8], this experiment design uses treatment as the independent variable and the result of the treatment as the dependent variable (problem-solving ability). In this testing, the effectiveness of manipulative use is not only measured by the results, but also the implementation of scientific approach activities shown by the description emergence of the students' scientific activities in response to the stimulus of teacher that has been designed previously. The effectiveness of learning was analysed with the completeness, and the effectiveness of the process is measured by adherence to students' scientific activities.

3. Result and Discussion

The problem-solving ability test resulted that there are three students among 35 students who did not pass the test. The result of proportion hypothesis testing analysis suggested that the null hypothesis that the percentage of students passed the test individually is less than 75% was rejected, which conclude that the alternative hypothesis that the percentage of students pass the test individually is greater than or equal to 75% was accepted with a significance level of 5%. This suggests that Missouri Mathematics Project learning with a scientific approach, aided with student worksheet, and manipulative can help students achieve the classical completeness of problem-solving competence.

The result of similarity test towards the students' responses (scientific activities indicator) from the observer 1 and two at each meeting did not differ significantly with $\alpha = 5\%$. Likewise, the Anova test gave Sig = 0.052> 0.05; then we accepted the null hypothesis which means there are no significant observed differences among the four meetings. Based on multiple comparison tables, we can see that all Sig> 0.05 then the four meetings did not have significant observed differences each other. Description of the observation of the student responses (scientific activities) at the four meetings is presented in Table 1.

In Table 1 above it can be seen that the activities which get not enough percentage (maximum score of 4) are asking activity and reasoning/associating activity, with the lowest percentage, is the asking activity. It commonly happens that Indonesian students are reluctant to ask questions during learning. The teachers are also not accustomed to delivering stimuli that require or provide opportunities for students to respond, to questions, or to express opinions. The stimulus that requires students asking questions is when the teacher asks students to create a question in written, as students do not leave questions orally. While in the activity of "reasoning/associating", teachers have been aided by the presence of media, namely the manipulative (classical and group/individual) and the student worksheet. It is suitable with the result of research conducted by Pujiastuti and Madhuri [6] which states that the use of manipulative could assist teachers in teaching mathematics with a scientific approach. The scientific activities (observing, questioning, experimenting, associating, and communicating) are set of activities which might appear during learning and enable students to find or to construct mathematics concepts and principles. Meanwhile, the problem-solving ability is developed as the ability to apply the concepts/principles earned. Reasoning ability is used to find the concept/principle as well as in problem-solving. Similar research conducted by Siregar & Margit [7]

about the influence of discovery learning approach with analogy aspect towards the student's reasoning ability. The presence of student worksheet helps students to solve the problem in a good structure and supports the development of students reasoning ability. The problem which requires reasoning is a non-routine problem (problem-solving).

Table 1. Percentage of Observed Score Earned against Maximum Score of the Implementation of Scientific Approach Learning aided with Manipulative

Activities	Percentage of Maximum Score for Each Meeting			
	1	2	3	4
Observing	93.8	100	87.5	93.8
Questioning	56.3	62.5	43.8	43.8
Experimenting	75.0	87.5	90.6	96.9
Associating	54.2	75	69.4	70.8
Communicating	65.6	96.9	93.8	84.4

Results of studies have shown that learning mathematics in materials of cuboid and cube, assisted with manipulative (classical and group) and students' worksheet is effective towards problem-solving ability, shown by the achievement of classical completeness. If the teacher can increase the percentage of activity particularly the "asking" and "reasoning", it can be expected to provide more optimal results. Reasoning ability of students contributes to the smooth running of students in problem-solving. It is supported by research of Tambychik and Subahan [9] they suggest that cognitive aspects of learning include the ability to do the perceptual thinking, the ability to use logic thinking, ability to memorise, and ability to recall. The main cognitive ability in learning which causes the difficulty for students is the ability to memorise and ability to recall the facts which support the making of connection in students' mind. Reasoning includes basic thinking, critical thinking, and creative thinking. Problem-solving is a means of an individual to use prior acquired knowledge, skills and understanding to meet the demand of unfamiliar situations. Problem-solving can and should be taught, problem-solving is a process that has been analysed and can be represented as a series of steps, from now on called heuristic [3]. Problem-solving pattern that is often used at school or in the study is the pattern of Polya, that in teaching students in problem-solving, the students are guided to carry out the steps of (1) understanding the problem; (2) planning; performing the plan; (4) confirmation of the answer [9]. In this study, we also integrated Polya patterns at the stage of training with a scientific approach aided by manipulative to improve students' problem-solving ability. Overview of the results of applying Polya strategy is illustrated by the conditions on the field today; while heuristic of Krulik & Rudnick [3] with five stages can be described as follows.

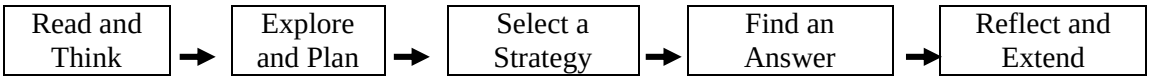


Figure 1. Steps of problem-solving [3]

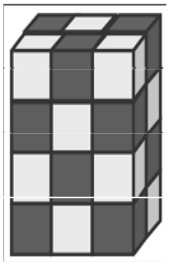
Among the above five steps, we can see that it is no different with the stages on Polya pattern, but Krulik and Rudnick stated that improving the competence of reasoning and problem solving will also emphasise the change in the ways teachers teach. It is no longer relevant that a teacher demonstrates in front of the classroom. Instead, the teacher would be a choreographer who designed an activity in which students gain experiences which are necessary for the development of mathematical power. Novotna et. all [4] in his paper illustrates how to develop a creative approach to students problem-solving. It is part of the long experiment that is focused on promoting a culture of problem-solving by students. The problem solving used heuristic strategies: analogy - guess - check - revise - systematic.

Higher order thinking skill is important in society. Therefore, students should be equipped with knowledge and skills so that they can solve problems in everyday life. Teachers must be able to

stimulate students to think; teachers should make sure to design and implement successful learning, teachers should be capable of setting up a map-bank of i-think map. Similar learning is done continuously so that the cultural thinking becomes a habit for students at all time [2]. In his research, he presents a visual tool of graphical representation as strategic thinking that will help students to see the appropriate thinking skills used to solve the problem. Besides, it also uses a group activity that requires students to give a reason of the thinking process that will never end. Missouri Mathematics Project learning with student worksheets and manipulative (classical and group) have successfully helped students achieve problem-solving competence, and the implementation of the scientific approach has been well performed on the activity of observing, experimenting, and communicating, but not yet on the activity of questioning and associating (reasoning).

Krulik and Rudnick present activities that are designed to assist teachers in creating classroom experiences that will help students achieve competence in reasoning and problem-solving. Here are some of the stimuli activities presented in mathematics learning refers to Krulik and Rudnick [3]. Stimulus in the form of the problem at each stage to train (habituation) students to think. The following questions are taken from the book of Krulik & Rudnick [3].

Step of Read and Think (facts from pictures/text/graphs/tables)



a) What is the shape of this model? (cuboid)
b) If the base of the cuboid is the lower face, then:
   – What is the length? (3 unit)
   – What is the width? (2 unit)
   – What is the height? (4 unit)
c) If the base of the cuboid is the front face, then:
   – What is the length? (3 unit)
   – What is the width? (4 unit)
   – What is the height? (2 unit)
d). What is the volume? (24 unit)
e) How is the appropriate way to calculate the volume of this cuboid? (4 unit x 3 unit x 2 unit)

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The step of Explore and Plan (What is the hidden question?)

Some problems have more than one part. You have to find the answer to a "hidden question" before you can finish the problem. The problem of the following, pick out the hidden question. Last week Amanda sold 18 boxes of Girl Scout cookies. This week she sold 15 boxes. If each box cost $2, how much did she receive for all the boxes of cookies she sold? *What is the hidden question*? (a) How many boxes did of-of Girl Scout cookies Amanda sell last week? (b) How many boxes did of-of Girl Scout cookies Amanda sell during both weeks? (c) How many money did Amanda receive for the cookies she sells?

4. Conclusion

The result of analysis and discussion lead to the conclusion that the Missouri Mathematics Project aided with students worksheet and manipulative could help the students achieve classical completeness in the learning result. The implementation of scientific approach in the activities of observing, experimenting, and communicating is good. However, it did not perform well in the activities of asking and associating, which are low. If the scientific activities could be optimised, then the problem solving and reasoning could also be optimised. Furthermore, it is recommended that teacher optimise the asking and associating activities by delivering stimuli to make a habituation of students to ask and to reason in the form of tasks which have been designed by the teacher. The task could be a problem or a clue; then the students determine things such as: "what the question?", "facts from pictures/text/graphs/tables", "find the hidden question", what's extra?", "what's missing?", "what's wrong?", alternatively, "make up the problem, ".

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