Inquiry-based learning through lesson study to improve the students’ mathematical problem-solving ability

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Abstract. Today, one of the skill that student needed to be success in mathematics is problem-solving ability. As educators we are charged with the great challenge and responsibility of engaging students in learning so that they develop the skills and knowledge they need to function in today’s world. Inquiry-based learning is an approach to teaching and learning that places students’ questions, ideas and observations at the centre of the learning experience. Lesson study (jugyou kenkyuu) is an inquiry model of teacher professional development used extensively throughout Japan and has begun to capture the attention of the American educational community as a potential strategy for enhancing teacher professional development in America. There would be implemented inquiry-based learning through lesson study about composition function and inverse function to improve the students’ mathematical problem-solving ability and used tests and questioners to know the students’ improvement. In this research, there was an improvement of students’ mathematical problem-solving ability after implemented these methods. So, we could know that inquiry-based learning through lesson study were successful to improve the students’ mathematical problem-solving ability.

1. Introduction

Problem solving is an integral part of all mathematics learning, and so it should not be an isolated part of the mathematics program. How can problem solving help students learn mathematics? Good problems give students the chance to solidify and extend what they know and when well chosen, can stimulate mathematics learning. With young children, most mathematical concepts can be introduced through problems that come from their worlds. Problem solving could and should be used to help students develop fluency with specific skills [1]. It is important that mathematics students improve their problem-solving abilities. In fact, some NCTM-oriented curricula aim to produce problem-solving abilities in their students and claim to be more successful at that task than the traditional curricula [2]. Mathematical problem-solving ability is defined by the ability to analyse mathematical situations, to plan, monitor and evaluate solutions, to apply strategies and to demonstrate creativity and self-reliance in using mathematics [3]. So how to improve their problem-solving abilities? One way to improve these abilities is by implementing the inquiry-based learning which combined with lesson study activity.

Inquiry-based learning is an approach to teaching and learning that places students’ questions, ideas and observations at the centre of the learning experience. Inquiry-based learning concerns itself with the creative approach of combining the best approaches to instruction, including explicit instruction and small-group and guided learning, in an attempt to build on students’ interests and ideas, ultimately moving students forward in their paths of intellectual curiosity and understanding [4]. Moving students from initial curiosity to a path of regular inquiry is one of the great challenges of inquiry-based learning. In this process, teachers play an important role. The teachers must be finding the creative ways to
introduce students to ideas and to subject matter that is of interest to them and offers “inquiry potential” or promise in terms of opportunities for students to engage in sustained inquiry of their own. Hence the teachers’ professionality must be improved. To improve teachers’ professionality, there would be implemented lesson study activity. Lesson study (jugyō kenkyū) is an inquiry model of teacher professional development used extensively throughout Japan and has begun to capture the attention of the American educational community as a potential strategy for enhancing teacher professional development in America. Lesson study involves groups of teachers meeting regularly over a period of time (ranging from several months to a year) to work on the design, implementation, testing, and improvement of one or several research lessons. There are three stages of lesson study: plan, do, and see [5]. The effective assessment of problem solving in math requires more than a look at the answers students give. Teachers need to analyse their processes and get students to communicate their thinking [6]. Next, we would identify the improvement of the students’ mathematical problem-solving ability by implemented inquiry-based learning that combined with lesson study activity. The lessons that would be taught in the classroom are composition function and inverse function.

2. Method
This research used inquiry-based learning through lesson study activity and the subjects of this research is the 34 students of XI IPA 2 Madrasah Aliyah Negeri (MAN) Selong, East Lombok, NTB. There was conducted in four cycles through three stages of lesson study: plan, do, and see.

2.1 Plan stage
The teacher focused on a specific teacher-generated problem, goal, or vision of pedagogical practice. The teacher carefully planned lesson plan and discussed it with the teacher colleagues. Focus on this research, there are seven teacher’s colleagues who work as teachers. In plan stage, there would be prepared and discussed the assessment instruments that used in this research. The assessment instruments were questionnaires of student activities, students’ worksheet, questionnaire of teacher’s ability to manage classroom, lesson study activities questionnaires, student response questionnaires, and learning evaluation tests. Students’ worksheet and learning evaluation tests would be used to measure the improvement of students’ mathematical problem-solving ability. The questionnaires of student activities, lesson study activities, and student response would be used to know the effectiveness after implemented this learning method. The questionnaire of teacher’s ability to manage classroom would be used to evaluate the teachers’ performances in the classroom.

2.2 Do stage
The teacher implemented what his planned before and the colleagues observed the lesson. In this research, the teacher motivated, taught, gave clues and made sure students to find the concept and solve problems about composition function and inverse function.

2.3 See stage
The teacher and colleagues evaluated and reflected the lesson results, shared and discussed their ideas, opinions, and conclusions regarding the research lesson. There would be discussed the weakness and advantages of the do stages. The teacher and colleagues together sought solutions for the weakness that would enable be better prepared and implemented in the next meeting. All of these stages were implemented for 4 cycles.

For each cycle in this research was carried out in accordance with the changes to be achieved on each of the problem-solving indicators to be achieved with the action plan for each stage. There would be used assessment based on scaled scoring 5 to assess questionnaires of student activities, questionnaire of teacher’s ability to manage classroom, and student response questionnaires with the ideal maximum score is 5, and the ideal minimum score is 1. The criteria of questionnaires of student activities would be changed from good to active criteria. We determined criteria of questionnaires as started in table 1.
Table 1. Assessment classification guidelines

<table>
<thead>
<tr>
<th>Score Interval</th>
<th>Criteria</th>
</tr>
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<tbody>
<tr>
<td>$\bar{x} &gt; M_i + 1.5 \text{ SD}_i$</td>
<td>Very good</td>
</tr>
<tr>
<td>$M_i + 0.5 \text{ SD}_i &lt; \bar{x} \leq M_i + 1.5 \text{ SD}_i$</td>
<td>Good</td>
</tr>
<tr>
<td>$M_i - 0.5 \text{ SD}_i &lt; \bar{x} \leq M_i + 0.5 \text{ SD}_i$</td>
<td>Fairly good</td>
</tr>
<tr>
<td>$M_i - 1.5 \text{ SD}_i &lt; \bar{x} \leq M_i - 0.5 \text{ SD}_i$</td>
<td>Poor</td>
</tr>
<tr>
<td>$\bar{x} \leq M_i - 1.5 \text{ SD}_i$</td>
<td>Bad</td>
</tr>
</tbody>
</table>

$\bar{x} = \text{ average score of each aspect } = \frac{\sum x}{n}$

$x = \text{ score of each aspect}$

$n = \text{ the number of assessment aspect}$

$M_i = \text{ Ideal mean } = \frac{1}{2} (\text{ideal maximum score} + \text{ideal minimum score})$

$\text{SD}_i = \text{ Ideal deviation standard } = \frac{1}{6} (\text{ideal maximum score} - \text{ideal minimum score})$ [7].

After implemented the learning methods, the improvement of student’s mathematical problem-solving abilities would be measured through the students’ work on the students’ worksheet and learning evaluation tests. Each student was said to be an individual learning completeness if the proportion of correct answers $\geq 65\%$ of students, and the classes learning completeness (classical completeness) $\geq 85\%$ of students who have individual learning completeness [8]. The individual mathematical completeness mark in Madrasah Aliyah Negeri Selong was 70 [9]. The improvement of all student would be measured by classical completeness:

$$KK = \frac{X}{Z} \times 100\%$$

$KK = \text{ classical completeness}$

$X = \text{ the number of students get minimum value 70}$

$Z = \text{ the sum of students [8]}$

3. Result and Discussion

The teacher made the students’ worksheets to prompt students to think mathematically and solve the problems about the topic of learning. Students submit solutions to problems on a per-worksheet basis and the teacher marks the students’ work [10]. This is an example non-routine problem on students’ worksheets that gave to students in first cycle:

Example 1: One time, Sarmadaen was given the task to convert the measured numbers from units of hectometer(hm) to units of meter(m) and decimeter(dm). In step I, Sarmadaen converts from unit of hm to m, in step II, he converts from unit of m to dm, in step III he converts from unit of hm to dm. If the result of the measurement he got was 5, 7.5, 9.75, and 12.25 (in units of hm). Please help him to make it easy to convert the measurement results using the following steps:
The essential things that teacher have to do in teaching problem solving were ensuring students to: understanding the problem, devising a plan, carrying out the plan, and looking back solutions [11]. This was where lesson study activity was expected to help teacher to be better in managing learning processes.

3.1. First Cycle
Every cycle in this research contains three lesson study stages. The first cycle was the first meeting with 34 students of XI IPA 2 MAN Selong. There used students’ worksheets to encourage students to find the mathematics concept through solving problem and in the last of students’ worksheets, there was a test to measure the students’ mathematical problem-solving abilities level. In this first cycle, the topic is composition function. After do stages, the teacher colleagues evaluate the learning process result. The teacher got some weakness in learning processes that discussed in see stages ware: (1) the groups division were still non-heterogeneous, (2) there were to many task in the students’ worksheets, (3) specified time allocations were not enough, (4) because the students, and (5) because of students were not accustomed to non-routine problems, so the teachers were overwhelmed to answer too many questions from students. (6) there were some passive students in the groups. Because of high curiosity of students, the students try harder to solve the problems. The results of this cycle were: (1) the average of student activity score was 3.47 or in active category, (2) the average of teacher’s ability to manage classroom was 3.14 or in fairly good category, and (3) the average of learning evaluation test score in the class was 80.24 with 80.24% classical completeness percentage and with the highest score obtained is 100 and the lowest score is 60. There are 4 students who are not complete.
3.2. Second Cycle
In this cycle, the teacher tried to fix the weaknesses that he was done in first cycle. As results the weaknesses was reduced. The weaknesses in this cycle were: (1) Although the number has decreased, but there are still some students who are still passive in the group. This resulted in a less than optimal process of discussion within the group, and (2) specified time allocations were not enough. The results of this cycle were: (1) the average of student activity score was 3.94 or in active category, (2) the average of teacher's ability to manage classroom was 4.50 or in very good category, and (3) the average of learning evaluation test score in the class was 80.35 with 91.18% classical completeness percentage and with the highest score obtained is 100 and the lowest score is 0. There are 3 students who are not complete and there was one of the students who did not attend to school. These results were better than before and there was an enhanced mathematical problem-solving ability.

3.3. Third Cycle
The teacher would fix again the weaknesses of the previous cycle by motivated the passive students and give more attentions. The topic on third cycle was inverse function. In the see stage, the learning process late start. When the see stages, there discuss the result and get some weaknesses: (1) because the late start of learning process, the learning process seemed done in a hurry, and (2) the student’s worksheets must be fixed to be more complex. The results of this cycle were: (1) the average of student activity score was 3.98 or in active category, (2) the average of teacher's ability to manage classroom was 4.50 or in very good category, (3) the average of students’ response score was 4.42 and (4) the average of learning evaluation test score in the class was 82.24 with 91.12% classical completeness percentage and with the highest score obtained is 100 and the lowest score is 0. There are 2 students who are not complete and there was one of the students who did not attend to school. Compared with the previous result, the mathematical problem-solving ability that measure by the test was improved again.

3.4. Fourth Cycle
Special on this cycle, the students would be given the student response questionnaires. This questionnaire was aimed to know what the student fell about the lesson process. The results of this cycle were: (1) the average of student activity score was 4.69 or in very active category, (2) the average of teacher's ability to manage classroom was 4.83 or in very good category, and (3) the average of learning evaluation test score in the class was 84.26 with 94.12% classical completeness percentage and with the highest score obtained is 100 and the lowest score is 0. There are 2 students who are not complete because they did not attend to school. Compared with the previous result, the mathematical problem-solving ability that measure by the test was improved again.

All of these results were presented by:

![Figure 2. The averages of observation results](http://science.conference.upi.edu/proceeding/index.php/ICMScE/issue/view/3)
In figure 2 and 3 above, we can see that there were improvements of every aspect of assessment in the learning process. This indicates the application of used inquiry-based learning through lesson study activities can improve students’ mathematical problem-solving ability.

4. Conclusion
Some National Council of Teachers of Mathematics oriented curricula aim to produce problem-solving abilities in their students and claim to be more successful at that task than the traditional curricula. It shown that problem-solving abilities can help students success in mathematics. The teachers need to improve this student ability. Flexibility and innovation are the good things that teacher need to be success in managing classroom. This research showed that there is improvement of students’ mathematical problem-solving abilities. It was shown by the improvement of students’ test results after implemented the inquiry-based learning that combined with lesson study activity. So, we can conclude that the implementations of inquiry-based learning through lesson study can improve the students’ mathematical problem-solving ability.

5. Acknowledgments
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6. References