Implementation of problem based learning to improve students' understanding of systems of linear equations in three variables

S A Sasmita and A Qohar*
Mathematics Department, Universitas Negeri Malang, Jl Semarang 5 Malang 65145 Indonesia

*Corresponding author: abd.qohar.fmipa@um.ac.id

Abstract. Based on the observation result conducted by researchers in class X-IPA 1 of UM Laboratory Senior High School, it could be seen that most students were less active during the learning process. Then from the pretest result of concept understanding problem, it was obtained that 38.89% of the 36 students were in the low category and 16.67% of the 36 students were in the medium category. Therefore, an innovation in implementation of mathematics learning to overcome the students’ poor concept understanding is needed. This research aims to describe the implementation of problem based learning model that can improve students' understanding of systems of linear equations in three variables learning in class X-IPA 1 of UM Laboratory Senior High School. This research type is Classroom Action Research. The research result showed that the students' concept understanding experienced an improvement. The percentage of students who had a high and very high concept understanding from cycle I to cycle II increased from 50.00% to 94.44% of the number of students, while the percentage of students who had a low concept understanding from cycle I to cycle II was reduced from 19.44% to 2.78%.

1. Introduction
Improvements in education, especially in the learning process must continue to be done and improved. One of the improvements is in the mathematics learning process in schools. One of the goals of mathematics in Permendikbud (Regulation of Indonesian Education and Culture Ministry) Number 58 of 2014 is to understand mathematical concepts. Mathematical concepts understanding is an important aspect in the principles of mathematics learning [1]. The mathematical material is interrelated with each other, so that it requires a strong understanding of the concepts to learn the mathematics.

Based on the initial result of the pretest of mathematical understanding in class X-IPA 1 UM Laboratory Senior High School, it was obtained that 38.89% of the students were in the low category, 16.67% in the fair category, 25.00% in the high category, and 19.44% in the very high category.

From the result of observations on the student’s work, the student found it difficult in solving System of Linear Equation in Three Variables (SLETV) questions. The student did not understand which equation should be eliminated and which solution should be determined. From the answer sheet, it could be seen that the students eliminated the wrong equation, resulting in an incorrect answer.

Based on the researcher’s observation of the class, it can be seen that most students were not actively participating in the learning process. Only a few students who were actively asking, answering, and
expressing their opinions during the learning process. Then the teacher taught the material mostly by giving lecture and dominated the learning process (teacher center).

Based on these problems, activities that can maximally improve the students’ understanding are needed. Besides, it shall be able to encourage the students to learn actively and learn together to understand the concepts being taught and then communicate their ideas. Ultimately, it will positively affect the students' understanding of mathematical concepts. According to the theory of constructivism in [2,3], understanding of mathematical concepts will be more meaningful if it is being built by the students themselves. In order to obtain this meaningful understanding, a learning activity that can make the students to experience the process of acquiring knowledge themselves is needed.

One of the ways to improve the understanding of mathematics is by using the Problem Based Learning (PBL) model. The learning model is based on a problem as a learning stimulus. The problems are based on students' daily lives so that it is easy to be understood and is interesting for the students. The results of the study indicate that based on research conducted by stating that the PBL model can improve students' mathematical reasoning abilities [4], mathematical problem solving and student self-confidence [5,6], mathematical literacy [7,8], critical thinking skills [9] and High order thinking skills (HOTS) [10]. The PBL can also improve interest in pursuing a career in science, technology, engineering and mathematics (STEM) [11], [12]. By applying this learning model, students to students and students to teachers interaction is improved, so that the students can understand the material being taught in the learning process better.

Based on the description above, the researchers hope that the PBL model can improve the students' concepts understanding. The purpose of this research is to describe the implementation of PBL model that can improve students' understanding of SLETV learning material in class X-IPA 1 UM Laboratory Senior High School.

2. Methods
This research type is a classroom action research (CAR). The data being collected in this research is analyzed descriptively. This research attempts to describe the learning process that uses the PBL model in improving the students' concepts understanding. In this research, the researchers participated directly in the research process from planning, implementing, observing and reflecting. In conducting this research, the researchers were assisted by one tutor teacher and two peers who acted as observers who observed the learning process. The subjects of this research were all students of class X IPA 1 of UM Laboratory Malang Senior High School. There were 36 students in the class which consisted of 14 male students and 22 female students.

Data collection techniques used in this research were as follows: (1) observation of teacher’s and students’ activities, (2) test of students' mathematical concepts understanding at the end of each cycle, (3) field notes. In this research, the researcher acted as the main instrument because the researcher himself acted as the teacher who did the activity. While the supporting instruments used in this research were as follows: validation sheets, lesson plans, student activity sheets (SAS), mathematics concept understanding test questions, observation sheets, field notes, and documentation.

Procedures / stages conducted by the researchers in this research were the pre-action stage and the research activities implementation stages. This class action research consists of several cycles in which each cycle consists of (1) planning, (2) action, (3) observation, and (4) reflection. The data obtained were analyzed qualitatively and quantitatively. Improvement of the students' concept understanding in the SLETV learning material in this research is shown by the large number of students with a high and very high concept understanding criteria that reaches the value of more than 70% and many students with a low concept understanding criteria ≤ 10%.

3. Results and Discussion
This class action research consists of action planning, action implementation, observation, and reflection. There were three meetings in Cycle I and three meetings Cycle II with each meeting was held...
for 2 x 40 minutes. During the research process, there were a number of results obtained as shown in Table 1.

| Cycle | Meeting | Observer | Student’s Observation | Activity |
|-------|---------|----------|-----------------------|----------|
|       |         |          | Score | Category |
| I     | 1       | I        | 71%   | Good     |
|       |         | II       | 71%   | Good     |
|       |         | III      | 70%   | Good     |
|       | 2       | I        | 78%   | Good     |
|       |         | II       | 80%   | Good     |
|       |         | III      | 81%   | Very Good|
|       | Average |          | 75.17%| Good     |

Table 1 shows the percentage of successful implementation of PBL as seen from the improvement of students’ activities in the first and second cycle (Cycle I and Cycle II) that is categorized as very good. Next, Table 2 shows the results of the students' concept understanding test.

| Cycle | Number/ Percentage | Concept-Understanding Category |
|-------|--------------------|-------------------------------|
|       | Number of students | Very High | High | Fair | Low   |
| I     | 13                 | 5     | 11   | 7    |
|       | Percentage         | 36.11%| 13.89%| 30.56%| 19.44%|
| II    | Number of students | 32    | 2    | 1    | 1    |
|       | Percentage         | 88.89%| 5.56% | 2.78% | 2.78% |

Based on Table 2, the percentage of students’ concept understanding in Cycle I that were in the category of “very high” and “high” was 50.00% from the total of 36 students, and the percentage of students’ concept understanding in the “low” category was 19.44%. The results obtained in the first cycle can’t be included in the success criteria determined by researchers, so that the researchers carried out improvements in the second cycle based on reflection of Cycle I. The results obtained in the second cycle shows that the percentage of students’ concept understanding that were in the category of “very high” and “high” was 94.45% from the total of 36 students. This means that the students' concept understanding can be included in the expected concept understanding improvement criteria, namely the students with high and very high categories percentage reach the score of ≥ 70%. On the other hand, the percentage of students’ concept understanding in the low category was 2.78%. It means that the students’ concept understanding can be included in the expected concept understanding improvement criteria in which the low categories is ≤ 10%.

Based on the research results, the stages of the PBL model are as follows:
3.1. Stage of Orienting The Students to the Problem
In this stage, the teacher motivates students to engage in a selected real problem-solving [13]. The teacher starts the learning process by conveying the learning apperception by giving challenging questions so that students are focused on what the teacher will tell them. Then the teacher conveys the benefits/importance of today's learning process so that the students are motivated to learn the material. At this stage, the teacher's knowledge of the individual characteristics of students is very important in order to manage learning [14]. In the Cycle I, only a few students responded and answered the questions raised by the teacher. However, in the Cycle II, all students enthusiastically responded and answered questions. Students at this stage are confident enough in expressing their opinions. Children's self-confidence is very important for their math development [15].

3.2. Stage of Organizing the Students to Learn
In this stage, the teacher helps students in defining and organizing the learning tasks[13]. The teacher divides students heterogeneously into groups and distributes worksheets. In Cycle I, the teacher gives the worksheets to each student in the group. But unfortunately, it resulted in the students getting the tendency of working alone. In Cycle II, the teacher only distributes two worksheets to each group, with the rule that one worksheet is going to be submitted to the teacher and the other one is going to become each group's archive that will be copied by each member of the group to their own book.

After that the teacher conditions the students to focus on reading, observing and asking questions that are less understood on the problems at the worksheet. The role of the teacher is very important in conditioning students in group learning [16]. In Cycle I, there were only a few students that were actively reading, observing and asking questions on the problems that was being presented. It was because the students were still not accustomed in understanding the problems and making questions from the problems. In cycle II, there was an increase of students who ask questions about problems given by the teacher in the worksheets, students already have a tendency to understand problems and ask questions. The tendency of students in learning is an important factor for achieving learning success [17].

3.3. Stage of Guiding Individual and Group Investigations
In this stage, the teacher encourages students to conduct an experiment to obtain the clarity needed to solve problems [13]. The students need to gather information from various sources to be used as investigation material in solving the problems. The teacher tells the groups that all students need to actively participate in discussing their opinions in solving the problems. For each group in which all members are active in discussion session, the teacher will give an award at the end of the learning. The teacher provides 'scaffolding' (help) to groups who find it difficult in investigating the problems.

In Cycle I, there were many groups that experience difficulties in the process of problem investigation. Many of the groups were asking questions so that the teacher needed to guide each one of the groups. Fortunately, each group were facing almost the same difficulties, so that the teacher conveyed the assistance and guidance classically (by giving lecture) to keep the time short. Then in the second cycle (Cycle II), the students were getting used to do the investigation with their group members so that only a few students that found it difficult in the problem solving process. The contribution of members in the group is very important for mathematical exploration [18].

3.4. Stage of Development and Presentation of Students’ Work Results
In this stage, students in each group needs to actively check the answer of their group discussions that are going to be reported on the worksheets. In the first cycle (Cycle I), there was a group that took a very long time to finish the report because some students were reluctant to group and only those who had a high ability made the report written on the worksheet. In Cycle II of this stage, all group members actively participated to present their work on the worksheets because they were more motivated by the appreciation that would be given by the teacher. Students who are involved in learning activities physically can be beneficial for learning mathematics [19].
3.5. Stage of Analyzing and Evaluating

In this stage, the teacher asks several groups to present the work that previously had been discussed in the group. Each group gives responses to the presentation result so that there will be exchange of ideas on the answer and different ways in solving the problems. The students analyze the problem-solving process by comparing their answers with the group currently presenting their answer. Then giving comment if there is any difference in the answers and giving question if there is any thing that are not yet understood. During the discussion, all students were given opportunities and challenges to want to express their opinions. This challenge is important so that all students in the group can be more united in working together, and reduce the dominance of one of the students in the group [20]. The teacher helps and directs all students to the conclusion of solving the problems, so that the conclusion does not go far beyond what is expected. In directing students in groups, teachers pay attention to interdependence and bring out diverse competencies in the group [21]. Teacher confidence in managing and managing the class is very necessary, because this will affect student learning outcomes [22].

In Cycle I, some students in the groups did not pay attention when another group were presenting their result. It was because several students in the not-presenting groups were busy thinking about their groups’ unfinished answers. Only a few students took part in correcting the presenting group's answers and expressed their responses if there was any difference in their answers. Besides, the limited learning duration caused some of the problems could not be discussed in the presentation, so that the teacher needed to immediately direct the students to conclude the learning outcomes.

In cycle II, there was an increase in the number of students who actively participated in checking the answers of the presenting group and giving responses on the correction results for answers and different ways of solving the problems. In addition, some students were asking questions about the unclear or difficult to be understood solutions. After that, the teacher and students concluded and reflected on learning activities. The teacher asked some of the students to express their conclusions and reflection results. In cycle II, students were more enthusiastic because of the reward that were going to be given by the teacher at the end of learning process to the most active group in terms of discussion, asking questions and giving responses. Giving awards is a teacher intervention so that students are more enthusiastic. This intervention is important to support the development of students' learning abilities and self-confidence [23].

Based on the results of the teacher’s and students’ activities observation as well as concept understanding test in cycle I, it can be seen that the average percentage of students’ activities in Cycle I was 75.17% and can be included in the category of "Good". Whereas the average percentage of teacher’s activities in Cycle I was 76.83% and can be included in the category of "Good". Then in the second cycle (Cycle II), it can be seen that the average percentage students’ activities was 80.33% and can be included in the category of "Very Good". Whereas the average percentage of teacher’s activities was 81.67% and can be included in the category of "Very Good".

Overall, an increase in the students’ and teacher’s activities can be seen in the Figure 1. The Figure 1 graph shows that the students’ activities in PBL learning model increased from Cycle I to Cycle II, and the same goes for the teacher’s activities.

![Figure 1. Graph of increasing students’ and teacher’s activities](image-url)
Students’ and teacher’s activities improvement also influences the result of students’ concept understanding tests. The test result shows that the result of Cycle I cannot be included in the criteria of increased concepts understanding as seen from the number of students that have a high and very high concept understanding of 50.00% out of the 36 students. This means that the percentage of students' concept understanding criteria in the high and very high category was \( \leq 70\% \) of the number of students. Whereas the students who were in the low category of concept understanding were 19.49% of the 36 students which means that the percentage of students’ concept understanding of low category was \( \geq 10\% \) of the number of students.

From the test result, it can be seen that Cycle II can be included in the criteria of increasing concepts understanding as seen from the number of students who had a high and very high concepts understanding that reach the value of 94.45% of the 36 students. This means that the percentage of students’ concepts understanding in the high and very high category was \( \geq 70\% \) of the total number of students. Whereas the students with the low category of concept understanding was 2.78%, which means that the percentage of students' concept understanding of low category was \( \leq 10\% \) of the number of students.

The results are in accordance with the research of Hendriana et.al.[5] which states that PBL can improve students' mathematical problem solving which means that their understanding of mathematical concepts also increases.

Overall, an increase in students’ concepts understanding can be seen in the Figure 2.

![Graph of increasing number of students’ percentage in each category of students' concepts understanding](image)

**Figure 2.** Graph of increasing number of students’ percentage in each category of students' concepts understanding

Based on the graph above, it can be seen that the increase in students' concepts understanding with very high categories has increased from initial value to Cycle I and Cycle II. Students’ concept understanding with the low category has decreased from the initial value to Cycle I and Cycle II.

### 4. Conclusion

Based on the data analysis, it can be concluded that the application of PBL learning model can improve students' understanding of mathematical concepts in SLETV learning material in class X-IPA 1 of UM Laboratory Senior High School. After the implementation of PBL model on the SLETV learning material, it was found that the number of students with high and very high concept understanding has increased from Cycle I to Cycle II, and the concept understanding of the low category students has decreased from Cycle I to Cycle II. Specifically, the number of students with a high and very high concept understanding from Cycle I to Cycle II was increased into 94.45%, which means that the percentage of students' concept understanding criteria with a high and very high category was \( \geq 70\% \) from the total of 36 students. Whereas the number of students with low category of concept understanding were 2.78%, which means that the percentage of students’ concept understanding of low categories was \( \leq 10\% \) from the total of 36 students.
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