Problem-based learning in real number topic for practising critical and creative thinking

F Adamura
FKIP Universitas PGRI Madiun
*corresponding author: * fatriya.mathedu@unipma.ac.id

Abstract. Research has been done is experiment research. Research has been done for knowing the effectiveness of problem-based learning in real number topic of Real Analysis 1. Applied learning devices have been developed in the last development research. This research is done in class VI B of Mathematics Education Program even semester of 2019/2020. Research outcomes show that implementation problem based learning in real number topic was effective. This is because lecturer capability in learning management was good, student activities were significant, student responses were positive, and classical student learning achievement was reached.

1. Introduction

Learning mathematics in schools not only aims to facilitate students in mastering as much math material as possible but also enables students to be able to build thinking skills. In the 2006 Education Unit Level Curriculum (KTSP), it is stated that Mathematics subjects need to be given to students ranging from primary education to higher education to equip students with the ability to think logically, analytically, systematically, critically, and creatively [1]. This is in line with the opinion of Soedjadi that school mathematics which is part of mathematics selected based on the interests of education and development of science and technology functions as a means of structuring students' reasoning [2]. By studying mathematics, students are expected to be able to reason and think logically, analytically, critically, and creatively.

Ministerial Regulation (Permen) number 22 of 2006 (2006) mandates that one of the goals of national education is so that students can reason and think creatively [3]. Implicitly, the regulation requires that one of the objectives of learning mathematics at the formal education level is so that students can reason and think creatively. The ability to maintain and think creatively possessed by students is expected to help students solve problems faced both at school and in everyday life.

The description above shows that critical and creative thinking must be owned by students studying mathematics. This is because critical and creative thinking is one of the goals of learning mathematics as well as national education, and this thinking ability is needed by students both at school and in everyday life. This shows that critical and creative thinking is very important for students, even though there are still many who have not mastered these thinking skills.

Several phenomena show that students' critical and creative thinking skills are still low. The Trends International Mathematics and Science Study (TIMSS) shows that in the field of mathematics, mathematics and science abilities of junior high school-aged students in Indonesia rank 34th out of 38 countries studied [4]. Furthermore, the study shows that the power of junior high school students in
Indonesia to solve non-routine questions is still feeble. However, the ability to solve routine questions is relatively good. Alimuddin stated that schools and colleges have not been able to produce creative graduates [5].

A low level of creativity is not only experienced by students but also experienced by teachers and students [6]. This is reinforced by the results of research by Alimuddin which shows that the way of thinking of superior SMA class II SMA students in Masamba in solving math problems still tends to converge (centred on one answer only)[5]. In other words, students’ creative thinking skills are still deficient.

Supriadi in Noerstates that teachers have a huge role in the development of student creativity [7]. The influence of teachers on students (children) is more significant than that of parents because teachers have more opportunities to support or inhibit the development of students' creative thinking abilities. Munandar in Alimuddin states that the ability to think creatively is closely related to the way teachers teach in schools [5]. If the teacher carries out learning that facilitates students to bring out creativity, then the student’s imagination will grow and develop.

One of the causes of students’ low creative thinking skills is that teachers still apply the old paradigm in teaching, namely learning that still relies on memory, understanding, application, analysis, synthesis, and evaluation [5]. The teacher has not applied a new paradigm in learning, namely, learning that relies on the revision of the cognitive process dimensions of Bloom's taxonomy: memory, understanding, application, analysis, evaluation, and creation [5]. The teacher still only gives convergent problem-solving tasks (problems that only have a single solution). Convergent questions cannot provide opportunities for students to develop creativity because convergent questions seem to force students to answer according to the procedure. Another opinion from Mahmudi shows that the low thinking ability of students is caused by the implementation of learning which emphasizes more on the mechanistic aspects [4]. Mathematics learning is more focused so that mechanically, students are able to memorize several mathematical facts and are relatively less able to develop thinking skills.

One solution to developing student creativity that can be done by teachers in schools is teachers carry out learning that facilitates students to develop creativity. One of the lessons that enable students to develop creativity is problem-based learning [8]. In problem-based learning, students are given problems in real-world contexts so that students can learn about critical thinking and problem-solving skills as well as learning knowledge and concepts (material). The teacher’s role in problem-based learning is to present problems, ask questions, and facilitate inquiry and dialogue.

Questions that can be asked by the teacher to facilitate students in doing critical and creative thinking are questions that have many possible answers [5]. Some questions the teacher can ask are questions that start with “Is there any other way?”, “What if ...?”, “What's wrong?” Or “What would you do?” [9]. These questions can be asked when the teacher carries out the lesson or in student books or student activity sheets (LKS).

A mathematics teacher must be able to carry out problem-based learning to practice critical and creative thinking. Mathematics teachers can carry out the implementation of problem-based learning if the teaching of prospective mathematics teachers is also carried out by problem-based learning. Based on this, in the learning of prospective mathematics teachers, problem-based learning must also be applied.

Real I Analysis Material is one of the materials studied by prospective mathematics teachers at the tertiary level. The material contained in the Real Analysis I course trains future mathematics teacher students to think critically and creatively. Problem-based learning can be applied to the Real Analysis I subject learning because it can train students to think critically and creatively in mathematics teacher candidates.

Based on the description above, the authors are encouraged to carry out problem-based learning in the Real Analysis I course. Problem-based learning in the Real Analysis I course is only applied to real numbers. The real number learning tool that has been developed is then applied in learning to see the effectiveness of the learning that has been implemented.
2. Methods

The research that has been done is descriptive qualitative research. The descriptive qualitative research design was in the form of a One-Shot Case Study [10]. Descriptive qualitative research was carried out by applying problem-based learning tools on the Real Numbers material in the Real Analysis I course, which had been developed in previous research. Some of the symptoms that appear in learning are observed to determine the effectiveness of the learning that has been implemented. Some of the observed symptoms include the ability of the lecturer to manage learning, student activities during learning, student responses, and student learning outcomes test scores (THB) after learning.

The descriptive qualitative research subjects were students of class VI C Mathematics Education Study Program, even semester of the 2018/2019 academic year. Some of the research instruments used were observation sheets of learning management by lecturers, student activity observation sheets, and student response questionnaires. The learning management observation sheet by the lecturer is used to collect data about the ability of the lecturer to implement problem-based learning steps according to the planned Lecture Unit (SAP). Student activity observation sheets are used to collect data about student activities during learning. Learning outcome tests are given to students to obtain data on student learning outcomes. The student response questionnaire instrument was used to collect data about student responses to problem-based learning activities.

The ability of lecturers to manage to learn is said to be good if the average score of each aspect is assessed for all meetings at least 3. Student activities are said to be effective if the time used to carry out each activity category of each meeting (SAP) is in accordance with the time allocation contained in the plan learning with a tolerance of 5%. Student responses are categorized as positive if the percentage of student positive responses is at least 85% for each aspect. Student learning outcomes data were analyzed using percentages. Learning outcome data is used to describe the completeness of classical learning outcomes. Classical completeness of learning outcomes is achieved if at least 85% of students in the class get a minimum score of 65% of the overall score.

Problem-based learning is effective for teaching real number material in the Real Analysis I course if classical learning completeness is achieved, and two of the following three things are achieved, namely: the ability of lecturers to manage to learn well, effective student activity (active students), and positive student responses.

3. Result and Discussion

Some of the research data used to describe the effectiveness of problem-based learning in real number material are the ability of lecturers to manage learning, student activities during learning, student responses, and student learning outcomes test scores (THB) after learning. The results of the descriptive analysis of the descriptive qualitative research data are presented as follows.

3.1. The ability of lecturers to manage to learn

The results of the lecturer ability assessment in managing learning in the class are presented in Table 1 below.

| No | Aspects Observed                                      | Lecturer Ability Value |
|----|-------------------------------------------------------|------------------------|
| A. | Introduction                                          |                        |
|    | (1). The ability to provide motivation to students    | 3,67                   |
|    | (2). Ability to convey learning objectives            | 4,33                   |
|    | (3). Ability to remind students about prerequisite material | 3,33                   |
| B. | Core Activities                                       |                        |
|    | (1). Ability to organize students to study            | 4                      |
(2). Ability to guide individual and group investigations 4,33
(3). Ability to develop and present results 3,33
(4). Ability to analyze and evaluate problem-solving 4

C. Closing
   (1). The ability to encourage students to make conclusions about the material that has been studied 4,33
   (2). The ability to convey material to be studied next 4,67

D. Ability to manage time 4,33

E. Class situation
   (1). Student enthusiasm 4,33
   (2). Lecturer enthusiasm 4

The table above shows that the average score of each aspect assessed for all meetings is at least 3. This means that the ability of the lecturer to manage to learn is good.

3.2. Student activities

The results of observing student activity during learning in the experimental class are presented in Table 2 below.

**Table 2 Student Activities During Learning**

| No. | Observation Aspects                                                   | Percentage of Student Activities during Learning (%) | Criteria for Limiting Effectiveness (%) |
|-----|-----------------------------------------------------------------------|------------------------------------------------------|-----------------------------------------|
| 1.  | Listening to the teacher/paying attention to the explanations of active lecturers or friends | 12,50                                                | 11,88 – 13,13                           |
| 2.  | Switching seats according to the group                                | 6,25                                                 | 5,94 – 6,56                             |
| 3.  | Working on LKM by discussing groups and asking lecturers or friends if there are difficulties | 23,96                                                | 23,75 - 26,25                           |
| 4.  | Implement and participate in class discussions                       | 31,25                                                | 29,69 – 32,81                           |
| 5.  | Evaluating the learning process that has been carried out             | 12,50                                                | 11,88 - 13,13                           |
| 6.  | Make a summary of the material that has been studied                  | 6,25                                                 | 5,94 – 6,56                             |
| 7.  | Noting the material to be studied next                               | 6,25                                                 | 5,94 – 6,56                             |
| 8.  | Behaviour that is not relevant to learning activities                 | 1,04                                                 | 0 – 2                                   |

Based on the table above, the average percentage of each aspect of student activity is at the interval of the effectiveness limitation criteria. This means that learning is effective in terms of student activities.

3.3. Student response

The results of the student response questionnaire to the implementation of problem-based learning can be seen in Table 3 below.

**Table 3 Student Response Questionnaire Results for Learning Devices and Implementation**

| No. | Aspects responded to | Percentage of Positive Responses | Percentage of Negative Responses |
|-----|----------------------|----------------------------------|----------------------------------|


1. Can you clearly understand the language used in:
   a. Student Activity Sheet (LKM) 89,74 10,26
   b. Tes Hasil Belajar (THB) 94,87 5,13

2. Are you interested or not with the appearance (writing, illustrations/pictures, and image locations) in:
   a. Lembar Kegiatan Mahasiswa (LKM) 92,31 7,69
   b. Learning Outcomes Test (THB) 89,74 10,26

3. Are you happy or not with:
   a. Subject matter 92,31 7,69
   b. Student Activity Sheet 94,87 5,13
   c. Learning Outcomes Tests 89,74 10,26
   d. Learning atmosphere in class 97,44 2,56
   e. How to teach lecturers 94,87 5,13

4. Do you like it or not if the next lesson uses learning like the one you just did?

Table 3 shows that the positive response of students to all aspects of learning is more than 85%. This means that learning is effective in terms of student responses.

3.4. Completeness of classical learning outcomes

The results of the study on the learning outcomes tests are shown in the following table.

**Table 4 Posttest Value of Experiment Class**

| Values | Experiment Class |
|--------|------------------|
| Highest | 112               |
| Lowest  | 53                |
| Average | 70,09             |

Students are said to have completed learning individually if the posttest score obtained is at least 65% of the overall score. A class is said to be complete learning if at least 85% of students in the class have studied individually. Student learning completeness, both individually and classically, is shown in Table 5 below.

**Table 5 Completeness of Student Learning Outcomes in the Experiment Class**

| Many students who complete their study individually | are 35 students or 89,74% |
|-----------------------------------------------------|---------------------------|
| Many students who do not complete learning individually | are 4 students or 10,26% |
| Classical learning completeness                      | Completely                |

Table 5 shows that in the research class, 89,74% of students completely studied individually. This means that classical learning completeness in the research class is achieved. These data indicate that learning based on problems in real number material can be said to be effective when viewed from the aspect of student learning completeness.

The achievement of the criteria for the effectiveness of problem-based learning tools for teaching real numbers material in the Real Analysis I course can be seen in the following table.
Table 6 Effectiveness of Problem Based Learning Model

| No | Aspect Category                      | Description |
|----|--------------------------------------|-------------|
| 1. | Lecturer ability in managing learning| Good        |
| 2. | Student activities                   | Effective   |
| 3. | Student responses                    | Positive    |
| 4. | Completeness of classical learning outcomes | Achieved   |

The table above shows that based on the results of the research, problem-based learning is useful for teaching real numbers in the Real Analysis I course. This is because it fulfils the requirements for the effectiveness of learning.

4. Conclusion

The results showed that problem-based learning was useful for teaching real numbers in the Real Analysis I course because it fulfils the following requirements: the ability of lecturers to manage to learn was good, student activity was effective, the student response was positive, and student learning completeness was classically achieved.

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