The impact of problem based learning using performance assessment on student’s mathematical problem solving ability

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Abstract. This study aims to determine the impact of problem based learning using performance assessment on student’s problem solving ability. Participants for the study consisted of 30 students. A pre-test–post-test control group design was used. Pre-tests and post-tests used to measure problem-solving abilities based on the cognitive level of Bloom and questionnaire used to measure student attitudes. Quantitative data were obtained from essay test and questionnaire and qualitative data were from interview and observation. The results showed that problem based learning using performance assessment had an positive effect on improving problem solving ability that can improve problem solving ability according to problem solving stage correctly.

1. Introduction

As a learning model, Problem Based learning (PBL) has a relatively long history. It was initially used in medical education, at the faculty of medicine, McMaster University in Canada in the mid 1960’s. Soon after, three other medical schools, the University of Limburg at Maastricht in the Netherlands, the University of Newcastle in Australia, and the University of New Mexico in the United States, adapted the McMaster model of PBL into their more specific subject areas before developing a model of their own. As a result of this various adaptation, PBL is believed to have become a solid learning model which can sufficiently support the development of learners’ critical thinking skills in a diverse subject areas [1], including mathematics education. In addition, also claims that this model is also supported by constructivist learning views which is applicable in all educational institutions from kindergarten to tertiary levels, including the area of medical education and training.

Theoretically, PBL is based on Piaget’s constructivist and Vygotsky’s social constructivist learning theories [2]. Piaget’s theory is based on the belief that learning should be based on the cognitive development of children with schemata as its basic structure. Meanwhile, Vygotsky emphasizes the importance of social environment in children’s construct development. Vygotsky’s theory centers on two main concepts: zone of proximal development (ZPD) and scaffolding. ZPD is understood as a distance between children’s level of actual development which is defined as autonomous critical thinking ability and that of their potential development which is defined as critical thinking ability under adult guidance through collaboration with peers of higher ability [2].

The PBL model requires students to be progressively responsible for their own learning processes [3]. PBL is a constructivist approach that emphasizes learning through problem solving experiences. Furthermore, it has been described as a teaching method that develops learners, problem-solving knowledge and skills through real-world problems. The problem in PBL is a centralized problem in a
dynamic process in which students are actively involved in asking questions and solving problems related to content and context under investigation. Problem-based learning is self-directed learning that allows for teamwork, as it encourages inquiry, collaboration, and active learner participation [4]. PBL is independent learning that allows teamwork, because it encourages active inquiry, collaboration, and student participation. This is characterized by the involvement of students as stakeholders in problem situations. This encourages collaboration among participants and helps them develop motivation to share.

Since its early conception in medical education, PBL has been growing significantly that it was later begun to be adapted and used in other areas of education, particularly mathematics education. Applying this model in their research, for instance, [2] found that PBL has positive results on students’ learning results as well as their understanding about concept and learning attitudes. Using a slightly different model, activity-based learning, [2] applied a similar study with the following criteria: a) using small group collaboration to solve the problem given, b) giving more autonomy for students to be the learning center, c) using real life problem, and d) assigning teacher as facilitator. The findings show that this model of activity-based learning can significantly improve learners’ attitudes, understanding of concepts and learning results.

The course in Educational Statistics requires students to solve problems, especially in the use of statistics in educational research. To solve problems students need to have critical thinking skills and analytical reasoning. Critical thinking in problem solving is a very important part of learning, because in the learning process students are allowed to gain experience using the knowledge and skills they already have to apply to non-routine problem solving. It is expected that students can show a logical attitude, critical, analytical, careful and thorough, responsible, responsive, and not easily give up in solving problems.

The problem is something that requires completion, so that an individual can overcome a problem then the individual must have the ability to solve problems. Problem solving is one of the main aspects in the mathematics curriculum that students need to apply and integrate many mathematical concepts and skills and make decisions [5]. As a result, it became evident that subject of problem solving has a positive effect on the development of mathematics teachers’ problem solving skills. Problem solving plays an important role in mathematics education and most of learning is an occur as a result of problem solving process [6].

Assessment has always been an important component of any educational reform. Policymakers have used tests and assessments to set benchmarks for accountability purposes and to initiate change in educational. In recent years, educators have emphasized the importance of alternative assessments, particularly performance and portfolio-based assessments [7]. Performance assessments not only measure student achievement but also are opportunities for student and teacher learning [8]; students learn through the process of completing the assessment, and teachers learn about their students’ abilities and knowledge and are subsequently better able to address their students’ learning strengths, interests, and needs. The process of designing, administering, and scoring complex performance assessments can provide a teacher information about students’ abilities and support teachers in learning to integrate higher level thinking skills. Research suggests that the use of performance assessments can produce positive instructional changes in classrooms, such as increased instructional time devoted to problem-solving and writing [8]. Based on the opinions above, this research is a study by applying the PBL model using performance assessment in an effort to improve students’ problem solving abilities.

Polya [6], describes the process of problem solving at four stages, including understanding the problem, determining the strategy, implementing the selected strategy and assessment. At the stage of understanding the problem, the student is expected to state what he understood from the problem and to determine what are the given and unknown in the problem and also to suggest clearly the condition of the problem. At the stage of determining the strategy, the student is expected to determine which steps such as calculation, drawing, etc. to follow in order to reach the requested. The teacher can promote the use of different problem solving strategies by writing the all strategies on the board and
can enable the student to choose the suitable strategy. The following stage includes the application of selected strategy by the student. At the stage of application the selected strategy, the solution should be checked step by step. At the stage of assessment, on the other hand, the student should control whether the solution he made is right and meaningful. During the process of control, it must be fully put forth what has been done and where it has been done.

The aims of the study was to improve students' problem solving abilities, and to analyze the descriptions of the students' problem solving abilities. This study uses a group's pre-test post-test design [9]. There are 100 students in 2018 who are registered as participants in the educational statistics course in the even semester of 2018/2019 academic year in the Department of Mathematics, Semarang State University. The sampling of this study consisted of 33 students who were students aged between 18-22 years without prior experience. Learning time in class is held 150 minutes per week for one semester in this case 14 weeks.

The variable in this study is the problem solving ability of students of mathematics education study program, mathematics majors, FMIPA Semarang State University who take the educational statistics courses in the sixth semester of the 2018/2019 academic year. The research instrument used to collect data consisted of pre and post test and questionnaire. The pre and post test are prepared by researchers, the test is intended to measure the students' ability to solve by referring to the cognitive level of Bloom. Prates are done before students are given learning with PBL, and after the test is done after students get learning with PBL. Before the instrument is used it has been tested about its validity and reliability. To validate the instrument, it was done with content validity and item validity, tested the reliability of the test, the test was tested with 30 students who were not the target group, and calculated for the reliability coefficient using the Alpha coefficient from Cronbach. After that, the test was given to participants before being given PBL treatment.

Instrument test results show that the test reliability coefficient is 0.73, and the validation results indicate that the instrument is valid. Based on these results the researchers decided to use instruments to measure problem solving abilities. The pre-test score and test post are analyzed by paired t test, after all prerequisite tests are met. In addition, in an effort to learn what students think about these learning activities, they are asked to answer the questionnaire after the post-test. Data obtained from pre and post test, as well as the first part questionnaire, were analyzed using paired t-sample tests with the help of the Statistical Package for Social Sciences (SPSS). The second part questionnaire was analyzed qualitatively qualitative, including analysis conducted for the mean, standard deviation and results of student answers to the questions given.

2. Result and Discussion
The first question in this study is whether PBL learning using performance assessment can improve students' problem solving ability in solving problems in the educational statistics course. The results showed the average value of students before and after PBL learning treatment using performance assessment mean for pre-test was 79 and the mean for post-test was 85. To find out whether students' problem solving abilities increased significantly, the pre-test scores and post-test compared to applying paired t-sample tests. The results in Table 1 showed that the average post-test score was higher than the pre-test average score.

| Table 1. Result the descriptions of the students' problem solving abilities |
|---------------------------------------------------------------|---------|---------|
| The stage of the students' problem solving abilities          | The presentage before treatment (%) | The presentage after treatment (%) |
| The stage of understanding the problem                        | 4       | 96      |
| The stage of selecting the strategy                           | 20      | 80      |
| The stage of application of the                               | 20      | 80      |
strategy
The stage of evaluation of the solution 20 80

According to the results obtained, the students determined the given and known in the problem in correct way to a large extent. It can be said that this result may change according students’ depending on the difficulty of the problem. In addition, it was concluded that the students were able to detect the given more easily than the required in determining the given and unknown data in the problem. This situation may be due to students’ being less in the habit of questioning what is exactly known in the problem.

A number of research results carried out similarly also suggested that after the students had been taught various problem solving strategies, they learned and used these strategies, their success in mathematics increased and their skills of problem solving improved [6]. According to the results of interviews, it was concluded PBL using perormance assessment affected students’ skills of problem-solving stages, their thinking processes, and their applying and evaluating the problem in a positive way. The actively participation of the students, who received the education of problem-solving, in the lesson was determined with their positive views to the subject. Presley [6] set forth that the students receiving education for problem solving strategies are more successful as compared with those not being informed about these strategies and their problem solving skills are high. The process of solving problems is now completely interwoven with the learning; children are learning mathematics by doing mathematics [10].

3. Conclusions
PBL learning using performance assessment can improve students' problem solving ability in solving problems in the educational statistics course. At the stage of understanding the problem, based on the work results of students who have done well there is 96%. This is better than the results before treatment, which is only 4%. At the stage of selecting the strategy, the percentage of students who can work correctly is 80%. This is better than the results before treatment, which is only 20%. This is suggests that the students selected the strategies of working backward. At the stage of application of the strategy, the percentage of students who can work correctly is 80%. This is better than the results before treatment, which is only 20%. At the stage of evaluation of the solution, the percentage of students who can work correctly is 80%. This is better than the results before treatment, which is only 20%. It was concluded that the students who reached the correct solution with the strategies they selected were successful at the stage of evaluation. PBL is an approach of learning in which the process of constructing knowledge activates students’ knowledge, and problem-solving strategies of ill-structured problems are developed and acquired through in-group discussions.

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