

The Application of Problem-Based Learning in Mechanical Engineering

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Abstract. The course of Technology and Material Testing prepare students with the ability to do a variety of material testing in the study of mechanical engineering. Students find it difficult to understand the materials to make them unable to carry out the material testing in accordance with the purpose of study. This happens because they knowledge is not adequately supported by the competence to find and construct learning experience. In this study, quasy experiment research method with pre-post-test with control group design was used. The subjects of the study were students divided in two groups; control and experiment with twenty-two students in each group. Study result: their grades showed no difference in between the pre-test or post-test in control group, but the difference in grade existed between the pre-test and post-test in experiment group. Yet, there is no significant difference in the study result on both groups. The researcher recommend that it is necessary to develop Problem-Based Learning that suits need analysis on D3 Program for Mechanical Engineering Department at the State University of Padang, to ensure the compatibility between Model of Study and problems and need. This study aims to analyze how Problem-Based Learning effects on the course of Technology and Material Testing for the students of D3 Program of Mechanical Engineering of the State University of Padang.

1. Introduction

National Education System is aimed to yield brilliant and competitive Indonesians with excellent personality and fond of quality, high-spirited, strong-willed, independent, able to build up networking, friendly with changes, innovative, willing to be the agent of change, productive, aware of quality, global oriented, and study for the whole life time [1]. Brilliant in this term involves spiritual, emotional, social, intellectual and kinetic intelligence. He becomes a person with competitive competence is capable to compete and fight for his life and becomes a person who can give meaning to his own life and the lives of others which is specified by UNESCO as 'How to Live Together'. From this point of view, it can be seen that the process of producing intelligent and competitive human resources is standardized on education. Since the development of quantity triggers high competition among universities, it is necessary for the university to present excellent quality graduates who can stand out in competition [2].

The Indonesian Law No. 20 2003 states that education is an effort intentionally made and well-planned planning to provide a good environment for study to enable students to actively develop their potentials, to have spiritual power, self-control, intelligence, good-manner, and as well as skills necessary for himself and other people. The vision of national education of 2025 is to produce intelligent and competitive Indonesians well-prepared to face anything to come. One of those efforts made to achieve these targets of national education is to provide people with vocational education. The basic



philosophy of vocational education is the interaction of students and business-like environment [3]. As a result, practitioners in vocational education have to pay a closed attention to students through educational programs.

As one of the educational programs at the Vocational pathways, the students of D3 Mechanical Engineering are educated through the learning program integrated with the needs of graduates' provision used in industry. Generally Technical Vocational Education plays an important role in preparing its graduates to face globalization and technological changes that affect the life of the social, political, economic and economy of the society. The challenge of the business world with job competence that increases with the advancement of technology requires that a higher education institution should be able to anticipate and address changes that occur by utilizing a variety of capacities by preparing the students with knowledge during their studies [4].

Problems that occur in the field associated with the process of learning in the course of Technology and Materials Testing which is a must for students of D3 Mechanical Engineering of the State University of Padang that the learning process is still carried out with conventional ways. Learning models that are less-triggering passion and creativity of students, learning activities are monotonous and cause boredom, the lack of activity of thinking which allows students to not gain the ability to solve problems that are factually and contextually appropriate to the reality in the field of employment. As a result, less innovative learning process which has been carried out causes the students to have low abilities in the subject of Technology and Testing of Materials. Students who are expected to develop reasoning and critical thinking in testing tend to have low ability.

Based on their motor skills students in practical coursework met the fact that they were not able to carry out the testing of materials in accordance with the standards of competence expected, although the course has been equipped with worksheet and teaching materials, as well as the application of the teaching method of discussion, lectures, a FAQ, cooperative learning, assignments and practices but the results of student learning is still inadequate. All of these result in low learning outcome, and many students get inadequate grade and thus have to retake the course in the next semester. The researchers face that the problem tends to re-occur every year so that it triggers polemics and thought that the material that is given to students may be too difficult for them to understand. If it is not based on the ability of students to find their own knowledge and construct a learning experience to solve problems through learning undertaken related with material Technology and Materials Testing. Departing from the above problems, the researcher has the initiative of researchers to apply Model-Based Problem learning so that the phenomenon of failure in learning Materials Testing can be overcome.

2. Theoretical study

2.1. The Course of Technology and Material Testing

The course of Technology and Materials Testing is the practice course through which students are equipped with knowledge about the various tests such as tensile testing, impact testing, and the testing of microstructure hardness of a material. This subject weigh 3 credits (2 credits 1 credits theory and practice). The contents of the course to the theory include: classification of engineering materials, the properties of engineering materials, phase diagrams, standardization of engineering materials, ferrous metals, nonferrous metals, non-metals, materials selection criteria, and corrosion. As for the practice include: testing of hardness, tensile testing, deflection testing, torsion testing, testing at the notch, the macro and micro structure.

Materials provided on this course was developed in accordance with the competencies to be developed concerning: 1) Describing the classification of engineering materials, 2) Describing the properties of engineering materials, 3) Explaining the diagram phase, 4) Describing the standardization of materials engineering, 5) Describing Miscellaneous uses of ferrous metals, 6) Describing the kinds and applications of nonferrous, 7) Describing the kinds and uses of non-metallic materials engineering, 8) Describing the criteria for the selection of technical material in the application, 9) Describing the corrosion and prevention, 10) Having the ability to perform tests and analyze the results of testing of

hardness, 11) Being able to perform testing and to analyze the results of tensile test, 12) Being able to perform testing and to analyze the results of torsion test, 13) Being able to perform testing and analyzing the test results at a notch, 14) Being able to perform the testing and analyzing the test results deflections, 15) Being able to do a test and analyze the test results of microstructure.

The Interest of the course of Technology and Materials Testing is that students are able to classify materials engineering, properties of engineering materials, diagrams phase, standardization of engineering materials, ferrous metals, nonferrous, non-metallic, criteria for the selection of materials and corrosion and practically able to do testing hardness, tensile testing, testing a deflection, torsion testing, testing at the notch, the macro and micro structure. From the learning objectives developed by the Syllabus, educators have to make some efforts to implement a learning model that can develop the ability of students to solve problems and become independent learners. Because it is believed that learners will never gain the ability if they do not have the experience that encourages their development [5]. Therefore, to achieve this goal of study, the researcher as an educator implements Problem Based Learning Model that is carried out in accordance with the lesson plan with Syntac expressed by the experts who developed this learning model.

2.2. Problem Based Learning Model

In achieving national educational goals that have been implemented, the quality of the defense-distance must be considered. The job of an educator to create learning that can help students understand the lessons given and realize the change of behavior from not understanding to understanding with a fun process, continuously and continues to change as thoughts and feelings that continue to be built and developed on an ongoing basis [6]. One effort in order to realize the quality learning is to use a learning model which has proven its accuracy and usefulness in achieving the learning objectives.

Teaching models that have been designed by experts through research that that has been done are considered to be a way to help learners acquire information, ideas, skills, values the way of thinking and purpose of expressing self-learners, so the capability of learners in the learning becomes easier and more effectively in the future. Embodiments of learning success through appropriate learning model obtained for students to better cope with the learning process. Through the PBL students can actively build a mental model of the problem and its solution, PBL encourages self-direction, so that students can set goals of study by themselves, identifying barriers and arbitrary been awarded by his own efforts in learning [7].

PBL allows students to be improve their ability to analyze a material, PBL is an instructional method that challenges students to learn, to work together in groups, and to find solutions to real problems that these problems can be used to remind curiosity as well as analytical and initiatives on the subject matter. Their curiosity can be enhanced through the model PBL, to attract students to learn is by presenting a problem that can be attractive so that the learning process is not monotonous and boring begins with providing an appropriate issue to the knowledge base of students that will foster the students' enthusiasm [8].

Thus, the models of educational practices that are considered beneficial in the century industrial, such as learning the facts, drill and practices, rules and procedures were replaced by learning in the context of real-world, authentic through problems and projects, inquiry, discovery, and invention into practice knowledge age. One model that is aligned with the development of information technology is a Model Problem Based Learning.

PBL is a set of models of teaching that makes the problem the focus on developing problem-solving skills, materials and self-regulation [9]. Model Problem-based learning is an innovation in the creation-learning because this model is the ability to think Learners truly optimized through the process of the work group or team is a systematic, so that learners can empower, sharpen, test and develop the capacity to think continuously [10].

PBL model is the most significant innovation in education [11]. Model PBL helps to enhance the development of skills for lifelong learning in a mindset that is open, reflective, critical, and active

learning, as well as facilitating the success of problem solving, communication, teamwork and interpersonal skills better than other models.

PBL is an instructional model that involves learners to solve problems through the stages of the scientific method so that learners can learn the knowledge related to these issues and also have the skills to solve problems [12]. PBL is a learning model that challenges learners to "learn how to learn", to work in groups to seek solutions to real-world problems. This problem used to bind Learners curiosity on learning in question. PBL is an approach to learning in which learners are faced with the problem of authentic (real) so hopefully they can draw up his own knowledge, to develop high-level skills and inquiry, to help learners be independent, and to increase their confidence [13].

It can be concluded that the model PBL is an instructional model that is designed where learners actively confronted with complex issues in a real-life situation learning model is centered on students, and the curriculum is presented in the form of the existing problems so that learners have a curiosity out, which in turn will solve the problem. Based on the inferred meaning of understanding the problem-based learning is considered a good learning model used in practical learning for students Materials Testing D3 Mechanical Engineering.

2.3. Application Procedures Learning Model

PBL characteristics is learning focuses on problem-solving, 2) responsibility in resolving the problem rests on the students, 3) teachers support the process when students are working on the problem. Based on these studies, the researchers designing and implementing problem-based learning is based Characteristics presented with descriptions syntac as follows [5]:

2.3.1. Reviewing and Presenting Problems. In this phase, the researchers begin by reviewing the initial knowledge needed to solve the problem and then presents a problem themselves. Researchers carefully consider the progress of the students in identifying the problems encountered in the material presented, to be more effective, the researchers in this phase determines the issues to be discussed by the students, it is for effective learning. The researcher also provides training in identifying problems associated with testing material. In this phase also formed group of study consisting of 4 to 5 students in one group.

2.3.2. Developing Strategies. In phase 2 students are directed to strategize in solving problems that have been identified. Researchers provide guidance in order to avoid waste of time for students in determining the strategy in solving the problem. In the concept of giving the guidance, the researcher simply directed students and still provided decision-making in the hands of student problem-solving strategies

2.3.3. Implementing Strategies Researchers apply the learning support to help students complete the tasks that are not able to be completed by themselves in applying problem-solving strategies.

The researcher studied carefully when he was able to implement troubleshooting strategy. So that students do not spend time in guessing the correct answer from the strategy they charge.

2.3.4. Discussing and evaluating Results. In this last phase the researchers asked students to discuss and display the problem-solving strategies that they have done in front of the class. Ask students to explain and evaluate its own strategy of testing materials that have been done assessing the validity of the strategy used. Other class members would ask questions and members of the group will maintain the strategy used while researchers are directing the address the complexities and difficulties that may be encountered disclosure of the results of students in solving problems that they have done. The final result is a draw the conclusion of solving problems that do and direct class members to draw the conclusion together.

3. Methods

3.1. Research procedure

This study uses a quasi-experimental study (quasi-experimental) design with pre-post-test with control group design ", with the treatment of PBL Model. This study was conducted to determine the change in the form of students' ability to learn the results before and after treatment of the application of learning models, then researchers compared two groups of students, namely the treatment group and the control group. The initial stage is to divide the two groups of students in the classroom and then take the initial value as a data protest.

3.2. Data analysis technique

Subjects in this study consisted of two groups of classes, namely class control group (Q1) and an Experiment Group (Q2). The number of subjects of each class is 22 students. The procedures performed in the study were (1) Perform the protest for each class at the beginning of the semester courses, (2) treatment group taught by the application of the Model Problem Based Learning (3) The control group were still taught by conventional Model, for example the method of lecture and using the practice of using job sheet without using the problem Based Learning Model. (4) At the end of the semester was done post-test. Data were obtained using an assessment rubric for the practice, and essay questions to measure the ability of theory. The data analysis was done to describe the data of each group by revealing Central Tendency data and formulas Percentage Rate of Achieved Respondents were categorized. Whereas, to measure the difference in the effect of the use of Model-Based Problem using Statistical Analysis The test (Paired sample t test) to find whether there is any difference in effect in the current group protest and post-test and use statistic test (independent sample t test) to find whether there is any difference in effect treatment control group and experimental group.

4. Results and discussion

4.1. Initial Capabilities Equality Group Control and Experiment

Based on data analysis that has been done it can be explained description of the results of research on each group during the protest associated with early ability students, a more complete can be seen in Table 1:

Table 1. Description of Study Result of Pretest

Group	N	Mean	Median	SD	Sum	Min-Max
Control (Q0)	22	68.41	68.00	5.903	1505	60-82
Treatment(Q1)	22	67.45	66.50	7.513	1484	55-80

Table 1. Based on the table above it is seen that the prior knowledge of students in the control group (Q0) and experimental (Q1) have on average relatively similar (Q0) = 68.41, and (Q1) = 67.45. While based on the analysis of the t test (independent Sample T Test) to see the equality of both groups note that the significance (Sig.) is placed on 0082 scores. This score means that the two groups have no significant difference in the results. It means that the two groups have in common tendency capability significantly.

4.2. Differences Results Pretest and Posttest Experimental Group and Control

To determine differences in learning outcomes at protest and post-test in the experimental and control groups, it can be seen in the description following studies:

Table 2. The result difference between Pretest and Post-test

Group	Mean	95% (CI)	t hit	t tab	P value
Control (Q0)					
Before	68.41	2.622 - 1.349	.667	1.717	0.512
After	69.05				
Diff	0.64				
Experiment (Q1)					
Before	67.45	12.877- 4.941	4.669	1.717	0.000
After	76.36				
Diff	8.91				

Based on the data analysis, it shows that the learning outcomes of students in the control group had an average difference of 0.64. Based on t test known that score $t < t_{\text{table}}$ which means that there are no differences in learning outcomes and initial ability of students between pretest and post-test, boosted with p value = 0.512 stating that no difference can be a real difference at 95% significance level. In the experiment group it was discovered that the average difference was 8.91. Based on t test known that score $t > t_{\text{table}}$ which means that there are differences in learning outcomes and initial ability of students in the subject of Materials Testing between pretest and post-test, boosted by the significance of the score of 0.000 in the sense that there are real differences were significant at the significance level 95%.

4.3. Difference between Learning Outcomes Group Control and Experiment

Based on data analysis that has been done it can be explained description of the results of research in each group at the time associated with the post-test of Student Learning Outcomes in Subjects Testing Materials, more complete can be seen in Table 3 below:

Table 3. Description of study result of Post-test

Group	N	Mean	Median	SD	Sum	Min- Max
Control (Q0)	22	69.05	70.00	7.377	1519	55- 80
Treatment(Q1)	22	76.36	76.50	8.561	1680	55- 90

Based on the above table it is seen that student learning outcomes in the control group (Q0) and experimental (Q1) have on average relatively distinct (Q0) = 69.05, and (Q1) = 76.36. While based on the analysis of the t test (independent Sample T Test) to see the difference in the results of both groups note that the significance (Sig.) on the score of 0.0973. This score means that the two groups have no significant difference in the results. It means that the two groups have in common tendency capability significantly. This shows that with the implementation of Problem Based Learning Model pretest and post-test although there are differences in the results of the experiment group, but there are differences in learning outcomes significantly in experimental and control groups.

5. Conclusion

The study aimed to analyze the effect of the application of the Model Problem Based Learning (PBL) on the subjects of Technology and Materials Testing showed that there was no difference in the value pretest and post-test in the group taught by using conventional means that there is no increase in learning outcomes in this group. There are differences in the value pretest and post-test student groups taught by PBL models, which means that there is an increase learning outcome through the implementation of

PBL Model. But the results of the study to analyze the differences in learning outcomes significantly in both groups showed that there were no differences in learning outcomes in both groups significantly and note the difference in the success of studying the treatment group was not too big (pretest 67.45 increased to 76.36 with a difference of 8.91 when post-test). This shows that with the application of PBL model although there are differences in pretest and post-test results in the group being taught by PBL models but there are differences in learning outcomes significantly in experimental and control groups at the end of the study. This shows that there are still many things that need to be considered in applying the model PBL because based on this study both groups showed significantly different results. Related to the results of this study, researchers recommend that there are things that are associated with the process of learning PBL to note, considering learning process is a system that is interconnected between one component to another, if educators do not pay attention to a component, the possibility of success in study will be hard to achieve. Rusman (2012: 93) argues that learning is seen as a system consisting of various components that relate to one another. The components cover objectives, materials, methods of study, strategies and evaluation. The method is an attempt to implement a plan that has been prepared in real activities to achieve the goal [14]. The method is a learning procedure chosen by educators to assist students in achieving the learning objectives with maximum outcome. The learning method is a series of activities deliberated with designing, developing, aligning implementation, and evaluating a particular method for backing facilitate learners with the goal of achieving a competency. As educators need me-develop a model that is closer with the needs and circumstances of the problem of system in place to teach, therefore it is necessary to develop PBL learning model that works for student learning needs D3 Mechanical Engineering University of Padang to overcome existing deficiencies in the PBL model that has been proposed by experts.

References

- [1] S Munadi 2008 *Transformasi Teknologi pada Pendidikan Kejuruan* FT UNP: Temu Karya Konvensi Nasional Aptekindo V
- [2] E Rosalin 2010 Membangun Kompetitif Advantage Perguruan Tinggi dalam Menghadapi Tantaangan dan Perubahan Abad 21 *Jurnal Manajemen Pendidikan* Nomor 02/Tahun VI/Oktobre 010
- [3] B C Miller and E M Duvall 1985 *Marriage and Family Development* (9th Ed)
- [4] A M Taufiq 2009 *Inovasi pendidikan melalui problem based learning. Bagaimana pendidik memberdayakan pemelajar di era pengetahuan* Jakarta: Kencana Prenada Media Group
- [5] Eggen and P D Kouchak 2012 *Strategi dan Model Pembelajaran*. Jakarta: PT. Indeks
- [6] Joyce, M Weil and E Calhoun 2009 *Models of Teaching* Edisi Delapan. Jogyakarta. Pustaka Pelajar
- [7] Williams, C Judith and D J Paltridge 2016 *What We Think We Know About the Tutor in Problem-Based Learning. Health Professions Education* Available online at www.sciencedirect.com.
- [8] S Maggi and H M Claire 2000 *Foundations of problem-based learning* New York: Open University Press
- [9] E P Sarafino 1998 *Health Psychology: Biopsychosocial Interactions* Third
- [10] Tan Oon-Seng 2004 *Enhancing thinking through problem-based learning approaches* Cengage Learning
- [11] Bound dan Felletti 1997 *Model Pembelajaran Berbasis Masalah* Online. <http://duniapembelajaran.com>.2012
- [12] W Kamdi 2007 *Model- Model Pembelajaran Inovatif*. Universitas Negeri Yogyakarta
- [13] Arends 2007 *Learning to Teach (belajar untuk mengajar)* Yogyakarta: Pustaka Pelajar
- [14] R Heinich, M Molenda and J D Russel 1989 *Instructional and new technologies of instruction* New York: Macmillan, Inc.