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Improving Problem Solving Ability and Skill Competence of Mechanical Engineering Students Through Project-based Learning

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ABSTRACT
This study attempts to reveal the effect of the application of Project Based Learning on the problem-solving abilities and skill competencies of SMK students in Metal Joining Techniques. This study was a quasi-experimental study with an intact group comparison design which was carried out in one class which was divided into two groups, namely the experimental group and the control group. Assessment of problem solving abilities is obtained based on students' ability to solve problems encountered in one job. To measure skill competence, it consists of the value of knowledge through a multiple choice test with a weight of 30% and skills through a project test with a weight of 70%. The results obtained indicate that the application of project based learning can improve problem solving abilities and skill competencies than the application of non project based learning of Metal Fabrication Mechanical Engineering students in Metal Joining Engineering abilities. By testing the T-Test, it was found that problem-solving abilities and student competency skills using project-based learning were higher than non-project based learning, namely $t_{count} > t_{table}$ for both problem solving abilities (3.446 > 2.101) and skill competencies (3.428 > 2.101). From the results of the study it can be concluded that there are significant differences between the two groups in problem solving abilities and expertise competencies.

Keywords: *Expertise, Competence, Problem Solving, Project Based Learning.*

1. INTRODUCTION

Vocational High School is an educational institution that has different characteristics from general schools, namely that there are productive or practical subjects. Practical subjects are groups of subjects whose function is to equip students to have work competencies in accordance with the Indonesian National Work Competency Standards (SKKNI) or competency standards agreed upon by institutions representing the world of business or industry. One of the practical subjects in SMK is Metal Joining Techniques, in which students are expected to be able to apply the welding process and welding position equivalent to the level/level of the KKNI certificate I [1]

Technological growth and development in the field of construction which is increasingly advanced and rapid cannot be separated from the metal joining process, or what is often referred to as welding. It has an important role in engineering and metal repair or repair. Working in the world of work, one often hears various complaints regarding the attitude/behavior of workers, including: "technicians who are smart but not disciplined, operators who are skilled but dishonest, secretaries who are skilled but bitchy, workers who are smart but cannot cooperate" [2].

The development of soft skills in Vocational Schools can strengthen skills that have been formed from the family environment, or provide reinforcement of the skills possessed by students in preparing themselves to enter the world of work. Developing soft skills in Vocational High Schools, it is hoped that graduates will be more accepted in the world of work and become individuals who love their work so that they become workers who 'feel at home' in the world of work. Their persistence is because SMK graduates are ready to be in the world of work with strong soft skills attributes. They 'feel at home', because they are able to work together, are able to communicate, are able to cooperate, are good at managing themselves, are able to think critically, are able

to solve problems, are tough, reliable, full of motivation and enthusiasm, highly committed, a strong willingness to learn, and various attributes attached to them.

Observations on the learning process of the Metal Joining Technique found that there were still many students sitting around, while their other friends were practicing. So that learning tends to be passive and monotonous. Then in practical learning, students are also found who are less able to work together, have poor communication, are passive and unable to solve problems. Teachers still use direct practice methods according to the job to be done, and students only follow what the teacher exemplifies. Learning is still centered on the teacher. If students find problems in welding practice, students tend not to solve the problem. Students tend to leave the results of welding practice rather than solve the problem. Students cannot think creatively and work intensively to solve the problems they face. While the competencies expected here are students who are skilled in welding practice and can solve problems in practice that must be solved.

Supposedly "engineering education should provide sufficient theories and provide examples of solving real projects" [3]. Learning activities need to prioritize problem solving because by facing problems students will be encouraged to use their minds creatively and work intensively to solve problems they face in their lives [4]. Therefore it is necessary to apply effective learning for students. Effective learning is characterized by traits that emphasize the active empowerment of students. Learning is not just memorizing and recalling, nor is it just emphasizing mastery of knowledge about what is being taught, but rather emphasizing the internalization of what is being taught so that it is ingrained and functions as a conscience (internal) content and is practiced in life by students. More than that, effective learning emphasizes how so that students are able to learn how to learn (learning how to learn) by obtaining information from fellow students and how each one obtains information, students can find learning models that are different from what is done and can be applied in future studies.

Through the teacher's creativity, learning in the classroom becomes a joyful activity (*joyful learning*). With this effective learning, students' personality development really improves. Therefore, the embodiment of effective learning will provide life *skills* to students. Learning to learn (learning to learn) grows from the synergy between intellectual and moral which is expressed from the results of authentic learning in the form of work and behavior. Therefore it is necessary to change the learning approach from teacher-centered to student-oriented learning activities (*Student Centered Learning* / SCL). Student-centered learning must provide space for students to learn according to their interests, personal abilities, and learning styles. Students naturally differ from one another both in their interest in a teaching material, their respective intellectual abilities and in their preferred learning style. The teacher acts as a facilitator who must be able to arouse students' interest in a learning material and provide various approaches to learning so that different students get the learning method that is most suitable for them. Teachers in the teaching and learning process must involve students to be active in practice because the best learning strategy is to involve students to be active in practice [5]. That's why in *Student Centered Learning* (SCL) learning in the 2013 curriculum, teachers need to provide vehicles, learning models and varied approaches to learning in cooperative learning/group work.

There are various learning models that can be chosen for SCL learning, one of which is *Project Based Learning* (PjBL). As stated by Nizwardi Jalinus, et.al [6] " *project based learning* provides opportunities for learning systems that are student-centered, more collaborative, students are actively involved in completing projects independently and working in teams and integrating problems real and practical". So is the opinion of Istarani [7] " *Project based learning* can be revolutionary in the issue of renewal of learning. Projects can change the nature of the relationship between teachers and students. Projects can reduce competition in the classroom and lead students to be more collaborative than working individually. Projects can also shift the focus of learning from remembering facts to exploring ideas.

One of the advantages why project based learning is important to implement is "providing learning experiences using project models gives children the opportunity to develop an ethos in themselves. Work ethic is a set of attitudes and habits in carrying out work diligently, accurately, thoroughly and on time [7].

SCL is a learning strategy that places students as active and independent subjects/learners, with psychological conditions as adult learners, fully responsible for their learning, and able to learn *beyond the classroom* " [8]. In line with Triyono's opinion [9] "student centered learning (SCL) is a learning method that empowers students to be the center of attention during the learning process takes place". "Student-centered states that graduate learning outcomes are achieved through a learning process that prioritizes the development of creativity, capacity, personality, and student needs, as well as developing independence in seeking and finding knowledge" [10]. Based on the opinions of several experts, it can be concluded that learning is a structured process of activity between teachers and students so that students are active in achieving learning goals.

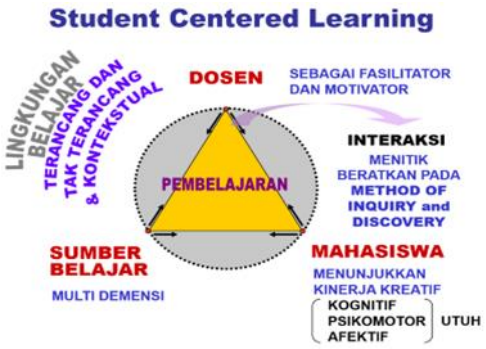

Figure 1. Characteristics of SCL Learning [10]

Figure 1 shows three main elements in a learning environment using the *student centered learning method;* teachers as facilitators and motivators, students/students with creative performance in developing cognitive, affective and psycho-motor abilities as a whole, and multi-dimensional learning resources as well as a designed and contextual learning environment. According to the Directorate General of Higher Education [10], there are three principles that must exist in an SCL learning, namely: "1) Viewing knowledge as something that is incomplete, 2) Viewing the learning process as a process for reconstructing and seeking knowledge to be learned; and 3) Seeing the learning process not as a teaching process (*teaching*) which can only be done classically, and not as a process for carrying out a standardized instruction that has been designed.

2. METHODOLOGY AND IMPLEMENTATION

2.1. Subjects and Research Design

The subjects in this study were students of the Mechanical Engineering Study Program at Mempura State High Vocational School 1. This study aims to determine the Application of *Project Based Learning* in Problem Solving Ability and Mechanical Engineering Competence in Metal Joining Techniques. The method used in this study is a quasi-experimental method with an *Intact Group Comparison design.* As Sugiyono's opinion [11], that " *Intact Group Comparison* is experimental research carried out in only one group but divided into two, namely half the group for the experiment (which was given treatment) and the other half for the control group (which was not given treatment)". *Quasi* experiment is a term from *Pre Experiment Design* .

This design can be described as follows:

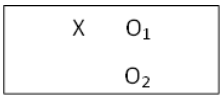

Figure 2. Intact Group Comparison Research Design [11]

Information:

O_1: Result of measurement of half of the treated group

O_2: Results of measurements of half of the group that was not given treatment

X: Treatment / treatment

This experiment was conducted to see differences in problem-solving skills and competency skills for students who apply *Project Based* Learning and those who apply *Non-Project Based Learning* .

2.2. Research Analysis Instruments and Techniques

The research instrument used in this study was a test instrument, which was used to find out data about differences in problem-solving abilities and skill competencies for students who applied Project Based Learning and those who did not. The test used in this study is in the form of multiple choice. The items in the concept mastery test cover the domains of knowledge, affective, skills and problem solving, namely C1, C2, C3, C4, C5, and C6. The test instrument is used, first a judgment is made. After that, trials were carried out and the results were analyzed. Trials were conducted to see the validity and reliability of the instruments used.

2.2.1. Validity

To find out the test content validity of the test, it is done by testing questions in other schools. The validity of the test according to Suharsimi Arikunto [12] can be calculated in the following way:

$$\gamma_{pbi} = \frac{M_{p-M_t}}{SD_t}\sqrt{\frac{p}{q}}$$

Information:

γ_{pbi} = i al correlation coefficient

M_p = Mean score of subjects who answered correctly for the item whose validity was sought

Mt = Average total score

SD_t = Standard deviation of the total score

p = Proportion of students who answered correctly

q = Proportion of students who answered incorrectly

2.2.2. Reliability

The technique used to measure test reliability in research uses the Richardson 20 formula (K–R. 20) in Febrianawati Yusup [13] namely:

$$r_{11} = \left(\frac{n}{n-1}\right)\left(\frac{S^2 - \sum pq}{S^2}\right)$$

Description:

r_{11} : Reliability of the test as a whole

p` : The proportion of subjects who answered the item correctly

q : The proportion of subjects who answered the item incorrectly

$$q = 1 - p$$

$\sum pq$: The number of multiplication results between p and q

n : The number of items

S : Standard deviation of the test.

2.3. Research procedure

This research consists of 3 stages, namely the preparation stage, the action implementation stage, and the report preparation stage.

2.3.1. Phase I (Research Preparation)

The activities carried out at this preparatory stage start from problem identification, preliminary study, relevant research review, determining the method, to the analysis and revision of the instrument after the pilot test.

2.3.2. Phase II (Research Implementation)

Activities carried out in this research include: making learning tools, implementing learning (treatment), to collecting data.

2.3.3. Phase III (Data Analysis, Data Processing and Drawing Conclusions)

Activities carried out in this stage include: data collection, processing and analysis of test instrument data results and drawing conclusions.

2.4. Research Data Analysis Techniques

The data obtained from this study were processed to measure problem-solving abilities and skill competencies in both groups. The data analysis techniques performed on the data above are:

2.4.1. Test Score Data

The data obtained to measure aspects of students' knowledge and skills in this study is 30% of the knowledge score plus 70% of the skills score. of the knowledge value of each student both pretest and post test. Before being processed the data is organized in the following steps:

a. Scoring: Scores for the multiple choice test are determined based on the right only method, namely the correct answer is given a score of one and the wrong answer is given a score of zero. The score of each student is determined by counting the number of correct answers

b. Data analysis: Hypothesis testing will be carried out using statistical test techniques such as data distribution normality test, homogeneity test and t-test.

2.4.2 Hypothesis testing

The hypothesis put forward in this study is that there is a significant increase in learning outcomes after implementing project based learning.

The t test used is the T Test. The t-test statistical technique is a parametric statistical technique used to test ratio or interval data comparisons [13].

The hypotheses to be tested are H0: $\mu_1 = \mu_2$ and H1: $\mu_1 \geq \mu_2$ which μ_1 are the average results of the experimental group and μ_2 are the average results of the control group. To test the hypothesis with the t test, namely *T Test* with the following formula:

$$t = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

With:

$\overline{X_1}$: The average value of the experimental group

$\overline{X_2}$: The average value of the control group

S_1^2 : Variance of the value of the experimental group

S_2^2 : Variance of control group value deviation

n_1 : The number of students in the experimental group

n_2 : The number of students in the control group

3. RESEARCH RESULT

3.1. Description of Research Data

The results obtained from this study on the learning activities of Metal Joining Techniques with the application of project based learning in problem solving abilities and skill competencies of class XI Metal

Fabrication students at Mempura State High Vocational School 1, are as follows:

3.1.1. Student Skills Competency Data

Knowledge

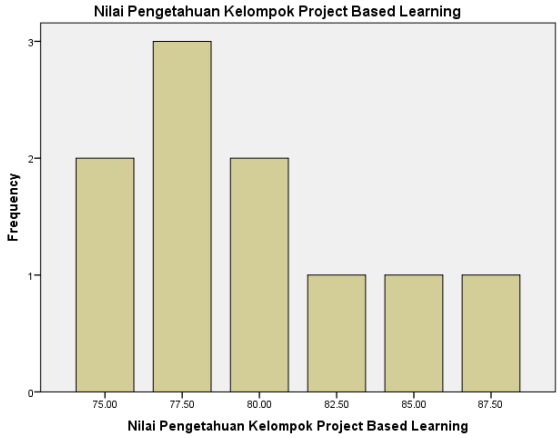

Figure 3. Graph of Group Knowledge Value Project Based Learning

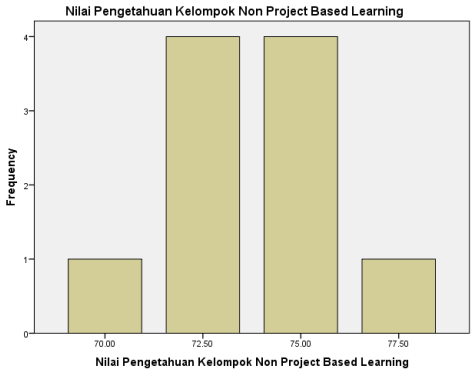

Figure 4. Graph of Group Knowledge Value Non-Project Based Learning

Skills

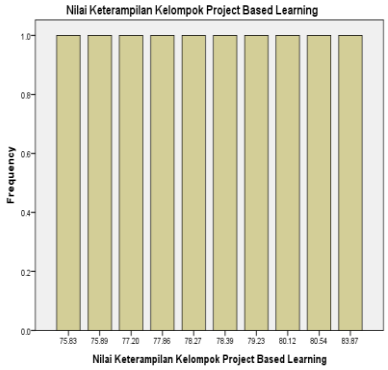

Figure 5. Graph of Group Skill Values Project Based Learning

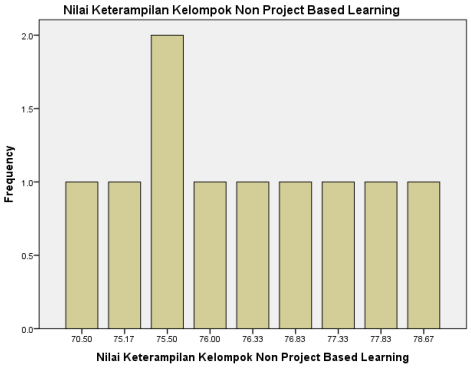

Figure 6. Graph of Group Skill Values Non-Project Based Learning

Expertise Competency

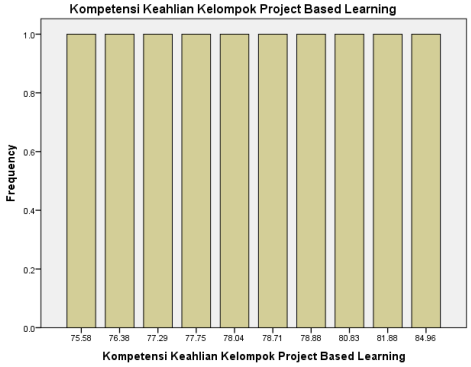

Figure 7. Skills Competency Graph Project Based Learning Group

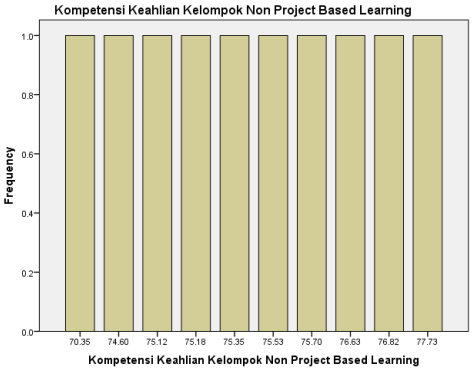

Figure 8. Group Skills Competency Graph Non-Project Based Learning

Problem Solving Ability Data

Problem solving is obtained based on students' ability to solve problems or obstacles encountered in one job

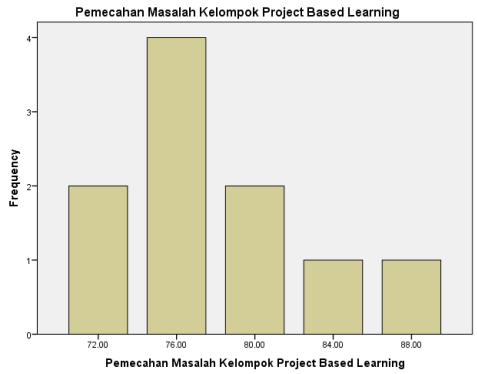

Figure 9. Graph of Problem Solving Ability Project Based Learning Group

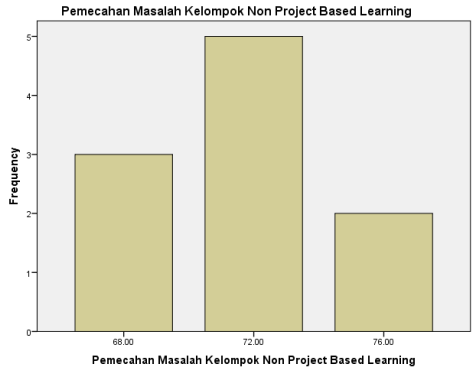

Figure 8. Graph of Problem Solving Ability Non-Project Based Learning Group

Based on the graphical description of the data above, the results of calculating the average and standard deviation of the *project-based learning group* and the *non-project based* learning group for competency skills and problem solving. This can be summed up as Table 1

Table 1. Project Based Learning Group Standard Deviation and the Non-Project Based Learning Group

Descriptive Statistics					
	N	**Min**	**Max**	**Means**	**SD**
Competence Skill Project Based Learning Group	10	75.58	84.96	79.03	2.81
Competence Skill Non-Project Based Learning Group	10	70.35	77.73	75.30	1.98
Solving Problem Project Based Learning Group	10	72.00	88.00	78.00	5.08
Solving Problem Non-Project Based Learning Group	10	68.00	76.00	71.60	2.95
Valid N (listwise)	10				

3.2. Hypothesis test

A statistical hypothesis test is a method of statistical inference used to determine a possible conclusion from two different, and likely conflicting, hypotheses [15]

Based on the test criteria received by Ha, if t > t 1-α where t 1-α is obtained from the t distribution list with degrees of freedom (dk) = (n1+n2) – 2 and probability (1-α). Competency skills t count obtained 3.428 and price t table = 2.101 with a chance of 0.95 and degrees of freedom dk = 18, while for problem solving abilities t arithmetic obtained 3.446 and price t table = 2.101 with an opportunity of 0.95 and degrees of freedom dk = 18 .

For skill competence, the price of t count > t table (3.428 > 2.101) is obtained, while for problem solving abilities the value of t count > t table (3.446 > 2.101) is obtained. Ha is accepted for skill competency as well as problem solving ability.

Ha for competency skills, namely there are differences in skill competencies for students who implement Project Based Learning and those who apply Non-Project Based Learning, where the Project Based Learning group is higher than the Non-Project Based Learning group. This means that there is a significant difference between the two groups in the competency skills.

Ha for problem-solving abilities, that is, there are differences in problem-solving abilities for students who implement Project Based Learning and those who apply Non-Project Based Learning. The problem-solving ability of mechanical engineering students on metal joining in the project-based learning group was higher than the non-project based learning group. This means that there is a significant difference between the two groups in problem solving ability. For more details can be seen in Table 2

Table 2. Hypothesis Test Calculation Results

No	Variable	T_{count}	T_{table}	Conclusion	Information
1	Expertise Competency	3.428	2.101	$T_{count} > T_{table}$	There is a difference
2	Problem solving skill	3.446	2.101	$T_{count} > T_{table}$	There is a difference

3.3. Discussion

Competency skills and problem solving abilities of mechanical engineering students in metal joining techniques at Mempura State High Vocational School 1 with project based learning is higher than non project based learning such as hands on learning. This can be seen in the average value of the project-based learning group of 78.10 for skill competencies and 78.00 for problem-solving abilities, while the non-project based

learning group such as hands-on learning is 75.30 for competence. expertise and 71.60 for problem solving ability. So that there are differences in the results of competency skills and problem solving abilities with the application of project based learning.

Project based learning provides opportunities for student-centered learning systems to be more collaborative, students are actively involved in completing projects independently, working together in groups and integrating real and practical problems.

4. CONCLUSION

The results showed that the average learning outcomes of students who were taught using the project-based learning method were higher than the average learning outcomes of students who were taught using non-project based learning methods. This shows that the project based learning method can improve student learning outcomes rather than using non-project based learning methods.

Behind the advantages and disadvantages of project based learning, there are drawbacks in its implementation, including:

1. Requires long and thorough planning before implementing project based learning.
2. It takes a long time and costs a lot to implement.
3. Requires facilities and infrastructure that support workshops during the project based learning process.
4. The long assessment process until the planned project is completed.

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