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Implementation of Project Based Learning for Cognitive and Psychomotor Students in the Basic of Workshop Technology Course Welding Sub-competency in the Automotive Engineering Study Program

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Abstract

The higher education curriculum adopts project-based learning (PjBL) method that emphasizes the provision of knowledge with the problem solving in an organized work project within study group. This is such a solution for the problems of current conventional learning method implementation that made low enthusiasm and slow understanding student especially for Automotive Engineering student in having welding practice in The Basic Workshop Technology Course. By using experimental method in this research to compare conventional learning and PjBL method toward twenty Automotive Engineering students to evaluate cognitive and psychomotor aspect. On the steps, the lecturer starts with provides theoretical enrichment and end with welding practice. To find out the effect of implementing this project-based learning, lecturer divides the class in two study groups by differentiating learning methods, namely the group with conventional learning and the group with PjBL learning. Comparison is made between conventional learning and PjBL learning with projects processed by statistical interpretation. The results of the study showed that there was a significant effect on the results of the psychomotor evaluation of students, but not too significant for the cognitive evaluation results. Based on this research, there is a prove that PjBL is good enough to increase student's abilities in welding practice as psychomotor representation increment.

Keywords: Project Based Learning, Basic of Workshop Technology, Welding Practice.

1. Introduction

The vocational engineering curriculum in higher education is identical with the purposes for achieving students' abilities in practical mastery of skills. Vocational engineering orientation refers to student competencies in order to achieve synchronization with the demand of the world of work in accordance with their fields by giving domination of practical rather than theoretical practice in the curriculum [1]. The achievement of this curriculum is applied to the Automotive Engineering Associate Study Program at Universitas Negeri Padang, especially in the case of Basic of Workshop Technology course, Welding Sub-competency. This basic automotive engineering course is essential for students to know it by providing effective learning methods. The indicator for achieving this welding sub-competence is that students are able to practice welding, a method for joining metals as a result of metallurgical processes [2].

During the course activity, welding concepts have been disseminated to students in the class before practicum as well as curriculum procedure but still with conventional learning method. A problem was found when the lecturer made general observation of student's behavior that show low interest of learning welding theory in the class. There is an unenthusiasm of students in trying to understand the detail about the welding concepts were taught in the class. Then, when course activity moved to welding work practicum, the indication that appears based on the observation was a lack of student creativity to

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develop welding project was given. The impact that may occur and is a matter of concern is the skill level of vocational students in previous research, observing one-way learning method is considered unsatisfactory [3]. This case is quite similar to the findings of the initial observations in this study, that conventional learning only relies on obtaining reference sources for students from books and oral information from educators [4]. This is considered less effective for learning in vocational education because there are those who perceive that conventional learning does not make students attractive enough to learn [5].

The solution that can be recommended is to change the learning method in the form of project-based learning (PjBL). A learning method that is organized in groups, builds a mindset, trains students to solve problems given during learning, then encourages students to create a problem-solving idea in the form of creating a final product [6]. This method has a principle of learning by providing a work project to be demonstrated by students in order to bring out the skills, curiosity, and imagination of students to create a work that can be demonstrated to many people [7]. This learning provides knowledge of students as a whole without just fixating on the achievement of learning objectives. There are three outputs from this learning method, namely the enrichment of students' abilities from cognitive aspects or theoretical knowledge and psychomotor aspects, as well as social [6]. The differences of current learning and project-based learning refer to student learning by project along with group, the students have ability to develop and express their idea to manage how to accomplish the project given together. The implementation of PjBL have four steps [8] and could be related with PjBL step design in this welding project of this case as seen on Figure 2. The four steps of PjBL are (1) Initiate the project, consist introduction of knowledge and create one topic of project related to its theory by lecturer. (2) Project development by student with their creativity and imagination to accomplish the project, (3) Reporting, students share the project progress to the educator for some stages and problem so the educator give feedback for that. (4) Project assessment, to measure quantitative ability of students along with group to accomplish the project. It is quite different with the current learning method with just applied the one-way as seen on Figure 1 that has conventional learning basic method within no project group created but for the quality, it still uses the standard assessment to quantified student ability for welding performance in this case.

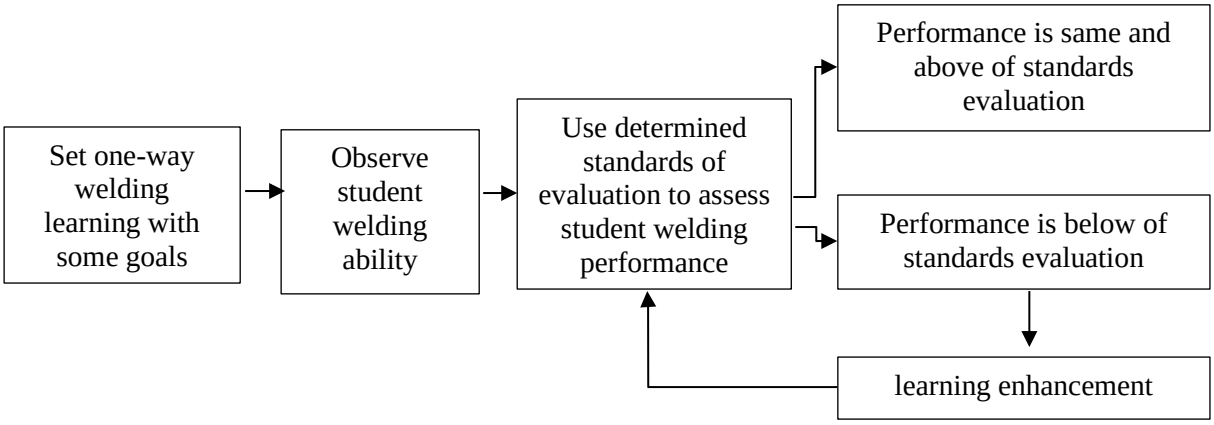

Figure 1.
Current step of one-way learning method in welding sub-competency, customize with previous literature [9]

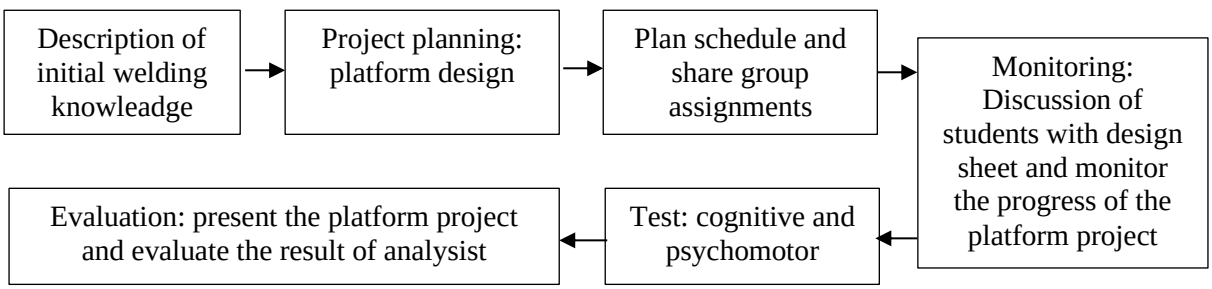

Figure 2.
Design step of PjBL method in welding sub-competency, customize with previous literature [10]

The cognitive aspect is an ability to store learning memory theoretically, which does not only emphasize short-term memory but long-term memory is preferred [11]. PjBL learning is not just a cognitive emphasis, students are required to be able actively constructing their knowledge with practical hands-on experience [7]. Giving a project to make works as in the welding sub-competency can improve students' psychomotor skills because in their learning objectives, students are required to be able organizing, create understanding and develop skills to complete the project [12]. The social values that arise in this learning arise from the ability of students to interact in solving problems in groups according to their cultural characteristics [8].

Welding practice using the project-based learning method is implemented with the purposes: (1) To make students accustomed to using welding practicum equipment. (2) Growing student creativity and imagination to complete projects. (3) Students are able to apply in real terms about the material obtained in class related to welding (4) Growing communication skills between students in working on projects. The learning objectives are generally in line with those stated in previous research[3], Therefore, (1) students are able to solve problems independently and in group work (2) help increase student motivation to carry out learning activities independently and in good groups (3) create good interaction between students and educators. Back to the research objectives, research on the comparison of conventional learning methods with PjBL which is applied to the welding sub-competence in the Basic of Workshop Technology course in the Vocational Automotive Engineering study program at Universitas Negeri Padang is implemented with the aim of knowing the effect of applying the PjBL method which is quantified by determining the significance of the effect of applying the method. This is based on the results of student cognitive and psychomotor evaluations.

2. Research Method

Research on the implementation of PjBL was going on Automotive Engineering Vocational students at Padang State University and was limited to electric welding competencies in the Basic of Workshop Technology course. With several approaches to existing educational research methods, this research approaches the use of classroom action research because it is an activity in the classroom when lecturer makes new breakthroughs in their efforts to make learning effective in accordance with the goals to be achieved in the lesson plan [13]. Table 1 shows some explanations about the differences of two learning method are tested in this research.

Table 1.
Comparative method between of current one-way learning and PJBL in welding competency

Aspects	Current learning	Project based learning
Purpose	Students are able to understand welding concept, equipment, technique, and practice	Students are able to understand welding concept, equipment, technique, and practice
Learning activities during in the class for welding theory	Lecture explanation with some presentation	Lecture explanation with some presentation, discussion, group strategies decision
Creating object in practice	workshop tool hanger platform as seen on figure 2.1	workshop tool hanger platform as seen on figure 2.1
Class control	Class was divided in two. One was within conventional learning	Class was divided in two. The other one was within PjBL. This part has some group for welding practicum
Learning feedback	Yes, for some part of learning activities	Yes, for all learning activities
Evaluations	Cognitive and psychomotor	Cognitive and psychomotor

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This learning experience has been designed in such a way according to the Semester Learning Plan in the automotive engineering vocational curriculum. As for the learning strategies that are in line with semester learning, the lecturer coordinates several actions in class. The first action, the welding theory with the lecture method using power point learning media without grouping students. Then, students are asked to do practicum in accordance with the material that has been presented. After that, the teacher does the evaluation of cognitive and psychomotor of students. The second action, the lecturer shares the theory by giving or assigning group projects or forming groups per project. Students are also asked to do practicum in accordance with the material that has been presented. After that, an evaluation of cognitive and psychomotor were done. Some of the cognitive evaluation questions given are (1) Explain the steps in welding (2) Explain what things affect the results of electric welding (3) Explain what effect the strong current of the electric welding machine has on the electrode and the material to be welded! (4) Explain what causes the welding material to have holes when welding! (5) What happens if the tip of the electrode with the material to be welded is too close or too far? The psychomotor assessment criteria are arranged in the rubric of Table 1. The psychomotor assessment process by summing the scores for the ten aspects of the skills assessed then dividing by the maximum score using equation 1 with the assessment criteria according to Table 2 [14].

Table 2. Psychomotor assessment rubric

No	Aspect of skills	Scores				
		1	2	3	4	5
1	Prepare tools and materials					
2	Perform work procedures according to SOP					
3	Application of HSE when welding					
4	Understanding work design					
5	Punctuality					
6	Welding technique					
7	Compatibility of current strength with welding technique					
8	Size precision					
9	Current accuracy					
10	Yield strength					

Table 3. Psychomotor assessment criteria

Criteria	Quantity
Very good	91-100
Good	71-90
Fair	61-70
Poor	<60

$$\text{Grade} = \frac{\text{Score obtained}}{\text{Maximum score}} \text{ x } 100 \quad (1)$$

Welding practicum to create a workshop tool hanger platform according to the design in Figure 3. The platform is made of 60 x 30 cm hollow metal rods and 1 mm thick hollow plate. In addition to hollow iron rods, the materials needed are welding electrodes with electrode rod diameters of 2.6 mm and 3.2 mm. While the equipment used is a portable electric welder, grinder, steel ruler, wire brush, hammer, and sandpaper. The personal protective equipment used is a welding helmet, gloves, and a mask.

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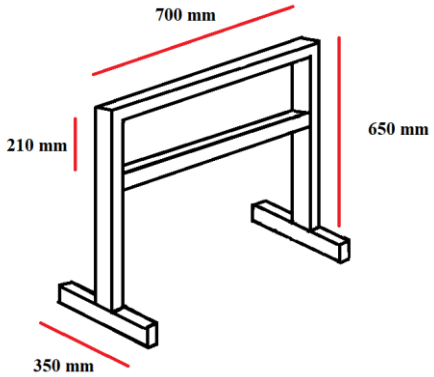

Figure 3. Workshop tool hanger platform design by lecturer for welding practicum

There are four quantitative data sets in this study, namely: results of cognitive evaluation without PjBL learning, results of cognitive evaluation of PjBL learning, results of psychomotor evaluation without PjBL learning, and results of psychomotor evaluation of PjBL learning. The four data sets were processed using statistical concepts, including homogeneity testing and the average difference test for independent data groups. Testing the homogeneity of the data using the Hartley test method or the F max test [15]. The homogeneity test of the data is processed as a first step for presenting data descriptively or inferentially. Then, testing each group of independent data pairs was re-tested using the independent sample t-test method [16]. This test's purpose to measure the significance value quantitatively of PjBL's learning treatment on the evaluation results of students' abilities in cognitive and psychomotor aspects.

3. Result and Discussion

3.1. Learning and Experiment Process

The part of the competencies mentioned in the Basic of Workshop Technology course is welding technology, takes place in one semester's lecture activities. The lecturer provides welding material in class. Classroom learning is arranged in such a way that learning communication becomes two-way. There are two study groups, each consisting of ten people. The two study groups differed in their treatment of learning methods, one group of students was not subject to PjBL learning and the other group was subject to PjBL learning. They two class control was set up based on Table 1 that one group just has along with one-way learning method, no practical group creating and no discussion. The other one group was along with practical group and discussion for completing project strategy.

The lecturer instructs students both of conventional learning control and also PjBL group to do practicum after the theoretical learning has been completed. The study group of conventional learning was asked to immediately carry out a practicum while still providing drawings of the design of the tool to be made, without being asked to form a working group, meaning that the practicum was done personally by relying only on the theoretical knowledge provided in class. Study groups of PjBL that are arranged to form project groups are asked to develop a work plan with the group with theoretical provision from the class and be guided by the design drawings of the tools provided. The welding practicum took place in one of the integrated open workshops at the Faculty of Engineering, Universitas Negeri Padang, which is documented as shown in Figure 4.

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(a)

(b)

Figure 4. (a) Group discussion analyze project design (b) Welding process

3.2. Comparison of Evaluation Results

Student knowledge is tested by giving five questions related to welding theory and practice. The test is done after students have finished practicing. The output obtained from this test is in the form of student cognitive evaluation results. In addition, student psychomotor are assessed based on the assessment rubric in Table 1 which consists of ten aspects of skills assessment. There are quantitative differences in the cognitive and psychomotor evaluations of each study group based on different learning methods. In this case, to find out the alignment between the regular learning method and the PjBL method, a scatter plot is plotted between the two evaluation results based on different learning methods, with the note that in this plot there is no correlation because the two groups of evaluation data are independent.

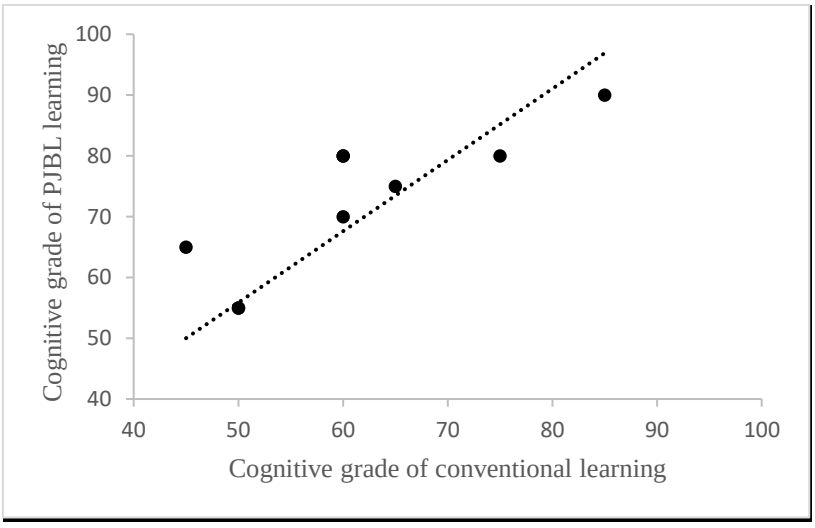

Figure 5. Scatter plot of cognitive evaluation results of conventional learning and PjBL

This data group, both cognitive data and psychomotor data, is independent because of the different practicum practices and the different students involved in each study group, meaning that the two data groups are not intentionally correlated. My only goal is to plot the data to see the alignment of the usual learning methods with the PjBL method. Visually, it appears that learning using the PjBL method improves the cognitive and psychomotor evaluation results of student welding learning. This is evidenced by the linear regression line of data that climbs up. This means that the impact of PjBL learning does not contradict conventional learning.

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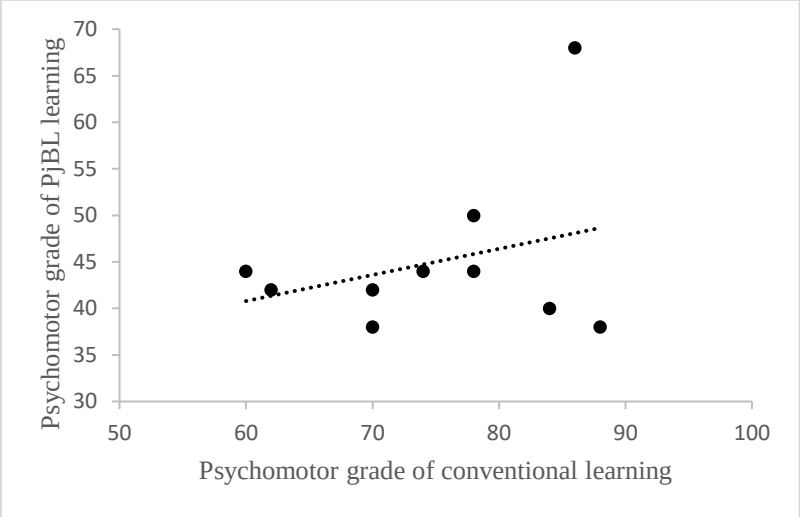

Figure 6. Scatter plot results of psychomotor evaluation of conventional learning and PjBL

Previously, as a first step in presenting statistical data descriptively and inferentially, the evaluation data group had been tested for the homogeneity of the data distribution using the Hartley test method or the F max test. The first step is to make a hypothesis. The first hypothesis (H_0) is that the tested data group is normally distributed. The second hypothesis is that the tested data group is not normally distributed (H_1). Selection of the hypothesis decision if F max count < F max table then H_0 is accepted. Meanwhile, if F max count > F max table then H_0 is rejected and H_1 is accepted [15]. The F max table value is obtained from the critical value according to the quantity of the data group being tested. In this case the data group being tested consists of two independent variables consisting of ten data (n) in each group, so the value of degrees of freedom (n-1) is 9. As for the calculation of F max, it is calculated using the following equation.

$$F_{\text{max count}} = \frac{\text{Highest variance}}{\text{Lowest variance}} \qquad \text{Equation. 2}$$

Table 4. Data homogeneity test results with the Hartley method

Asessment	s^2	df	F_{max} count	F_{max} table	Sig
Cognitive of conventional learning	169,1	9	2,37	4,03	0,05
Cognitive of PjBL learning	401,1	9			
Psychomotor of conventional learning	77,5	9	1,19	4,03	0,05
Psychomotor of PjBL learning	92,6	9			

The results of the homogeneity calculation according to Table 4 consist of two groups of cognitive evaluation data giving an F max count of 2.37 and an F max table of 4.03. Meanwhile, the calculated value of the homogeneity of the two groups of psychomotor evaluation data gives a calculated F max value of 1.19 and F max table of 4.03. From these calculations it can be interpreted that the hypothesis H_0 is accepted, meaning that the group of cognitive and psychomotor evaluation data for student welding learning is homogeneous.

3.3. PjBL Learning Significance Test

Comparing the different values of cognitive and psychomotor evaluations is a method for achieving the objectives of this study in the form of determining the magnitude of the effect of the application of PjBL learning on welding practice, which was previously usually applied to conventional learning. The significance of the effect of PjBL learning was calculated based on the difference in average scores between the cognitive and psychomotor evaluation results in the two study groups with different learning methods. The test method that fits the two groups of data, each of which is independent, is the

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independent sample t-test method based on the T test to determine difference both of two data. The two hypotheses set are the first hypothesis (H_0) which means that there is no deference between the two learning methods when viewed from the average difference both cognitive and psychomotor. The second hypothesis (H_1) is that there is a deference between the two learning methods when viewed from the difference in the average evaluation of both cognitive and psychomotor. The determination of the T table can be seen from the T table by entering several data characteristics, such as the value of degrees of freedom (n-1) of 9 and the significance level used is 5%. Determination of the value of T table using the following equation.

$$T_{count} = \frac{\bar{X}_2 - \bar{X}_1}{\sqrt{\left(\frac{(n_2-1)s_2^2 + (n_1-1)s_1^2}{(n_2-1) + (n_1-1)}\right)\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} \quad \text{Equation. 3}$$

The value of $\bar{X}$ is the average, n is the amount of data, s^2 is the variance. The average for cognitive data for conventional learning and PjBL is 59.5 and 67 respectively, so that the average difference is 7.5 and the percentage increase in cognitive value after implementing PjBL learning is 12.6%, as shown in Figure 7. Meanwhile, the average for psychomotor data for conventional learning and PjBL is 45 or poor criteria and 75 or good criteria so that the average difference is 30 and the percentage increase in psychomotor scores after implementing PjBL learning is 66.7%.

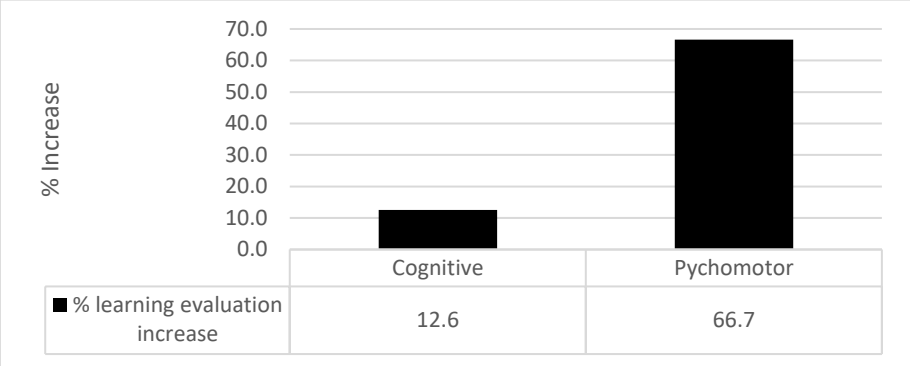

Figure 7. Comparison diagram of the percentage increase in cognitive and psychomotor scores from conventional learning and PjBL learning

The criterion for making a hypothesis decision is T count > T table then H_0 is rejected and H_1 is accepted, whereas if T count < T table then H0 is accepted [16]. The calculation of the paired independent sample T test according to Table 4 for the two groups of cognitive evaluation data gives a T value of 0.99 and a T table of 1. Meanwhile, the paired independent sample T test for the two psychomotor evaluation data groups gave a T count of 10.7 and a T table of 1. Interpretation of the data that can be done for the cognitive evaluation value data group that hypothesis H_0 should be accepted, with the percentage increase in cognitive scores after implementing PjBL is only around 12.6% or it can be interpreted that there is indeed an effect of increasing learning outcomes but not too significant. However, in contrast to the difference in psychomotor scores after implementing PjBL with a percentage increase of 66.7%, by linking it to independent paired sample T testing, hypothesis H_1 is accepted, meaning that there is a significant influence between the psychomotor scores of conventional learning and PjBL learning.

Table 5. Paired independent sample T test results

Asessment	$\bar{X}$	df	$T_{calculated}$	T_{table}	Sig
Cognitive of conventional learning	59.,5	9	0.99	2.1	0.05
Cognitive of PjBL learning	67	9			

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Psychomotor of conventional learning	45	9	10.77	2.1	0.05
Psychomotor of PjBL learning	75	9			

3.4. Discussion

The application of the project-based learning method in this welding practicum has a significant effect on cognitive and psychomotor aspects [7] for students to understand welding practice. Comparison of research data with previous research can also prove. Previous research [13] in student project-based learning, information was obtained that the percentage increase in psychomotor scores after implementing PjBL was higher than the percentage increase in student responses or including cognitive assessments. Nonetheless, previous research has proven that PjBL learning improves students' cognitive abilities when compared to applying conventional learning [5]. By observing the differences between the two aspects, it is clear that the learning method is very helpful in improving students' practical skills. If learning is only focused on formative or refers more to the theoretical basis, then students will not be able to develop cognitive abilities without involving skills, planning, critical reflection, and self-regulation, all of which are in the psychomotor aspect [17].

A taxonomy of Simpson's psychomotor domains [12] which contains several important achievements, namely: (1) awareness, the ability to control movement activities; (2) Alertness, readiness to act; (3) Guided response, the ability to translate visual objects into real objects due to motor responses; (4) Proficient in mechanics, able to follow the stages of a job; (5) responsive response; (6) adjust to the surrounding environment; and (7) able to coordinate a job to completion. This taxonomy, when associated with the psychomotor assessment according to Table 1, almost represents the Samson psychomotor domain mentioned, where the main target is the achievement of the work of the tool designed or in accordance with the final assessment aspect in Table 1, namely the strength of the welding results which affect the robustness of the designed workshop tool hanger platform. Conventional learning only produces an average score of 1.8. Precisely with PjBL learning the scores generated for aspects of the assessment of platform strength doubled or an average score of 3.6.

4. Conclusion

The project-based learning method is applied to welding practicum in the Basic of Workshop Technology course for Automotive Engineering students at Padang State University. This learning method has a significant effect on aspects of students' psychomotor assessment in welding practices, proved within a percentage increase compared to conventional learning methods. The impact is quite significant but not too influential and is observed from the results of cognitive compared to conventional learning methods. This PjBL teaching method is recommended for several practical courses, especially in the vocational curriculum.

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