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The Effectiveness of Project-Based Learning On 4Cs Skills of Vocational Students in Higher Education

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Abstract: The results of the previous study showed that the implementation of the project which is based on the potential of the students' region was better in improving soft skills, engagement and core competencies of learning for students. This study aims to continue the investigation on revealing the effectiveness of the model in improving the students' 4Cs skills. It is driven by educational needs in this 21st century which requires vocational students to have those skills to adapt to the complexities of the real industry. This study was conducted by using a quasi-experimental method. The potential of the students' region-based project was implemented to an experimental group; meanwhile, the free theme-based project was administered to a control group. Upon completion of the assessment, each student's 4Cs skill in the experimental group had higher scores than those of the control group. Overall, after being analysed by using ANCOVA, there were significant differences found between the 4Cs skills scores of the experimental group and those of the control group. Therefore, it can be concluded that the project which is based on the potential of the students' region is more effective in improving the 4Cs skills of vocational students in higher education than the free theme based-project is. The syntaxes of the project based on the potential of students' region explained here can be a reference for teachers and lecturers in implementing it. In addition, as it is being developed, it can also inspire and be a reference for other researches focusing their study in the learning quality development at vocational education.

Keywords: Project-based learning, experimental research, soft-skills, critical thinking, collaborative, communication skills

1. Introduction

Based on the data from the Central Statistics Agency on Indonesia's employment in the last 3 years, the number of vocational education graduates has always ranked the highest in the unemployment category (Badan Pusat Statistik, 2021). This is the impact of industrial technology development (Robot and Smart factory) which is no longer dominant in employing human beings. The increasing number of vocational education students, both at the vocational high school and higher vocational education level, has led to an increase in the supply of vocational graduates for the workforce (Kemendikbud, 2016). In addition, the Covid-19 pandemic has also caused major reductions in the number of employees and has also become a driving force for industries to implement 4.0 industrial technology. The impact of the Covid-19 pandemic on workers in formal and informal sectors is also felt in Malaysia (Mammal, 2020).

Considering the conditions, the researchers have developed Project-based Learning (PjBL) in vocational education level by orienting the project tasks based on the potential of each student's region in the previous study. The integration

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of region's potential in learning is one of the strategies in strengthening vocational education (Kemendikbud, 2016). In implementing this model, each student produces a tool, or a machine based on their regions' problem in an effort to develop the potential of their area with the hopes that this project can be developed to become a proper business after graduating from the college. Some previous studies show that the implementation of project which is based on the potential of students' region improves students' learning achievement, increases students' engagement and positive perceptions toward learning, and develops students' soft skills (Syahril, Nabawi, & Prasetya, 2020; Syahril, 2020; Syahril, Nabawi, & Safitri, 2021).

As a newly developed learning model, revealing its effectiveness is needed to ensure the students have the competencies required in this 21st century since educational world must be dynamic along with the changing times. This article discusses the effectiveness of a project which is based on the potential of students' region in improving 4Cs skills of vocational students in higher education. The Partnership for 21st century learning has developed learning and innovation skills that have been widely recognised as the right skills for students to be able to face an increasingly complex life and work environment in the 21st century (The Partnership for 21st century learning, 2019). In learning and innovation, there are four skills that must be possessed by every student, namely creativity and innovation, critical thinking and problem solving, communication and collaboration. These skills are then widely known as the 4Cs Skills. Thus, teachers must be able to create a creative learning which gives the students an opportunity to improve their 4Cs skills as a new competency standard in this 21st century (Astuti, Aziz, Sumarti, & Bharati, 2019).

2. Method

2.1 Subject and Research Procedure

The subjects of this study were 61 students of the Mechanical Engineering Diploma program at Universitas Negeri Padang who were enrolled in Mechanical Drawing classes. The research method used was quasi-experimental with control-experimental group design. The control-experimental group design that is carried out with pre-test and post-test can accurately describe the causal relationship between variables (Allen & Babbie, 2013; Romo, 2013). Two homogeneous groups were selected from the sample to be an experimental group and a control group. The procedure in conducting the research is shown in Fig. 1.

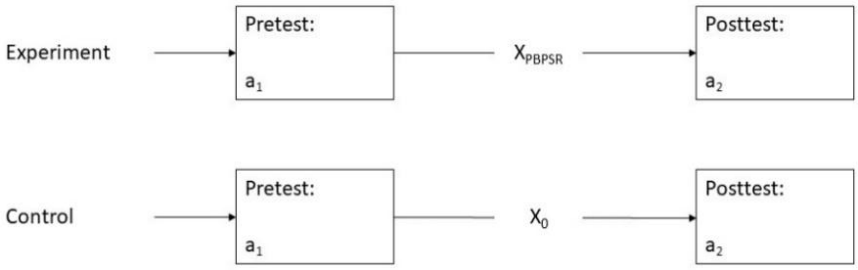

Fig. 1 - Research procedure (*a*= 4Cs skills instrument)

The experimental group implemented the potential of students' region-based project by firstly identifying the potential of their regions. In the control group, the free theme-based project model was applied in which the students were free to decide the theme of their project and were not directed to the potential of their regions. The students' competencies assessment was assessed by two evaluators. The pre-test was conducted at the fifth meeting where the students had to present their project proposals and the evaluators assessed their 4Cs skills. Furthermore, different treatments were carried out in the two groups for ten meetings to see the different learning outcomes between them (Allen & Babbie, 2013). The post-test was given in the sixteenth week where the students had to present their final project assignments and the evaluators assessed them by using the same instrument used in the pre-test.

The implementation of the potential of students' region-based project in learning was carried out in five stages. In the first stage, the students identified the potential of their regions. The second stage was to analyse the problem of why the potential of the region had not been developed or had not been optimal in its development. In the third stage, they formulated problem solving to be their project and made it relevant to the core competencies of the course. In the fourth stage, they carried out project making, and in the fifth stage, they presented their projects through class seminar. At the completion of each learning stage, the lecturer evaluated the progress of the project work carried out by the students. Here, the students used the developed module based on project based on the potential of students' region (Latifa, Syahril, Jalinus, & Ridwan, 2022). In each stage of the implementation, a formative assessment with active feedback was given to improve the students' academic achievement (Waskito, Irzal, Wulansari, & Kyaw, 2022).

2.2 Research Instrument

The assessment instrument used was based on the 4Cs skills indicators developed by The Partnership for 21st century learning (2019). The 4Cs skill indicators assessed were creativity and innovation, critical thinking and problem solving, communication, and collaboration. The measuring instrument used in this study was validated by five experts who have deep experiences in teaching and research in the field of TVET. The characteristics assessed in each 4Cs skills indicator were sufficiency, clarity, coherence, and relevance. The data from the experts were analysed by using *V* coefficients formulation (Aiken, 1985), with a high interpretation of > 0.5. Statistical validation on the characteristics of the 4Cs skills instrument is presented in the following table 1.

Table 1 - Statistical validation on the characteristics of the 4cs skills instrument

Aspect	Characteristics	*V* coefficients	Interpretation
Creativity and Innovation	Sufficiency	0.66	Valid
	Clarity	0.65	Valid
	Coherence	0.68	Valid
	Relevance	0.67	Valid
Critical thinking and problem solving	Sufficiency	0.64	Valid
	Clarity	0.67	Valid
	Coherence	0.65	Valid
	Relevance	0.67	Valid
Communication	Sufficiency	0.62	Valid
	Clarity	0.66	Valid
	Coherence	0.60	Valid
	Relevance	0.63	Valid
Collaboration	Sufficiency	0.70	Valid
	Clarity	0.70	Valid
	Coherence	0.65	Valid
	Relevance	0.70	Valid

2.3 Data Analysis Technique

The statistical analysis used for each hypothesis in this study can be seen in Table 2. The analysis technique for each indicator of the 4Cs skills was carried out using *T*-Test independent sample, and the statistical analysis for the overall skills or 4Cs skills was done using ANCOVA.

Table 2 - Analysis technique on hypothesis

No.	Hypothesis	Analysis Technique
Hypothesis 1	There is a difference on creativity and innovation skills between the students in the control and experimental group	Independent Sample *T*-test
Hypothesis 2	There is a difference on critical thinking and problem-solving skills between the students in the control and experimental group	Independent Sample *T*-test
Hypothesis 3	There is a difference on communication skills between the students in the control and experimental group	Independent Sample *T*-test
Hypothesis 4	There is a difference on collaboration skills between the students in the control and experimental group	Independent Sample *T*-test
Hypothesis 5	There is a difference on 4Cs skills between the students in the control and experimental group	ANCOVA

3. Results

3.1 Creativity and Innovation Skills

The analysis results on the mean, standard deviation, normality, and homogeneity in the aspect of creativity and innovation skills are presented in Table 3. From the results of the descriptive analysis, in the experimental group, the mean of those skills in the pre-test is 32 with a standard deviation of 5.5, while in the post-test it is 38.2 with a standard deviation of 3.33. It shows an increase in the average scores of students' creativity and innovation skills. The post-test value has a smaller standard deviation compared to that of the pre-test which can be interpreted after being treated, the students' creativity and innovation skills scores are closer to the mean or the students' skills level is almost the same. In the control group, the mean of students' creativity and innovation in the pre-test is 32.16 with a standard deviation of 5.08, while the post-test has a mean of 33.97 with a standard deviation of 6.11. In the control group, it shows that the mean also increases, but the standard deviation of the post-test data is greater than that of the pre-test. This shows that after the treatment was given, the student's skills became increasingly diverse or many of them were not approaching the mean.

The normality test was carried out using the Kolmogorov Smirnov test and the calculations were performed by SPSS. The interpretation of the data is based on the reference that if the data significance value is greater than 5% or 0.05; then, the data can be said to be normally distributed. Table 3 shows that the data for the students' scores on creativity and innovation are normally distributed, the experimental group [$p > 0.05 = 0.300$, $K\text{-}S = 0.085$] and the control group [$p > 0.05 = 0.200$, $K\text{-}S = 0.091$]. This homogeneity test used Levene's test with the calculations performed by SPSS. If the data significance value is greater than 5% or 0.05 then the data can be considered homogeneous. Based on the homogeneity analysis using Levene's test, the pre-test scores of all variables are not significantly different from the population [$p > 0.05 = 0.966$, $L = 0.002$]. Based on the results of the normality and homogeneity test, the creativity and innovation data can be continued for the independent sample t-test and ANCOVA.

Table 3 - Descriptive analysis, normality and homogeneity on creativity and innovation skills

				Normality		Homogeneity	
		Mean (*M*)	***SD***	**Statistics (*K-S*)**	***P* value**	**Levene's Statistic**	***P* value**
Experimental group	Pre-test	32.0	5.5	0.085	0.300	0.002	0.966
	Post-test	38.2	3.33				
Control group	Pre-test	32.16	5.08	0.091	0.200		
	Post-test	33.97	6.11				

Hypothesis 1 was tested using independent sample t-test which was analysed by using SPSS. This test was done to determine whether there were differences on creativity and innovation skills between the students in the control and experimental group. The results of the data analysis of hypothesis 1 are presented in Table 4. Based on the results of the independent sample *t*-test, it is found that there is a significant difference in the creative and innovation skills between students in the control and experimental group [$t = 3.373$; $p < .05 = 0.007$].

Table 4 - Independent Sample *T*-test of hypothesis 1 on creativity and innovation skills

		F	**Sig.**	***t***	***df***
Value	Equal variances assumed	7.672	.007	3.343	59.0
	Equal variances not assumed			3.373	46.647

3.2 Critical Thinking and Problem-Solving Skills

The data analysis results of students' score on critical thinking and problem-solving skills between experimental and control group which cover descriptive data, normality, and homogeneity are presented in Table 5. The mean score of critical thinking and problem-solving skills of experimental group students in the pre-test is 32.7 with a standard deviation of 6.23, and the mean score in the post-test is 36.5 with a standard deviation of 3.93. The standard deviation of the post-test is lower than that of the pre-test. This shows that the students' average score before being treated is close to that of after being treated. In the control class, the mean of students' critical thinking and problem-solving skills in the pre-test is 32.39 with a standard deviation of 6.43, and in the post-test, it increases to 33.7 with the standard deviation decreasing to 5.57. This result also shows that the students' average scores are close to the mean. Based on the results of the descriptive analysis, in both experimental and control group, the value of critical thinking and problem-solving skills increases.

The normality test result of the assessment data on students' critical thinking and problem-solving skills in the experimental group is [$p > 0.05 = 0.200$, $K\text{-}S = 0.100$] and the control group is [$p > 0.05 = 0.150$, $K\text{-}S = 0.126$]. Referring to the result, it can be concluded that the data are normally distributed. Based on the results of the homogeneity analysis

on all variables, it is found that there is no significant difference in the population [$p > 0.05 = 0.419$, $L = 0.656$]. Based on the results of the normality and homogeneity test on critical thinking and problem-solving skills data, the data can be continued for the independent sample *t*-test and ANCOVA.

Table 5 - Descriptive analysis, normality and homogeneity on critical thinking and problem-solving skills

				Normality		Homogeneity	
		Mean	***SD***	**Statistics (*K-S*)**	***P* value**	**Levene's Statistic**	***P* value**
Experimental group	Pre-test	32.7	6.23	0.100	0.200	0.656	0.419
	Post-test	36.5	3.93				
Control group	Pre-test	32.39	6.43	0.126	0.150		
	Post-test	33.7	5.57				

Based on the test result of the independent sample t-test on hypothesis 2 (Table 6), it is found that there is a significant difference in the average critical thinking and problem-solving skills between the students in the control and experimental group [$t = 3.238$; $p < 0.05 = 0.008$).

Table 6 - Independent Sample *T*-test of hypothesis 2 on critical thinking and problem-solving skills

		F	**Sig.**	***t***	***df***
Value	Equal variances assumed	7.549	.008	3.226	59
	Equal variances not assumed			3.238	44.047

3.3 Communication Skills

The results of the data analysis on the mean, standard deviation, normality, and homogeneity of students' communication skills assessment data are presented in Table 7. The mean of communication skills of the experimental group in the pre-test is 16.6 with a standard deviation of 4.37, and in the post-test, it increases to 20.67 with the standard deviation decreasing to 1.65. The lower standard deviation in the post-test shows that the scores of students' communication skills are close to the mean. In the control group, the mean in the pre-test is 16.68 with a standard deviation of 3.77, and in the post-test, it is 17.74 with a standard deviation of 5.17. In the control group, the standard deviation of the post-test is higher than that of the pre-test. This indicates that the students' skills are not the same or far from the mean.

The result of normality test on students' communication skill assessment data in experimental group is [$p > 0.05 = 0.290$, $K\text{-}S = 0.188$] and control group is [$p > 0.05 = 0.480$, $K\text{-}S = 0.111$]. Based on the results, it can be concluded that the students' communication skill assessment data are normally distributed. Referring to the result of the homogeneity analysis on all variables, it is found that there is no significant difference in the population [$p > 0.05 = 0.144$, $L = 2.165$]. Therefore, it can be continued for the independent sample *t*-test and ANCOVA.

Table 7 - Descriptive analysis, normality and homogeneity on communication skill

				Normality		Homogeneity	
		Mean	***SD***	**Statistics (*K-S*)**	***P* value**	**Levene's Statistic**	***P* value**
Experimental Group	Pre-test	16.6	4.37	0.188	0.290	2.165	0.144
	Post-test	20.67	1.65				
Control Group	Pre-test	16.68	3.77	0.111	0.480		
	Post-test	17.74	5.17				

. Based on the result of the independent sample *t*-test between the control and experimental group (table 8), it is found that there is a significant difference in students' communication skill [$t = 3.108$; $p < .05$].

Table 8 - Independent Sample T-test of hypothesis 4 on communication skill

		F	Sig.	*t*	*df*
value	Equal variances assumed	16,444	,000	3,074	59
	Equal variances not assumed			3,108	42,408

3.4 Collaboration Skills

The results of descriptive statistical analysis, normality, and homogeneity of students' collaboration skills assessment data are presented in Table 9. The mean of students' collaboration skills in the pre-test of the experimental group is 9.8 with a standard deviation of 2.34 and increases to 12.73 in the post-test with a decreasing standard deviation to 1.7. This shows that the mean of the students' collaboration skills increases and the standard deviation in the post-test decreases which show that the students' scores are close to the mean. The normality test result of the students' collaboration skills assessment data in the experimental group is [$p > 0.05 = 0.100$, $K\text{-}S = 0.158$]. In the control group, the mean of the students' collaboration skills in the pre-test is 9.29 with a standard deviation of 3.7, and in the post-test, the mean increases to 10.45 with a standard deviation of 2.45. The normality test result of the students' collaboration skill assessment data in the control group is [$p > 0.05 = 0.160$, $K\text{-}S = 0.126$]. Referring to the result of the homogeneity analysis on all variables, it is found that there is no significant difference in the population [$p > 0.05 = 0.144$, $L = 2.165$], related to the scores of the students' collaboration skills. Based on those results, the students' collaboration skills data can be continued for the independent sample *t*-test and ANCOVA.

Table 9 - Descriptive analysis, normality, and homogeneity on collaboration skills

				Normality		Homogeneity	
		Mean	*SD*	Statistics (*K-S*)	*P* value	Levene's Statistic	*P* value
Experimental group	Pre-test	9.8	2.34	0.158	0.100	2.399	0.380
	Post-test	12.73	1.70				
Control group	Pre-test	9.29	3.70	0.126	0.160		
	Post-test	10.45	2.45				

Based on the result of the independent sample *t*-test, it is found that there is a significant difference in the average students' learning outcomes between the control and experimental group on the skills to collaborate [$t = 3.949$; $p < .05$).

Table 10 - Independent Sample *T*-test of hypothesis 4 on collaboration skills

		F	Sig.	*t*	*df*
value	Equal variances assumed	10,305	,002	3,905	59
	Equal variances not assumed			3,949	41,348

2.5 4Cs Skills

Hypothesis 5 "there is a difference on 4Cs skills between the students in the control and experimental group" was tested using ANCOVA. The results are presented in Table 11.

Based on the results of the ANCOVA, it is found that there is a significant difference of 4Cs skills between the students in the control and experimental group [$F(1, 52) = 23{,}738$, $p < 0.05$]. Referring to the results, it can be concluded that the 4Cs skills of the students in the experimental group statistically significantly increases after implementing the project which is based on the potential of students' region in learning compared to the 4Cs skills of the students in the control group who did not implement the model in learning. The use of pre-test and post-test in this study was aimed to see the impact of implementing the potential of students' region-based projects that were implemented to the students.

Table 11 - ANCOVA of hypothesis 5

Source	*df*	Mean Square	*F*	Sig.
Corrected Model	2	1342,563	14,387	,000
Intercept	1	5717,351	61,269	,000
Pre-test	1	417,125	4,470	,039
Group	1	2215,163	23,738	,000
Error	58	93,315		
Total	61			
Corrected Total	60			

4. Discussion

In this study, the experimental class students who implemented the potential of students' region-based project obtained higher 4Cs skills than the control group students who did not implement it. This result is in line with those of the previous studies on the impact of implementing projects in learning to improve the 4Cs skills, namely the skills to collaborate (Chen, Hernandez, & Dong, 2015), communicate (Kovalyova, Soboleva, & Kerimkulov, 2016), critical thinking (Alawi & Soh, 2019), and creative thinking (S.-Y. Chen, Lai, Lai, & Su, 2019). The findings of this study on improving students' critical thinking skill are in line with the research carried out by Alawi and Soh (2019). This is because this project contains complex and challenging tasks and requires students to be able to design, solve problems, make decisions and carry out investigative activities so that all of them can hone their critical thinking skills. The findings of this study on improving students' creative thinking skill are consistent with the results of the research conducted by S. -Y. Chen, Lai, Lai, and Su (2019) that students can produce unique, interesting and brilliant ideas in completing a project. The project completion stage stimulates them to develop their knowledge and confidence so that they can generate new, creative, and innovative ideas in completing a project. The finding on students' collaborative abilities is in line with the result of P. Chen, Hernandez, and Dong (2015) where high motivation to learn, active learning in a team and enjoying sharing tasks in learning activities with PjBL lead to high students' teamwork skill. Huang (2010) states that through project assignments on PjBL, the students encounter various problems which lead them know how to work in a team to be able to solve the problems. High motivation and interest in doing project assignments from the potential of their regions lead them to increase cooperation in carrying out the project assignments (Alves, Mesquita, Moreira, & Fernandes, 2012). The excellence of project-based learning is due to its effectiveness in covering diverse needs of the students (Campos-Roca, 2021). Furthermore, the students get experiences from other projects carried out by other groups. They can revise and upgrade their project work by learning and sharing with the successful groups.

The result of this study on communication is consistent with the research finding of Kovalyova et al. (2016) that PjBL which is implemented to engineering students can improve their communication skill. The students' communication skill is divided into two forms of communication, namely written and oral or verbal. Students' written language skills can be seen in their project proposals and assignment reports. The students get an opportunity to experience a direct communication with society in identifying the potential of their regions and the problems, and discussion to solve them. Students' oral or verbal skills are shown when they are proposing a project assignment proposal and project assignment reports where they have to be able to convince lecturers about the accuracy of the tool or machine that will or has been drawn (Magleby & Furse, 2007).

Based on the research results, the students in the experimental group who implemented the project which is based on the potential of their region felt that the project was very useful. The reasons why it is so being that designing, solving problems, making decisions and conducting investigative activities can hone students' critical thinking skills. Furthermore, the stages of the project completion can increase the students' self-confidence so that they can generate creative and innovative ideas. The project completion encourages students to improve teamwork and allows them to communicate the solutions effectively. This makes them aware of the benefits of implementing the projects in learning. In developing the students' 4Cs skills, the implementation of this model is one of the right strategies to be applied in learning since it is a learning model that directs students to focus on developing the four skills. The main benefit of the model is increasing students' motivation since the projects they carry out are beneficial for the development of their own area of expertise. Therefore, the model stimulates them to think creatively in generating unique ideas, think critically in identifying existing potentials, collaborating in completing projects and communicating solutions effectively. This makes the implementation of the potential of students' region-based project effective to be implemented in learning to improve

4Cs skills. Besides, the model provides more meaningful learning features for students to create authentic connection with the latest knowledge and technology (Miller, Severance, & Krajcik, 2021).

5. Conclusion

Based on the results, the potential of students' region-based project is more effective in improving students' 4C skills than the free theme-based one. The students did the projects more actively as the designed machine was dedicated to improving the potential of their region. They also actively investigated the problems of their region and thought critically to get the solution. Furthermore, the project which is based on the potential of students' region could stimulate them to be more creative and innovative in designing machine. Their communication skill improved since they got an opportunity to experience being in an interview with people in the community to find the problem, to present their project proposal and progress, and to report their project work in a seminar class. They also collaborated actively both within and outside the team in learning and discussing difficulties found during their work. This study is limited to the development of the 4Cs skills only (creativity, critical thinking, collaboration and communication), so it is suggested that other researchers investigate the impact of implementing this model in learning on other variables, especially on Higher Order Thinking Skills (HOTS) that has not been covered here.

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