Improving the 21st Century learning skills of a vocational teacher candidate through an industrial project approach

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Improving the 21st Century learning skills of a vocational teacher candidate through an industrial project approach

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ABSTRACT: This study is focused on analysing the vocational teacher candidate's ability to communicate, collaborate, think critically and be creative based on an industrial project learning approach. The participants in this study were students from the Mechanical Engineering Vocational Education Department at the State University of Semarang (Universitas Negeri Semarang) in Indonesia, who participated in an industrial project. An experimental method using a pre-test/post-test control group design was employed in the study. The collected data were examined utilising both descriptive and inferential statistical methods. The findings indicate that learning though the involvement in industrial projects can help students in mechanical engineering vocational programmes become better communicators, collaborators, critical thinkers and creative innovators. When they become vocational school instructors, it is anticipated that these skills will positively affect the learning experiences of their trainees and help in preparing competent graduates that the industry will require in the future.

INTRODUCTION

In the 21st Century, vocational education requires students to think critically and to solve problems, communicate and collaborate, and be creative and innovative. Because of the needs and demands of the industry, vocational school education must be effective in creating graduates with these competencies. Thus, the need for vocational education teachers who have a future-focused perspective, are able to work collaboratively, are able to develop adaptable student personalities, and who can adjust to industry advances and the dynamics of vocational education. Additionally, vocational education teachers must be digitally proficient in order to incorporate effective educational technology in tasks like creating and refining students' learning experiences and digital assessments, as well as encouraging and enabling student innovation [1].

However, in practice, students in vocational schools still face numerous challenges related to the development of those skills. For example, students from the Mechanical Engineering Vocational Education Department at the State University of Semarang (Universitas Negeri Semarang) in Indonesia still struggle with a number of issues, including poor verbal and nonverbal communication skills, a lack of understanding of modern innovations in vocational learning models, an inability to carry out necessary steps because of a lack of analytical and decision-making skills, and a lack of drive to share ideas. These issues have a bearing on whether they will eventually work as teachers. Moreover, criticism from partner industries that students lack creativity in their task completion has to be seriously considered. Students struggle to detect flaws in repair work, making them hesitant to decide on appropriate corrective measures.

It is vital to have a suitable learning model for aspiring vocational education teachers in line with 21st Century learning skills. With such a model in place, these teachers will add value to social capital, student learning experiences will be enriched, and the graduates will meet the expected competency standards of employers. The amount of experience and student achievement after the class depends on how well an effective learning model was chosen.

Teacher performance in the implementation of student learning affects the learning experience, motivation and the level of student competency achievement [2].

One of the learning breakthroughs that combines academic and industrial-based learning is the industrial project learning model. To enhance communication and co-operation skills, student engagement, learning quality and learning outcomes, project-based learning gives students real, hands-on learning experiences based on business needs [3][4]. Project-based learning is widely acknowledged to aid in students' competency and self-development [5]. Students can combine cross-subject skills through industrial project learning, which supports the development of process competencies and their application. To enhance student learning, foster discussion of problem-solving and guarantee that students are excited about completing their projects, teachers must have the necessary expertise.

The steps of determination, alignment, observation, conception, design, execution and evaluation are used in this study's industrial project learning approach. The determination stage involves selecting the project to be carried out from a variety of options. The alignment step is carried out by matching up learning objectives with tasks and different kinds of industrial projects in accordance with the chosen work. The phase of observation involves visits to companies, during which students learn about project management and workplace culture. The conception step is carried out by giving students a clear idea of the project learning process that will be conducted and asking them to work in groups to decide which projects will be developed at the completion of the learning process.

Students are encouraged to create detailed designs during the design stages based on different project options, where each group member is accountable for his or her portion of the job. The creation of a product takes place at the implementation stage. If the product is not working correctly, troubleshooting takes a lot of time. Students must truly be able to solve the problem at this point and they must also resist giving up easily. Presenting the final products to stakeholders serves as the evaluation stage.

Project-based learning stages increase learning activities because students have real learning experiences according to the needs and problems [6]. Project-based methods also help teachers internalise important values in completing their work and motivate students to be active in the verbal evaluation process [7]. This learning model emphasises the skills to manage the given task and helps implement creative thinking processes in understanding real problems [8].

Based on the description above, a study was conducted to analyse the ability to think critically, co-operate, communicate effectively, and be creative in learning using industrial projects in regard to vocational teacher candidates in Indonesia. The 21st Century learning skills of vocational school teacher candidates will become the provision in the future that these vocational teachers will competently fulfil the expectations and contribute to vocational education graduates' skills development needed by the industry. The study results are also expected to be an alternative model of industrial project-based learning to improve the learning experience and skills of vocational graduates.

METHOD

An experimental method with pre-test/post-test control group design was used in this study. The research design included both a control group and an experimental group. A job sheet prepared by the lecturer was used by the control group. The treatment for the experimental group was a job sheet for an industrial project prepared by students. The controlled variables for the two groups included similar workshops and equipment, having passed the required courses and presence in the same class. The two groups participated in pre-tests and post-tests. The subjects of this study were students from the Department of Mechanical Engineering Vocational Education Department at the State University of Semarang (Universitas Negeri Semarang) in Indonesia.

The evaluation of collaboration skills, communicating, critical thinking and creativity was conducted using a questionnaire. Questionnaires were given to the control and experimental groups, both before and after the learning process. The questionnaire consisted of 30 statements covering the ability to communicate, analyse content, present ideas, identify problems, develop alternative solutions to problems, make conclusions, build trust, act in openness and present a variety of ideas and confidently complete tasks.

The data were analysed by using descriptive and inferential statistics. Descriptive quantitative analysis was used to analyse data on 21st Century learning skills including the ability to communicate, collaborate, think critically and be creative. An inferential quantitative approach to test the difference in group improvement relied on the *t*-test. The increase in the 21st Century learning skills values was calculated using the normalised gain (N-gain). The calculation of the N-gain was based on equations and criteria adapted from Hake [9], and is as follows:

$$\text{N-gain} = \frac{\text{Post-test score} - \text{Pre-test score}}{\text{Maximum score} - \text{Pre-test score}} \qquad (1)$$

The gain criteria were normalised as shown in Table 1.

Table 1: Normalised gain criteria.

N-gain score	N-gain criteria
$0.000 < \text{N-gain} < 0.300$	Low
$0.300 \leq \text{N-gain} \leq 0.700$	Medium
$\text{N-gain} > 0.700$	High

RESULTS OF THE STUDY

Table 2 displays the study findings on the communications skills of the experimental and control groups based on the industrial project-based learning approach. According to these findings, the experimental group's N-gain average is 0.628

and the control group's N-gain average is 0.546 in terms of the Hake criterion, which implies that if the value is above 0.300 and below 0.700 it is qualified as medium [9]. For the low criterion, the control group's N-gain communication ability is 5.410 percent, and for the medium criterion, it is 94.590 percent. The experimental group's distribution is as follows: 10.810 percent for the low criterion, 40.540 percent for the medium and 48.650 percent for the high criterion.

Table 2: N-gain for communication skills.

N-gain score	Control group (%)	Experimental group (%)
0.000 < N-gain < 0.300	5.410	10.810
0.300 ≤ N-gain ≤ 0.700	94.590	40.540
N-gain > 0.700	0.000	48.650
N-gain average	0.546	0.628
Criterion	Medium	Medium

Table 3 displays the outcomes of the *t*-test for enhancing communications skills in the control and experimental groups. The table displays the results of the *paired sample test* for communication skills. It is known that the value of Sig. (2-tailed) of 0.000 < 0.050 can be used to draw the conclusion that utilising the industrial project-based learning model makes a difference in communication skill improvement. The communication skills of a vocational teacher candidate placed in an industrial project demonstrate improvement in relation to verbal and non-verbal communication, writing and presenting ideas regarding various complex problems, analysing and evaluating content appropriately, and building positive relationships to increase self-confidence.

Table 3: Results of the *t*-test on the N-gain for communication skills - paired samples test.

		Paired differences					*t*	df	Sig. (2-tailed)
		Mean	SD	Std. error mean	95% confidence interval of the difference				
					Lower	Upper			
Pair 1	Control group - Experimental group	-0.13576	0.20803	0.03420	-0.20512	-0.06640	-3.970	36	0.000

Table 4 displays the outcomes of the analysis of the N-gain for critical thinking skills. According to the table, the experimental group's average N-gain of critical thinking abilities is 0.595, whereas the control group's is 0.503, which according to the Hake criterion, places the values in the medium qualifying range [9]. The low criterion in the control group is 24.320 percent, the medium criterion - 62.160 percent and the high criterion is 13.520 percent. The N-gain low criterion is 2.700 percent, the medium - 70.270 percent and the high criterion is 27.030 percent for the experimental group. Table 3 displays the outcomes of the N-gain distribution of critical thinking skills.

Table 4: N-gain for critical thinking skills.

N-gain score	Control group (%)	Experimental group (%)
0.000 < N-gain < 0.300	24.320	2.700
0.300 ≤ N-gain ≤ 0.700	62.160	70.270
N-gain > 0.700	13.520	27.030
N-gain average	0.503	0.595
Criterion	Medium	Medium

Table 5 displays the results of the critical thinking N-gain test of the experimental and the control groups. As the results of the *paired sample test* N-gain for the critical thinking ability have the Sig. (2-tailed) of 0.016 < 0.050, so it can be concluded that there is a difference in the N-gain of critical thinking skills between the control and experimental groups, indicating that engaging students the industrial project-based learning model resulted in an increase in critical thinking skills. The difference in the increased critical thinking skills of vocational teacher candidates can be seen from the ability to identify problems, collect relevant information, develop alternative problem-solving ideas, make conclusions from problems logically and be able to express arguments clearly.

Table 5: Results of the *t*-test on the N-gain for critical thinking skills - paired samples test.

		Paired differences					*t*	df	Sig. (2-tailed)
		Mean	SD	Std. error mean	95% confidence interval of the difference				
					Lower	Upper			
Pair 1	Control group - Experimental group	-0.11932	0.28844	0.04742	-0.21549	-0.02315	-2.516	36	0.0160

Table 6 displays the results of the N-gain calculation for improving collaboration skills in the control and experimental groups based on the industrial project learning model. The experimental group's mean N-gain score for collaboration is 0.680, whereas the control group's is 0.601. According to the Hake standards, both groups have scores between 0.300 and 0.700, which indicates the medium criterion [9]. The low criterion corresponds to the 8.110 percent of N-gain in the control group, whereas 48.650 percent to the medium and 43.240 percent to the high criterion. The distribution for the experimental group is 2.700 percent, with the low criterion at 51.350 percent, the medium at 48.650 percent, and the high criterion at 48.650 percent.

Table 6: N-gain for collaboration skills.

N-gain score	Control group (%)	Experimental group (%)
0.000 < N-gain < 0.300	8.110	2.700
0.300 ≤ N-gain ≤ 0.700	48.650	51.350
N-gain > 0.700	43.240	48.650
N-gain average	0.601	0.680
Criterion	Medium	Medium

The findings of the *paired sample test* N-gain for collaboration skills analysis are displayed in Table 7 with the Sig. (2-tailed) value of 0.024 < 0.050. According to the analyses, there is a difference in the N-gain value between the experimental and the control groups, which indicates that the two groups' progress in collaborating based on the industrial project-based learning model also differs. The increased ability to work together based on the industrial project learning model can be seen in trust building with the principle of respecting each other's position, an attitude of mutual belonging in the group, building an open atmosphere by appreciating the thoughts of others, respect for differences in opinion within the group, and providing feedback to others in regard to the tasks already completed.

Table 7: Results of the *t*-test on the N-gain for collaboration skills - paired samples test.

		Paired differences					*t*	df	Sig. (2-tailed)
		Mean	SD	Std. error mean	95% confidence interval of the difference				
					Lower	Upper			
Pair 1	Control group - Experimental group	-0.11549	0.29863	0.04909	-0.21505	-0.01592	-2.352	36	0.024

Table 8 displays the results of the N-gain for creative skills based on the industrial project learning model. The table illustrates that the moderate conditions are met by the control group's N-gain score of 0.388 for creative skills. The experimental group has a high value N-gain of 0.706, which is over 0.700. The results distribution for the control group is as follows: the low criterion of 43.240 percent, the medium of 43.240 percent and the high criterion of 13.520 percent. The distribution for the experimental group include the high criterion of 64.870 percent and the medium criterion of 35.130 percent.

Table 8: N-gain for creative skills.

N-gain score	Control group (%)	Experimental group (%)
0.000 < N-gain < 0.300	43.240	0.000
0.300 ≤ N-gain ≤ 0.700	43.240	35.130
N-gain > 0.700	13.520	64.870
N-gain average	0.388	0.706
Criterion	Medium	High

Table 9: Results of the *t*-test on the N-gain for creative skills - paired samples test.

		Paired differences					*t*	df	Sig. (2-tailed)
		Mean	SD	Std. error mean	95% confidence interval of the difference				
					Lower	Upper			
Pair 1	Control group - Experimental group	-0.31830	0.24354	0.04004	-0.39950	-0.23710	-7.950	36	0.000

Table 9 displays the results of the N-gain test for creative skills. The table shows the results of the creative ability using the N-gain *paired sample test* with the Sig. (2-tailed) value of 0.000 < 0.050. Considering these results, it can be concluded that there is a difference in the N-gain of creative skills between the control group and the experimental group, indicating that following the industrial project-based learning model makes a significant difference in increasing creative skills. Engaging teacher candidates in industrial project learning improves their creative ability in generating various ideas, seeing problems from different perspectives, creating different works, helping other people to develop ideas, and also in their increased confidence in completing the assigned tasks and desire to explore knowledge in depth.

DISCUSSION

The results revealed that there were differences between the experimental and control groups in terms of how well students in the Department of Mechanical Engineering Vocational Education were able to collaborate, communicate, think critically and be creative. The students were given the opportunity to organise learning activities, carry out projects in teams, create work products that could be demonstrated to the public as preliminary research, and align their competencies with industry needs through industrial project learning. Through this training, future vocational educators may co-operate to address complex issues and technology advancements while fostering students' critical thinking ability. Competencies relating to various scientific fields are required for complex projects in which knowledge is further developed, problem-solving abilities are strengthened and collaborative abilities reinforced [10].

The ability to communicate is demonstrated by improving verbal presentation using the appropriate words, tone and intonation, and also by expressing one's ideas or opinions in writing, having the courage to respond, appropriately analysing and evaluating content, presenting ideas flexibly and developing optimism in teamwork. In vocational education, social capital is built to help students join the workforce effectively [11]. Effective communication can prevent misconceptions brought on by a failure to comprehend or receive information. As mentioned before, the abilities needed for 21st Century learning include coming up with ideas, handling project issues and creative thinking [12]. Future vocational educators that possess critical thinking abilities are better equipped to recognise issues, gather data and come up with creative solutions, along with being able to examine the given responses and state logical conclusions.

The impact of industrial project learning for vocational teacher candidate is refers to an increase in the personal capacity to implement 21st Century learning skills, possessing the ability to apply 21st Century learning steps methodically, and an increased creativity in determining effective learning. Vocational teacher candidates also have valuable learning experiences and the ability to innovate, so they add value to social capital in the future as teachers. These teachers can foster creativity in the classroom, assist students in their creative progress, spark their creativity, collaborate more productively, develop ideas and produce technology-based creative products [13].

Industrial project learning conducted by experienced teachers provides an opportunity to integrate various competencies across disciplines and encourage the achievement of those competencies by students and their implementation in practice. Creative students enhance the overall learning environment by positively influencing their teachers and peers [14]. With the help of industrial project-based learning, vocational teacher candidates can develop knowledge of current technological advancements, the ability to reason and solve complex problems, oral and written communication skills, teamwork, project management, and more specialised independent learning skills. As the expected competencies develop, project learning can be focused on other relevant skills [15][16].

Industrial project learning provides crucial benefits for the vocational teacher candidate by developing effective learning models to achieve learning goals more easily and aiding students in building learning experiences. The development of learning models is needed along with the recognition of differences in student characteristics, personalities, and ways of learning. In addition project-based learning can motivate students to be more passionate about their studies. Increasing teachers' understanding of learning models, will help them to develop their own imagination, increase the power of reasoning and the ability to analyse students systematically, and also to keep students engaged in learning activities.

The industrial project learning model can be an alternative model to improve 21st Century learning skills in institutions that educate vocational teacher candidates. Vocational teachers must demonstrate creativity in line with technological developments, student developments and graduate competencies. The creativity of teachers is determined in their education process when they are taught how to innovate and be creative in effective learning. The success or failure of education is determined by the choice of an appropriate educational model preparing vocational education graduates for the 21st Century workplace. As highlighted in some studies, 21st Century teachers must have effective teaching strategies, higher thinking skills and knowledge to develop students' adequate life and career skills [17].

CONCLUSIONS

The industrial project learning model outlined in this article can increase the communication, collaboration, critical thinking and creative skills of vocational teacher candidates. The details of the increase on each skill are as follows:

The normalised gain in communication skills falls into the medium range, indicating that the industrial project learning model has a positive impact on the verbal and non-verbal communication skills, the ability to analyse and evaluate content, and self-confidence of vocational teacher candidates.

The ability to collaborate has the normalised gain in the medium range, indicating the vocational teacher candidate's increased openness in appreciating the work of others, their respect of differences between groups, and the ability to provide and act on feedback.

In regard to critical thinking skills the normalised gain falls into the medium range, indicating an increased ability to identify problems, develop alternative problem-solving ideas, present sound arguments and draw appropriate conclusions.

Creative ability has the normalised gain in the high range, indicating more confidence in completing assignments, a higher motivation to learn and explore knowledge, and an increased ability to developed ideas and innovate.

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