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Muhammad Sadam Rizkylillah
State University of Jakarta, Indonesia

Soeprijanto
State University of Jakarta, Indonesia

Muksin
State University of Jakarta, Indonesia

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Muhammad Sadam Rizkylillah, Soeprijanto, Muksin

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Abstract

The implementation of project-based learning programs that are in line with the concept of 21st century learning is very important in the era of the Industrial Revolution 4.0 for vocational schools. However, in practice in the field, the learning results in vocational learning programs at vocational schools that implement Project-Based Learning have not shown optimal results in improving students' skills and work readiness. This study aims to analyze the application of project-based vocational learning programs in vocational schools as a 21st century learning approach, as well as identify its effectiveness in improving students' critical thinking, collaboration, communication, and creativity skills (21st century skills). This study applies a collective case study method or multiple case study with a qualitative approach. Data were obtained through interviews, observations, and documentation, and were checked for validity through triangulation and analyzed using the Miles & Hubberman model. The results of the study show that the concrete form of project-based vocational learning programs in vocational schools in the Tangerang region has three main forms: PjBL for schools, PjBL for industrial cooperation, and PjBL for the community. Overall, the PjBL program implemented has had a positive impact on improving students' competence and work readiness. However, its effectiveness in improving job readiness still faces challenges, especially related to the relevance of the project to industry needs as well as the gap in technical and non-technical skills of learners. In addition, other challenges found include limited facilities, continuity of industrial cooperation, and the readiness of teachers and students in managing projects.

Introduction

The implementation of learning programs that are in line with the concept of 21st century learning is very important in the era of the Industrial Revolution 4.0. This aims to equip vocational school students with various soft skills known as 21st century skills, such as critical thinking, creativity, communication, and collaboration (Mardhiyah, et al., 2021). One of the models applied in learning program in vocational schools in Indonesia is Project-Based Learning (PjBL), which is a form of implementation of the 21st century learning concept (Buck Institute for Education, 2024; Öztürk, 2023; Wiranto & Sukardi, 2022; Redhana, 2019; Sadrina, et al., 2018). The PjBL allows learners to master the material in depth by connecting it to real situations, discussing various

problems they face (Natty, et al., 2019), and producing real products that help them identify and respond to problems critically (Wiranto & Sukardi, 2022). In addition, PjBL also trains them to be more independent and improve their skills in completing assignments, so that their understanding of the subject matter becomes more optimal (Wena, 2009).

Since 2021, project-based learning has begun to be mandatory in the vocational curriculum, along with the gradual introduction of the Independent Curriculum (Kurikulum Merdeka). The Ministry of Education and Culture (2021) also emphasized that the application of this model is one of the important indicators in the implementation of vocational education, as referred to the postulate of Prosser (Nitiswito & Maksum, 2021), as explained in Table 1. The legal basis for the implementation of PjBL in the learning structure of vocational schools, both intracurricular and cocurricular, is also listed in Appendix II Point E of the Minister of Education and Culture Number 12 of 2024 which regulates the Early Childhood Education Curriculum, Basic Education Levels, and Secondary Education Levels. In addition, the implementation of PjBL in vocational schools is also liked by vocational teachers because of the various advantages and benefits presented from the model (Karomatunnisa, et al., 2022; Mardhiyah, et al., 2021; Setiawan & Wardani, 2021).

Table 1. Indicators of Vocational Education Implementation in Indonesia

No.	Indicators of Vocational Education Implementation
1.	Curriculum compiled together
2.	**Real project-based learning from consumers or business/industry partners**
3.	The role of teachers/instructors from industry and experts from the world of work
4.	Fieldwork practice
5.	Competency certification
6.	*Technology* updates and training for teachers/instructors
7.	Applied research supports *Teaching Factory*
8.	Commitment to absorption by the World of Work
9.	Cooperation that can be done with partners in the world of work

(Source: Ministry of Education and Culture, 2021)

However, in practice in the field, the learning results in vocational learning programs at vocational schools that implement Project-Based Learning have not shown optimal results in improving students' skills and work readiness. Project-Based Learning has been proven to be effective in improving students' final scores (Wibowo, Armanto, & Lubis, 2022), teamwork skills (Sadrina, Mustapha, & Ichsan, 2018), and new insights and experiences (Samsiadi & Romelah, 2022). However, learning programs that apply this model have not been able to significantly improve students' work skills (Ciddi, 2025; Samsiadi & Romelah, 2022). Many vocational school graduates are still not ready to enter the world of work or are only able to compete in the first five years before being challenged by high school graduates (Istiqamah & Jalal, 2020). Data from the Central Statistics Agency (BPS) also shows that vocational school graduates are the largest contributor to the Open Unemployment Rate in Indonesia as shown in Table 2.

Table 2. Open Unemployment Rate Based on Education Level in Indonesia in 2021 – 2023

Education Level	**Open Unemployment Rate (in %)**		
	2021	**2022**	**2023**
No/Never Been to School/Haven't Graduated & Graduated from Elementary School (SD)	3,61	3,59	2,56
Junior High School (SMP)	6,45	5,95	4,78
Senior High School (SMA)	9,09	8,57	8,15
Vocational High School (SMK)	**11,13**	**9,42**	**9,31**
Diploma I/II/III	5,87	4,59	4,79
University	5,98	4,80	5,18

(Source: BPS, 2024)

Data from the Central Statistics Agency (BPS) in Table 2 shows that vocational school graduates still dominate the open unemployment rate compared to graduates of other levels of education. The industry still assesses that the skills of vocational school graduates are not yet able to compete with non-vocational school graduates (Wijaya & Utami, 2021). This shows that there is a discrepancy in the vocational learning program, which is supposed to produce a quality workforce but is actually the largest contributor to the unemployment rate in Indonesia. Based on the national labor force survey in February 2024, Banten Province has the highest unemployment rate due to limited employment, economic inequality, and low quality of human resources (BPS, 2024; Apriliana & Setyawijaya, 2024). Therefore, an analysis of the implementation of project-based learning in vocational schools is important to ensure its effectiveness in increasing the competitiveness of graduates, as affirmed in the Presidential Regulation of the Republic of Indonesia Number 68 of 2022 concerning the Revitalization of Vocational Education.

Analysis of the implementation of learning programs in the context of evaluation is very important because it is useful in improving the running program, providing data for decision-making (Widoyoko, 2013), and helping teachers assess student progress and identify aspects that need to be improved to make learning more effective (Faizin & Kusumaningrum, 2023; Rahma, et al., 2023). Research related to project-based learning evaluation has been conducted by Wibowo et al. (2022) and Rahma et al. (2023), who used the CIPP evaluation model to assess the effectiveness of project-based learning at the elementary and junior high school levels. In addition, research by Endrizal et al. (2021) and Efronia & Ahyanuardi (2022) evaluated project-based learning programs in vocational schools in the field of electricity, but only focused on planning, implementation, and outcomes aspects with the CIPP and Countenance Stake evaluation models in one school only. Based on the studies in these studies, the analysis and evaluation of the implementation of project-based learning programs is still limited to certain aspects and is carried out within a narrow school scope using the literature method or individual interviews only (research gap).

The novelty of this research with the previous research is that it will analyze the application of project-based learning (PjBL) in vocational learning programs at vocational schools, especially in one area in Banten Province, namely Tangerang City. The city of Tangerang, known as the "City of 1000 Industries", takes part for 6.76% of

the unemployment rate in Banten and has 120 vocational schools, making it the city/district with the second highest number of vocational schools in the province (BPS, 2024). With great industrial potential, the low quality of vocational school graduates is a serious concern because it contributes to the high unemployment rate in Banten, the province with the highest unemployment rate in Indonesia. This study aims to analyze the application of project-based vocational learning programs in vocational schools as a 21st century learning approach, as well as identify its effectiveness in improving students' critical thinking, collaboration, communication, and creativity skills (21st century skills). This research makes a new contribution in the field of vocational education by revealing the extent to which PjBL in vocational schools has been implemented in accordance with the principles of 21st century learning, as well as evaluating the challenges and opportunities in its implementation to improve the readiness of vocational school graduates in the world of work.

Method

This study applies a collective case study method or multiple case study with a qualitative approach. This approach allows researchers to collect information directly from informants to investigate the process and gain a deeper understanding, both at the individual, group, and situational level that comes from different research sites and is analyzed simultaneously (Wu et al., 2022). This research data is sourced from primary and secondary data, where primary data is obtained through interviews and observations, while secondary data is collected through documentation from research articles, books, and school documents. This research was conducted in several vocational schools in Tangerang City with a focus on the concentration of expertise in Electrical Power Installation Engineering (TITL), which is part of the Energy and Mining expertise program with the highest number of graduates in Indonesia, reaching 32.40% of the total graduates of vocational schools (Ministry of Education and Culture, 2020). The large number of enthusiasts in this field is due to the high need for labor in the electric energy sector that continues to grow. Therefore, the number of TITL Vocational Schools is quite significant, including in the Tangerang area, Banten.

The validity of the data in this study was tested using triangulation techniques, while the data analysis was done using the model of Miles & Huberman (1984) which was updated in their book in 2014. According to Miles & Huberman (2014), data analysis in qualitative research is carried out from the time the research process takes place and continues until it reaches data saturation, where there are no more new findings. This analysis model includes four main components, namely data collection through three techniques, data condensation, which is summarizing, sorting, and reducing data through triangulation, data display in the form of tables, diagrams, and data interpretation, and conclusion drawing and verification related to the analysis of the implementation of project-based vocational learning programs at vocational schools. especially vocational schools with a concentration in Electrical Power Installation Engineering (TITL) in the Tangerang City area, Banten.

Results and Discussion

This research was conducted in several vocational schools with the concentration of TITL expertise in Tangerang City, namely SMK Negeri 1 Tangerang, SMK Negeri 4 Tangerang, SMK Negeri 8 Tangerang, SMK Voctech 1

Tangerang, and SMK Yuppentek 1 Tangerang. The subjects in this study consist of teachers who teach electricity learning, coordinators of expertise concentration (head of department) of Electrical Power Installation Engineering, and vice principals for curriculum. The discussion of the results of the research analysis of the implementation of project-based vocational learning programs as 21st century learning at SMK includes: the form of implementation of project-based vocational learning programs at SMK TITL, syntax models in project-based vocational learning programs at SMK TITL, 21st century skills (4C skills) as outputs of project-based vocational learning programs at SMK TITL, and the sustainability of project-based vocational learning programs at SMK TITL.

Form of Implementation of Project-Based Vocational Learning Program at SMK TITL

According to Joan, as quoted by Tayibnapis (2000), a program is an effort designed with the aim of creating a certain impact or influence. These programs can be tangible, like a curriculum, or abstract (intangible), like procedures. Ananda & Rafida (2017) explained that a program is a series of plans that include various units, policies, and activities that must be implemented in a certain period of time. To categorize an activity as a program, there are three main aspects that need to be considered, namely: (1) the implementation of a certain policy, (2) it lasts for a relatively long period of time, and (3) it consists of a series of continuous activities involving various parties in the organization with a high level of participation. In the context of vocational education, vocational learning programs are learning activities applied in vocational schools, which are commonly referred to as expertise or productive subjects. Each concentration of expertise at SMK has different learning program characteristics according to its field of expertise.

One of the specializations that has the largest number of graduates in Indonesia is Electrical Power Installation Engineering (TITL), which is included in the group of energy and mining expertise programs, with 32.40% of the total vocational school graduates (Ministry of Education and Culture, 2020). This program has many enthusiasts because the need for electrical energy continues to increase along with technological developments, so that workers in this field are always needed. Therefore, the number of TITL Vocational Schools is quite large, including in the Tangerang area, Banten. Based on the Decree of the Head of the Ministry of Education and Culture Standards, Curriculum, and Assessment Agency Number 033/H/KR of 2022, Electrical Power Installation is the main element in the Electrical Power Installation Engineering (TITL) learning program. This program aims to equip students with competencies in designing, installing, testing, and reporting the results of electric power installations. The competencies that must be mastered include making working drawings, calculating the need for tools and materials, and estimating project costs. In addition, students are also trained to work on lightning distribution installations, grounding installations, generator installations, and solar power systems for public street lighting (PJU) and their protection. This program is designed so that students can work according to technical standards and work procedures in the field of electric power, and be able to compile reports according to applicable operational standards.

Based on the results of the research listed in Figure 1, Electrical Power Installation is a key element in TITL Vocational School learning. Information from the teaching teacher and the coordinator of the expertise program

shows that Electrical Power Installation is the main competency that must be mastered by TITL graduates. This element is also the foundation in the instructional design of the TITL program that adopts project-based learning (PjBL). Since the introduction of the Independent Curriculum about 3-4 years ago, the Electrical Power Installation learning program at SMK TITL has implemented PjBL in grades XI and XII (Phase F) with a total of 28 JP (12 JP in class XI and 16 JP in class XII).

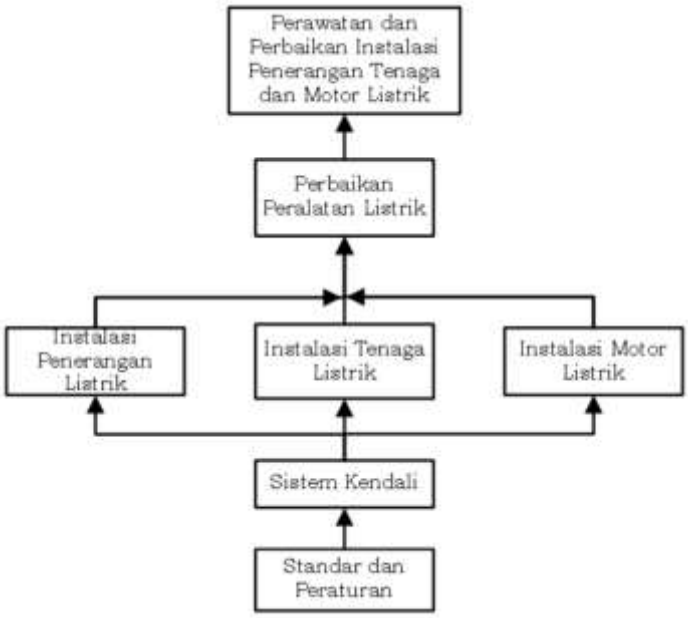

Figure 1. Structure of Learning Elements in the Concentration of Electrical Power Installation Engineering Expertise

The results of research in several TITL Vocational Schools in Tangerang City show that project-based learning is more in demand than other methods, especially in learning Electrical Power Installation. The concept of PjBL is different from practicum-based learning, where in practicum students only work on worksheets according to instructions. On the other hand, in PjBL, students are given real cases that they must solve by creating projects in the form of products as solutions. The implementation of PjBL at SMK Tangerang is divided into three project categories, namely projects only for internal schools which will be exhibited in the student work week, work projects resulting from MoU cooperation with industry, and collaborative projects with the community where the resulting project forms are directly used by the community around the SMK. The teaching teacher and head of the expertise program stated that in the future PjBL will continue to be applied in vocational learning programs, especially in the field of Electrical Power Installation, considering the importance of this competency for graduates of SMK TITL. With the many advantages offered, PjBL is an effective learning strategy to improve students' skills to be ready to compete in the industrial world.

The Syntax Model in the Project-Based Vocational Learning Program at SMK TITL

The syntax in a learning model reflects the order of learning stages consisting of a series of activities that must be carried out by teachers and students (Hamdayama, 2016). The results of research in several TITL Vocational

Schools in Tangerang City show that although each school has different stages of project-based learning, further analysis reveals that the syntax used refers to the model developed by the George Lucas Educational Foundation (2005). The Project-Based Learning (PjBL) model consists of six main stages: essential questions, project planning, preparation of activity schedules, progress monitoring, assessment of work results, and reflection and evaluation of learning experiences. This approach is in accordance with the guidelines for implementing Project-Based Learning released by the Ministry of Education and Culture of the Republic of Indonesia in 2018 (Halimah & Marwati, 2022). The syntax of PjBL is stated in the Handbook of Learning Oriented to Higher Level Thinking Skills (Ministry of Education and Culture, 2018), as explained in the following Table 3.

Table 3. Steps (Sintak) of Project-Based Learning

Order	**Step**	**Teacher Activities**	**Student Activities**
First	Start *with essential question*	The teacher conveys the topic and asks questions on how to solve the problem	Ask basic questions about what students should do about the topic/problem-solving
Second	Design project	The teacher ensures that each student in the group chooses and knows the procedure for making the project/product that will be produced	Students discuss developing a plan for making a problem-solving project including the division of tasks, preparation of tools, materials, media, and resources needed
Third	Create *Schedule*	Teachers and students make an agreement on the schedule for making the project (stages and collection)	Students prepare a project completion schedule by paying attention to the deadline that has been determined together
Fourth	Monitoring *the students and progress of project*	Teachers monitor the activeness of students during the implementation of projects, monitor the realization of developments and guide if they experience difficulties	Students create projects according to schedule, record each stage, discuss problems that arise during project completion with teachers
Fifth	Assess *the outcome*	Teachers discuss project prototypes, monitor student engagement, measure standard achievement	Discuss the feasibility of the project that has been created and make a product/work report to be presented to others
Sixth	Evaluation *of the experience*	The teacher guides the process of presenting the project, responds to the results, then the teacher and students reflect/conclude	Each student presented a report, the other students gave a response, and together with the teacher concluded the results of the project

(Source: Ministry of Education and Culture, 2018; George Lucas, 2005)

21st Century Skills (4C Skills) for Students as Outputs of Project-Based Vocational Learning Programs at SMK TITL

Since ancient times, education has focused on strengthening basic skills such as reading, writing, and numeracy (Larson & Miller, 2012). While these skills remain important, the demands of 21st century skills are increasing, encompassing creativity, innovation, communication, collaboration, research, critical thinking, problem-solving, decision-making, and digital literacy and technology (Halimah & Marwati, 2022). Project-based learning (PjBL) is one of the approaches that is able to answer this challenge (Wiranto & Sukardi, 2022; Sadrina et al., 2018; Redhana, 2019). This model is often associated with strengthening critical thinking, communication, collaboration, and creativity skills (4Cs), which are at the core of 21st century skills (Halimah & Marwati, 2022; Ulrich, 2016). The dimensions of 21st century skills (4C skills) and their elaboration position in the project-based learning syntax can be seen in Table 4 below.

Table 4. Dimension of 4C Skills and Position in the PjBL Syntax

4C Skills	**Skill Dimension**			**Sintak PjBL**
Critical Thinking	*Creative Process*	*Creative Environment*	*Creative Product*	First Second Third
Creativity	*Critical Thinking About the World*	*Critical Thinking About Oneself*	*Critical Action and Decision Making*	Fourth
Communication	*Message Formulation*	*Message Delivery*	*Message and Communication Feedback*	First Second Third Fifth Sixth
Collaboration	*Engagement and Participation*	*Perspective Taking and Openness*	*Social Regulation*	Fourth Fifth

(Source: Miller, et al., 2023; Nirmayani & Dewi, 2021)

Critical thinking refers to the ability to analyze complex problems, evaluate information from multiple perspectives, and draw logical conclusions based on evidence (Turski, 2015). In addition, critical thinking also involves rational thinking, perspective taking, and evaluation of arguments and evidence (Halimah & Marwati, 2022). Meanwhile, communication is a fundamental skill that includes reading, writing, listening, and speaking, as well as assisting learners in organizing and conveying their thoughts and findings effectively (Turski, 2015; Halimah & Marwati, 2022). Pasquinelli et al. (2021) added that communication also includes the ability to assess the quality of information and take action based on that analysis.

In the context of learning, collaboration is a collaborative process between students, teachers, and the community to investigate a question or problem (Halimah & Marwati, 2022). Creativity, according to Vincent-Lancrin et al.

(2019), is the ability to produce something new, original, and relevant. Halimah & Marwati (2023) define creativity as a skill that consists of fluency (generating a lot of ideas), flexibility (diverse ideas), originality (new ideas), and elaboration (further development of ideas). By understanding and developing these 4C skills, students can be better prepared to face the challenges of the world of work and life in the modern era.

The results of the study show that the application of the 21st century learning concept in project-based vocational learning programs in the learning of Electrical Power Installation (ITL) at vocational schools with the concentration of expertise of TITL Tangerang City has been carried out according to the expected principles. Based on information from the teaching teacher, project work in project-based ITL learning has been proven to improve student learning outcomes, including in mastering the 4C (Critical Thinking, Communication, Collaboration, Creativity) skills. These findings are in line with previous research that stated that Project-Based Learning (PjBL) is effective in improving students' academic scores (Wibowo, Armanto, & Lubis, 2022; Lubis, 2022), develop teamwork skills (Sadrina, Mustapha, & Ichsan, 2018), and enrich students' practical insights and experiences (Samsiadi & Romelah, 2022). However, even though learning has been adopted in practice the 4C skills, both teachers and students have not fully understood this concept in depth.

The gap between theoretical understanding and implementation of 4C skills in project-based learning at SMK TITL should be a serious concern. Ideal learning must balance conceptual understanding and practical application so that students can develop critical thinking, communication, collaboration, and creativity skills optimally. In the era of the Industrial Revolution 4.0, 4C skills are a key factor in improving the quality of vocational school graduates, so that their integration in learning is not only carried out implicitly but must also be realized and applied systematically. If the understanding of 4C skills is not strengthened, then the effectiveness of its application in project-based ITL learning programs at vocational schools can be less than optimal in preparing students to face an increasingly dynamic world of work.

In addition to the findings from the results of interviews and observations, the documentation of this study also shows that in the teaching and learning planning module at SMK TITL Tangerang City, 21st century skills or 4C skills have not been explicitly listed. In terms of learning evaluation, 4 out of 5 schools studied did not have a specific instrument that specifically assessed 4C skills. This is a challenge because without a clear assessment instrument, 4C skills are difficult to measure and evaluate effectively. Therefore, there needs to be a strengthening in the aspect of learning planning and evaluation by developing an instrument that specifically measures 4C skills, not just evaluating learning outcomes (outputs). With the right evaluation instruments, 21st century skills can be measured, directed, and really have a real impact in improving the quality of vocational school graduates.

Sustainability of Project-Based Vocational Learning Programs at SMK TITL

The results of the study show that even though Project-Based Learning (PjBL) has been applied in the Electrical Power Installation (ITL) learning program at SMK TITL, this method is still not able to optimally improve students' work skills (Samsiadi & Romelah, 2022). This can be seen from the fact that there are still many vocational school graduates who are not ready to enter the world of work, or even if they work, they are only able

to survive in the first 5 years before losing competition with high school graduates (Istiqamah & Jalal, 2020). In addition, data from the Central Statistics Agency (BPS, 2024) shows that vocational school graduates are still the largest contributors to the Open Unemployment Rate in Indonesia, which indicates that the learning system in vocational schools, especially in project-based ITL programs, still needs improvement. Nevertheless, the teaching teacher, coordinator of expertise concentration, head of department, and vice principal for curriculum at the school where this research took place stated that PjBL will continue to be maintained and developed as the main model in electrical vocational learning, because it is considered to be able to provide practical experience that is closer to real working conditions.

The findings in this study provide important implications for vocational education, especially in increasing the effectiveness of PjBL as a 21st century learning approach. This study also strengthens the findings of previous studies, such as in the study "Meta-Analysis of Project-Based Learning Models in Improving 21st Century Skill Abilities" (Karomatunnisa et al., 2022), which concluded that PjBL can significantly improve students' 21st century skills, especially in the aspects of critical thinking, communication, collaboration, and creativity (4C). Therefore, the sustainability of PjBL in vocational learning programs at SMK TITL needs to be accompanied by improving the quality of implementation, so that students not only gain technical understanding but also have job skills that are in accordance with the demands of modern industry.

Conclusion

Based on the results of the research, the project-based vocational learning program of Electrical Power Installation at vocational schools in the Tangerang area has three main forms: PjBL for schools, PjBL for industrial cooperation, and PjBL for the community. Each form of PjBL makes a different contribution in improving student competence. PjBL for schools focuses on developing technical skills through internal projects, PjBL industry cooperation allows students to gain real work experience in accordance with industry standards, while PjBL for society encourages students to apply their expertise in social need-based projects. Overall, the PjBL program implemented has had a positive impact on improving students' competence and work readiness. However, its effectiveness in improving job readiness still faces challenges, especially related to the relevance of the project to industry needs as well as the gap in technical and non-technical skills of learners. In addition, other challenges found include limited facilities, continuity of industrial cooperation, and the readiness of teachers and students in managing projects.

Although some schools have implemented a more flexible approach in selecting projects according to industry needs, there are still limitations in access to adequate resources and practice tools. In addition, although 21st-century skills such as critical thinking, communication, collaboration, and creativity are increasing, evaluations of the long-term impact of these programs on graduates' job readiness are still limited. Therefore, it is necessary to strengthen the relationship between schools and industry so that learning programs are more adaptive to the demands of the job market. As a recommendation, further research can focus on developing a more integrated PjBL model to increase the effectiveness of learning in shaping a workforce that is ready to compete. In addition, it is necessary to conduct a more in-depth study related to the long-term impact of the implementation of PjBL on

graduates of SMK TITL with mixed research methods.

Recommendations

Although this study has succeeded in mapping the application of PjBL in the learning of Electrical Power Installation at SMK TITL Tangerang City, there are limitations in the research approach used. This study is still qualitative, so it has not evaluated in detail the shortcomings in the implementation of PjBL. In addition, this study emphasizes more on mapping the concrete form of the implementation of PjBL, without in-depth research on its effectiveness in improving students' skills. In fact, several literature studies show that PjBL has been proven to be able to improve learning outcomes, but there is still a lack of research that examines the direct impact of PjBL on the development of 21st century skills of students.

Based on these findings, further research is needed to evaluate the impact of PjBL more comprehensively, especially in relation to the development of students' 4C skills at SMK TITL. Future research can use quantitative approaches or mixed methods to measure more objectively the extent to which PjBL has truly improved 21st century skills. In addition, it is necessary to develop more specific evaluation instruments so that the improvement of work skills and readiness of graduates of SMK TITL can be measured better, so that the graduates produced are more competitive in the electricity industry. Further development in research with this focus is also very important for the world of vocational education as a whole, as PjBL has become an integral part of vocational learning in Indonesia. With more in-depth research, the PjBL approach can continue to be refined so as not only to improve students' technical skills, but also to equip them with competencies that are more adaptive, innovative, and in accordance with the needs of the modern industrial world. This will ultimately contribute to reducing the unemployment rate of vocational school graduates and increasing the competitiveness of the vocational workforce at the national and global levels.

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Author Information

Muhammad Sadam Rizkylillah

https://orcid.org/0009-0009-0239-5564

Magister of Technology and Vocational Education,
Faculty of Engineering, State University of Jakarta
Tower A Building Lt. 7 Campus A UNJ,
Rawamangun Muka, Jakarta 13220
Indonesia

Soeprijanto

https://orcid.org/0000-0001-9447-698X

Magister of Technology and Vocational Education,
Faculty of Engineering, State University of Jakarta
Tower A Building Lt. 7 Campus A UNJ,
Rawamangun Muka, Jakarta 13220
Indonesia

Muksin

https://orcid.org/0000-0002-5255-5302

Magister of Technology and Vocational Education,
Faculty of Engineering, State University of Jakarta
Tower A Building Lt. 7 Campus A UNJ,
Rawamangun Muka, Jakarta 13220
Indonesia
Contact e-mail: *muksin@unj.ac.id*