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Development of problem and project-based learning syntax to improve vocational student learning outcomes

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ABSTRACT

Problem- and project-based learning help vocational students understand vocational material. Vocational school teachers need help in structuring problem- and project-based learning with efficient syntax. This research aims to develop a syntax for problem- and project-based learning to help teachers improve vocational learning outcomes. The research uses a research and development approach. The population in this study consisted of all students in class X, Department of Electronics, SMK Negeri 2 Sukoharjo. Data were collected using tests and non-tests. Data analysis used two-way ANOVA. The research results show that 1) The analysis of teacher and student needs includes: a) A need for better learning. b) Teachers must have many choices of learning variations and innovations. 2) The syntax of the problem-based learning model comprises four phases: problem presentation, problem investigation, problem resolution, and procedure evaluation. 3) The syntax of the project-based learning model includes project startup, solution design, solution development, and presentation. 4) The results of the Wilcoxon Test analysis for both problem-based learning and project-based learning show differences in scores before and after treatment. Therefore, it can be stated that problem-based learning and project-based learning methods are suitable for improving student learning outcomes.

Keywords: Problem-Based Learning, Project Based Learning, Syntax Development

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INTRODUCTION

The basis of electricity and electronics is an empirical science with an abstract concept that is difficult to imagine (Hutagalung, 2018). Learning the basics of electricity and electronics requires an understanding of facts and concepts; they cannot be accepted directly without comprehension and reasoning (Chen Y., 2019). Knowledge is actively formed by students, not just passively received. However, in the learning process, students are often less encouraged to develop thinking skills (Chai, 2019). The current learning approach tends to focus more on the ability to memorize information, placing students in a position where their brains are forced to remember and accumulate various facts without a corresponding emphasis on understanding and relating this information to everyday life (Afifah, A.N. et al, 2019). Consequently, students may excel in theoretical knowledge but struggle with its practical application.

Based on preliminary research conducted through interviews with several teachers, information was gathered indicating that the learning process carried out so far is still oriented towards teacher-dominated patterns. In the Electronics Major at the Vocational High School in Sukoharjo Regency, learning tends to be passive. Although the teachers have implemented good learning models and approaches, students consistently lack confidence in their abilities and exhibit very low interest in the field of basic electricity and electronics studies. This is attributed to several factors, including a lack of appreciation for students by the teachers.

One identified obstacle is the shift from mastering the basic concepts of electricity and electronics to memorizing theories and formulas. Consequently, students become rigid and passive in the learning process. The learning steps employed by teachers have been using conventional models, which, according to studies (Baran M., et al, 2021), contribute to a decline in student interest and motivation.

Another observation reveals a lack of students expressing their opinions and showing low motivation to ask questions. Students often exhibit a sense of doubt and uncertainty, remaining silent when posed with a question with correct answers, and waiting for someone else to respond. In such conditions, teachers are urged to adapt and change their teaching styles (Kang, N. H., 2019). This insight serves as a reference for conducting research in the Electronics Major at the Vocational High School in Sukoharjo Regency.

The learning methods employed thus far, such as the lecture method, providing sample questions, and working on problems at the Electronics Department in Sukoharjo Regency, have proven to be less engaging. Problem-Based Learning (PBL) and Project-Based Learning (PjBL) are anticipated to be employed as alternatives, fostering longer retention of the basic concepts of electricity and electronics among students. The selection of these models for development is grounded in their relevance to supporting the attainment of vocational learning goals (Coronado, J., M. et al, 2021).

The Problem-Based Learning model emphasizes the process of solving problems either individually or in groups (Laili et al., 2019; Nurhikmayati & Aep Sunendar, 2020). This approach guides students to become independent learners actively participating in group-based learning (Phasa, 2020; Sianturi et al., 2018). It aids students in honing their critical thinking skills by encouraging them to search for data, leading to a rational and authentic problem solution (Tiarini et al., 2019). Previous studies have indicated an improvement in student learning outcomes following the implementation of the PBL model (Suarni, 2017). The use of the Problem-Based Learning (PBL) model can enhance mathematics learning achievement and student activity in learning (Widayanti & Dwi Nur, 2002).

In the PBL model, the problem is presented at the beginning of the lesson, and students are expected to find concepts through the given problems, specifically by identifying the right solutions (Mawati et al., 2021). For instance, consider a natural phenomenon in the basics of electricity and electronics: why do sticks appear to break on the surface when submerged in water? Solving real problems allows students to comprehend concepts rather than merely memorizing them.

Project-Based Learning (PjBL) is a learning model that utilizes projects/activities as tools for achieving attitudes, knowledge, and skills competencies (Qadafi et al., 2022). PjBL offers educators the opportunity to manage classroom learning by involving project work (Duke et al., 2021). This approach serves as an alternative to teacher-centered learning, emphasizing student activities that, by the end of the learning process, result in meaningful and useful products.

Project work involves complex tasks based on problems (Samsudin et al., 2020). With the PBL and PjBL methods, it is hoped that teachers can communicate effectively with students, fostering diverse thinking insights among all students. Teachers can also assign projects for students to complete (Maskur et al., 2020; Matilainen et al., 2021), enabling students to learn all concepts and understand how to relate them to real life (Valladares, 2021). Such learning activities can boost their motivation and desire to learn (Sumarni & Kadarwati, 2020).

Generally, students in the Electronics Major at Vocational School in Sukoharjo Regency are predominantly natives of the Sukoharjo region. Consequently, the sense of belonging to the school is substantial, but this sometimes leads to conflicts between students and teachers, resulting in a lack of interest in learning. Based on the description above, this research aims to increase student motivation in learning by developing a problem and project-based learning syntax. Choosing a project-based learning model is essential for teachers to implement to overcome the low interest in learning of vocational school students.

METHOD

This research employs a mixed-method approach with a research and development design. The population in this study consisted of 288 students from four Class X Electronics departments at SMK Negeri 2 Sukoharjo during the academic year 2020/2021. The sample for this research included two classes, namely Class X1 and X3, comprising the experimental group with 64 students. Data were collected through observation, documentation, and questionnaires (Creswell, 2014).

Observation data aimed to determine student learning activities, while documentation aimed to identify changes in student learning outcomes. Meanwhile, the questionnaire sought to assess the effectiveness of the developed syntax. Observation and documentation data were collected during the research stage, while questionnaire data were gathered to evaluate the efficacy of syntax development.

The research instrument was validated using the expert judgment method. Observation and documentation data were analyzed descriptively, while questionnaire data were analyzed using descriptive statistics. The research procedure comprises five stages: needs analysis, conceptual model preparation, validation, limited model testing, and conclusions. The research question begins by proposing a hypothesis and is proven using two-way analysis of variance (ANOVA) in accordance with the design and a 2×2 factorial design.

The research commences with a needs analysis. The stages and results of the needs analysis are explained as follows. The needs analysis is carried out in two ways: initial observation and interviews. Based on the results of initial observations obtained from online media, it is evident that SMK Negeri 2 Sukoharjo does not yet possess a school information system that can be accessed anytime and anywhere, providing the latest information about the school and other important announcements. A school information system is a collection of integrated school data that complements each other to produce sound output for solving problems and making decisions (Bagus et al., 2019). This deficiency may have an adverse impact on the school, as it is perceived to be unable to harness rapidly developing information technology.

In the results of the Focus Group Discussion (FGD) with teachers at SMK Negeri 2 Sukoharjo, it was revealed that there are several needs for the implementation of the learning methods development currently under research. The findings from the needs analysis include: 1) Consistent demands for better results in learning evaluations. 2) The necessity for a variety of learning variations and the ability for teachers to innovate in their teaching methods based on the results of teacher assessment analysis. 3) Strategies derived from data analysis, including details of operational programs, guidelines for implementing strategic plans, duties and roles of parties involved, as well as guidelines for evaluation and monitoring.

During the discussion, the school committee underscored the crucial position and role of teachers in assisting students facing difficulties. The teachers, when encountering problems in the learning process, can communicate these issues to the school committee, enabling the committee to promptly offer assistance to the school.

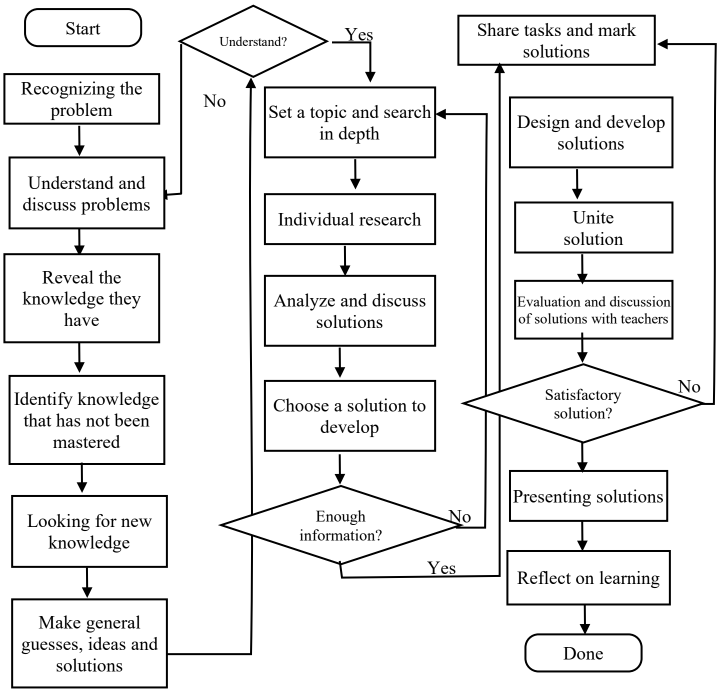
The committee can help oversee the teaching and learning activities of teachers, providing input or opinions for the teachers' benefit. Both principals and teachers feel that the development of learning tools represents progress. Based on the results of the Focus Group Discussion (FGD), it can be concluded that the prototype designed to address learning difficulties using the Problem-Based Learning (PBL) and Project-Based Learning (PjBL) methods is feasible for application and implementation. This development can be carried out gradually, considering the level of importance and the situation and condition of the school in the long term. During the FGD, there were no objections to the research results and the proposed strategic plan. However, there were some inputs regarding the assessment of the learning achievement instrument.

RESULTS AND DISCUSSION

Results

The following are the results of the design and development of the Problem-Based Learning (PBL) and Project-Based Learning (PjBL) syntax model products. The learning model development involves the incorporation of a problem-based learning syntax (Problem-Based Learning). The syntax developed has been inserted into the Learning Implementation Plan. This development includes formulating empirical steps that teachers can use during learning to solve problems.

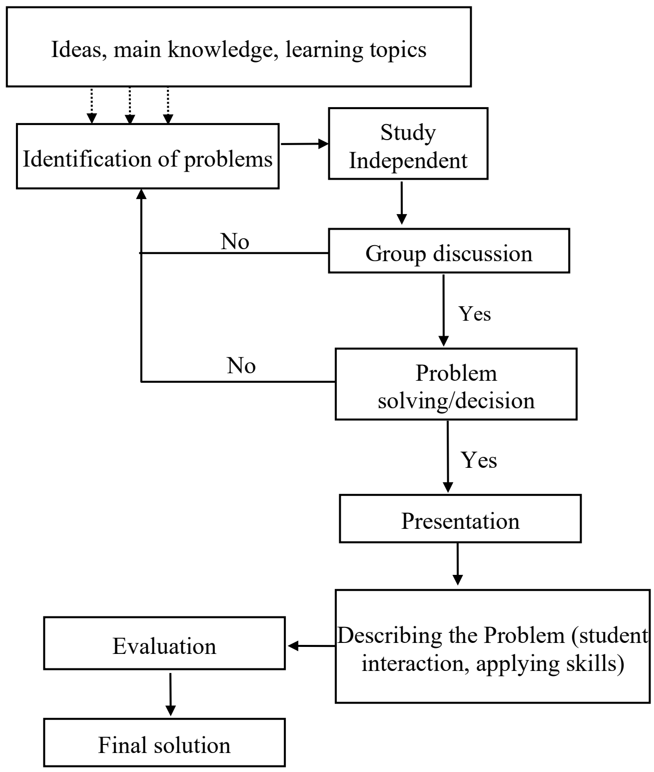
Table 1. Syntax Problem Based Learning Model



The problem-solving flow is depicted in Figure 1, representing a problem-based approach. Problem-based learning activities are generally conducted in four phases: presentation, investigation, resolution, and procedural evaluation. These activities stimulate students to engage in honest, complex, and open thinking. Such thinking encourages students to utilize higher-level, creative, cooperative, independent, and collaborative ways of thinking. Independent student involvement trains them regularly in grouping, sharing, and evaluating each other's work. Through these activities, students not only receive but also give meaning to values in life by learning to solve problems in groups.

The development of a project-based learning model is a method crafted with a student-centric approach to practical application. Project-based learning involves providing problems related to practical subject matter.

Table 2. Project-based learning model syntax



1. Stage 1, also called project startup. At this stage, students plan the project. Information gathering and generalization of ideas are discussed in groups. This discussion directs the flow of thinking to find solutions to the designed project.
2. Checkpoint 1, also called accuracy of understanding. At this stage, students discuss whether the planned project is worth continuing. The main activity in this stage is analyzing the idea's suitability with the solution.
3. Stage 2, solution design. After determining the solution in the previous stage, students focus on designing the solution. They are directed to think about how to find solutions effectively.
4. Checkpoint 2: Adequate information and appropriate solutions. At this stage, the teacher ensures that the collected information is sufficient to find the chosen solution. This decision will determine further development steps.
5. Phase 3, Solution Development: This phase requires more time. Students are expected to develop their creativity to build solutions. The scope of work at this stage depends on the project's complexity.

6. Checkpoint 3, Correct Solution: The activity in this stage involves checking whether the solution and its construction are proven to solve the problem. This will be the basis for determining the success of the development.
7. Stage 4, Presentation: At this stage, students and teachers observe the project results through presentations. This stage also concludes the activity. Evaluation and appreciation are essential for teachers at this stage. Reflection is carried out at the end of this stage to address deficiencies and reinforce strengths.

Design validation is a step taken to assess the Syntax Development of Problem-Based Learning and Project-Based Learning Models in Basic Electrical and Electronics Subjects. The validation was compiled based on a review of the design and material within the Syntax Development of Problem-Based Learning and Project-Based Learning Models in Basic Electrical and Electronics Subjects. Validation is carried out to determine the feasibility of the developed school information system for testing. The design validation assessment involved two experts: one in Research Development and another in Learning Method Development.

The validation assessment results for Research Development and Development of Learning Methods use a rating scale, assigning numbers based on the evaluated indicators. Additionally, validation of the test instruments used at the product trial stage was also conducted. After validation, the next step is to analyze the results of the validation assessment from the experts.

The results of the evaluation by the Development Research expert, Expert I, are presented in the following table. Expert I is a lecturer at Sebelas Maret University, Surakarta, specializing in educational evaluation. Based on the evaluation results from Expert I, the effectiveness assessment and average content score are both 4. This indicates a relatively high level of expert approval.

Table 3. Evaluation Results of Development Research Experts

No	Rating Items	Approval Rate			
		1	2	3	4
	Effectiveness				
1	Learning steps are easy to do (effectiveness)				√
2	Language in easy-to-understand syntax (effectiveness)				√
3	RPP needs to be added syntax to facilitate the implementation of learning				√
	Contents				
4	Learning steps ensure students get completion (content/content)				√
5	Students find problems in learning (content)				√
6	Students can discuss learning problems with other friends (content)				√
7	Students can propose solutions for problem solving (content)				√
8	Students can share solutions for problem solving (content)				√
9	Students can explain the root causes of learning problems (content)				√

Meanwhile, the results of the expert evaluation of Learning Method Development by Expert II are presented in the table below. Expert II is a seasoned professional and senior teacher in electrical studies, possessing competence to assess the depth and breadth of the substance of the material being measured. Based on the results from Sunardi, S.Pd., M.Pd., the effectiveness assessment and average content score were both 3.67. This indicates a relatively high level of expert approval.

Table 4. Results of Expert Evaluation of Learning Method Development

No	Rating Items	Approval Rate			
		1	2	3	4
	Effectiveness				
1	Learning steps are easy to do (effectiveness)				√
2	Language in easy-to-understand syntax (effectiveness)				√
3	RPP needs to be added syntax to facilitate the implementation of learning			√	
	Contents				
4	Learning steps ensure students get completion (content/content)				√
5	Students find problems in learning (content)			√	
6	Students can discuss learning problems with other friends (content)				√
7	Students can propose solutions for problem solving (content)				√
8	Students can share solutions for problem solving (content)			√	
9	Students can explain the root causes of learning problems (content)				√

The normality test is conducted on data to determine whether the data follows a normal distribution. This information is crucial to ensure the validity of analysis results and to consult their significance using the t-distribution table. The data tested in this case are the learning outcomes from problem-based methods and project-based methods.

The results of the normality test using the Shapiro-Wilk test indicate that the significant value for the Problem-Based Learning Method Result Data is less than 0.05. According to the normality test cutoff, a significance value below 0.05 implies that the data does not come from a normal distribution. Consequently, the data from the problem-based learning method is analyzed using a non-parametric analysis tool, namely Wilcoxon.

Table 5. Normality Test Results with Shapiro Wilks Data on Problem-Based Learning Method Results

	Shapiro-Wilk		
	Statistics	df	Sig.
Before PBL	0.922	72	0.000
After PBL	0.958	72	0.016

a Lilliefors Significance Correction

Normality testing was also conducted using the Kolmogorov-Smirnov(a) approach. According to the normality test cutoff, if the significance value is less than 0.05, then the data is deemed not to follow a normal distribution. The results of the normality tests using both the Shapiro-Wilks and Kolmogorov-Smirnov approaches indicate that the values before PBL are not normal, whereas the results after PBL are found to be normal.

Table 6. Normality Test Results with Kolmogorov-Smirnov (a) Problem Based Learning Method Result Data

	Kolmogorov-Smirnov(a)		
	Statistics	df	Sig.
Before PBL	0.161	72	0.000
After PBL	0.101	72	0.066

a Lilliefors Significance Correction

In the results of the normality test using Shapiro-Wilks, it is evident that the Project-Based Learning Method Result Data obtained a significant value of less than 0.05. According to the normality test cutoff, if the significance value is less than 0.05, the data is considered not to follow a normal distribution. Consequently, the data from the project-based learning method is analyzed using a non-parametric analysis tool, namely Wilcoxon.

Table 7. Normality Test Results with Shapiro Wilks Data on Project-Based Learning Method Results

	Shapiro-Wilk		
	Statistics	df	Sig.
Before PjBL	0.790	72	0.000
After PjBL	0.944	72	0.003

a Lilliefors Significance Correction

Normality testing was also conducted using the Kolmogorov-Smirnov(a) approach. According to the normality test cutoff, if the significance value is less than 0.05, the data is considered not to follow a normal distribution.

Table 8. Normality Test Results with Kolmogorov-Smirnov(a) Project-Based Learning Method Result Data

	Kolmogorov-Smirnov(a)		
	Statistics	df	Sig.
Before PjBL	0.283	72	0.000
After PjBL	0.186	72	0.000

a Lilliefors Significance Correction

In the results of the normality test using the Shapiro-Wilks and Kolmogorov-Smirnov approaches, the values before and after PjBL are identified. Similar to the normality test results, the subsequent analysis process employs the Wilcoxon non-parametric analysis tool.

The homogeneity test is conducted to ascertain the balance of the research sample, or the test is carried out to determine whether two or more groups of sample data come from populations that have the same variance (homogeneous). The following are the results of the homogeneity test for the research sample in the PBL class.

Table 9. Results of Homogeneity Test of Research Samples in Class Problem-Based Learning Methods

	Levene Statistics	df1	df2	Sig.
Before PBL	0.367	1	70	0.547
After PBL	2,111	1	70	0.151

To determine whether the data is homogeneous or not, we consider its significance value. If the value is less than 0.05, it can be concluded that the data is homogeneous. Conversely, if it is more than 0.05, the data is considered too varied and not homogeneous. Based on the homogeneity test, both the data before and after PBL were found to be homogeneous.

Table 10. Results of Homogeneity Test of Research Samples in Project-Based Learning Method Class

	Levene Statistics	df1	df2	Sig.
Before PjBL	0.594	1	70	0.443
After PjBL	1,790	1	70	0.185

For the PjBL data, it is observed that the significance value of the analysis results is also more than 0.05. This analysis result indicates that the sample data group comes from a population with the same variance, thus confirming homogeneity.

The hypothesis test in this study aimed to compare student learning outcomes before and after PBL, as well as before and after PjBL. Here are the results of the complete analysis.

Table 11. Wilcoxon Test Results in Problem-Based Learning Method Class

	After PBL - Before PBL
Z	-6,691(a)
asymp. Sig. (2-tailed)	0.000

a Based on negative ranks.
b Wilcoxon Signed Ranks Test

The results of the Wilcoxon test analysis reveal a difference in the values before and after problem-based learning. This leads to the conclusion that there has been an effect of problem-based learning on student learning scores.

Table 12. Wilcoxon Test Results in Project-Based Learning Method Class

	After PjBL - Before PjBL
Z	-6,910(a)
asymp. Sig. (2-tailed)	0.000

a Based on negative ranks.
b Wilcoxon Signed Ranks Test

The results of the Wilcoxon test analysis indicate a difference in scores before project-based learning and scores after project-based learning. It can be concluded that there has been an effect of project-based learning on student learning scores.

Regarding the trial analysis of learning development outlined in the lesson plans, it can be concluded that problem-based learning methods and project-based learning are feasible for use in improving student learning outcomes.

Table 13. Data on Learning Outcomes on Problem-Based Learning Methods and Project-Based Learning Methods

	Before PBL	After PBL	Before PjBL	After PjBL
N	72	72	72	72
Minimum	75.00	75.00	77.00	77.00
Maximum	80.00	88.00	89.00	97.00
mean	77.1944	82.1806	79.6667	87.5833
Std. Deviation	1.54408	3.72024	3.20651	4.26169

Data on learning outcomes before the PBL intervention averaged 77.19 with a deviation of 1.5. The lowest score was 75, and the highest score was 80. Data on learning outcomes after PBL measures averaged 82.18 with a deviation of 3.7. The lowest score was 75, and the highest score was 88. Data on learning outcomes before the PJBL intervention averaged 79.66 with a deviation of 3.2. The lowest score was 77, and the highest score was 89. The data on learning outcomes after the PjBL intervention had an average of 87.58 with a deviation of 4.2. The lowest value was 77, and the highest value was 97.

The hypothesis test in this study aimed to compare the achievement of student learning outcomes before PBL with after PBL, as well as before PjBL and after PjBL. The research hypothesis was tested using the Wilcoxon Test. Based on the hypothesis test 'After PBL - Before PBL,' it is known that Z is 6.691 with Asymp. Sig. (2-tailed) of 0.000. It can be concluded that there is a significant effect of PBL on learning outcomes, as the Asymp value. Sig. (2-tailed) is less than 5%.

Similarly, the research hypothesis for 'After PjBL - Before PjBL' was tested using the Wilcoxon Test. It is known that Z is 6.910 with Asymp. Sig. (2-tailed) of 0.000. It can be concluded that there is a significant effect of PjBL on learning outcomes, as the Asymp value. Sig. (2-tailed) is less than 5%.

The results of the Wilcoxon test analysis reveal a difference in scores before learning and scores after learning, both project-based and problem-based. It can be concluded that there has been an effect of project- and problem-based learning on student learning scores. As for the results of the trial analysis of learning development outlined in the lesson plans, it can be concluded that problem-based learning methods and project-based learning are feasible for use in improving student learning outcomes.

Discussion

Based on the results of the study, it is evident that the research process commences with a needs analysis. The needs analysis process forms the initial foundation for making improvements in learning. The needs in the learning process, both for teachers and students, differ, even though they interact within the same group. Students' needs revolve around the accessibility, understanding, and practicality of the learning provided by the teacher. In contrast, teachers prioritize elements that can enhance the effectiveness of learning for students.

Learning development is executed by implementing syntax in learning tools. The success of the learning development is measured by comparing values before and after using the development prototype. The data from the assessment results indicate the success of the learning method development prototype.

The learning methods studied are problem-based learning and project-based learning. The two learning methods, with complete syntax integrated into learning tools, are then applied in teaching and learning activities for basic electrical and electronics subjects.

The results of hypothesis testing indicate a significant effect of PBL on learning outcomes. This aligns with research findings from Setiyowati, et al. (2020), (2019), (2021), and (2020), which state that problem-based learning models have an impact on student learning outcomes.

Tugwell (2020) asserts that PBL, as an active teaching-learning approach, enhances students' ability to develop relevant skills applicable in industry work, relying on creativity and continuous practice. Thus, student learning outcomes in engineering and technology-based subjects largely depend on the learning strategies implemented by the teacher. Any learning or teaching method that involves students as active participants in the teaching-learning process is considered a student-centered approach and should be applied by teachers in delivering technical instruction to enhance skills and creativity.

Firmansyah, et al. (2020) in their research, stated that problem-based learning (PBL) has an effect on motivation with an orientation to problem-solving and learning outcomes. Meanwhile, research conducted by (Supriyanto et al., 2022) found that the Problem-Based Learning strategy has a significant effect on critical thinking skills and student achievement motivation. In problem-based learning, students are given the opportunity to learn actively, seek information, think critically, and solve the problems they face. This approach makes them more sensitive, independent, and actively develops their abilities, enabling them to face the challenges of the times (Loppies et al., 2021).

The results of hypothesis testing also confirm a significant effect of PjBL on learning outcomes. This is supported by research findings from Guo, et al. (2020), (2021), (Refualu & Suriani, 2021), (Mulyono & Agustin, 2020), (Ningsih et al., 2022), and (Iswantari, 2021) which state that there is an effect of project-based learning models on student learning outcomes.

(C.-H. Chen & Yang, 2019) conducted a meta-analysis to synthesize existing research comparing the effects of project-based learning and traditional learning on student achievement. They analyzed forty-six effect sizes (comparisons) drawn from thirty eligible journal articles published from 1998 to 2017, representing 12,585 students from 189 schools in nine countries. The results showed that project-based learning had a moderate to large positive effect on students' academic achievement compared to traditional teaching.

(Fahrezi et al., 2020) in their research demonstrate that learning using the Project-Based Learning (PBL) model can improve student learning outcomes. This is further supported by the results of research by (M. et al., 2022) which indicates that the integration of the Project-Based Learning model in tourism courses enhances students' academic motivation. Increased academic motivation has a direct impact on improving student learning outcomes. Additionally, the project-based learning model can positively influence students' life skills.

In an effective project-based learning experience, students actively participate in decision-making and time management. They confidently handle responsibilities within their team and develop quality products and performances within deadlines. Students not only enhance technical and practical skills but also develop leadership and teamwork skills, contributing to their development as better future citizens of society (Sharma et al., 2020).

Project-based learning enhances success by equipping students with various skills, making learning more fun, entertaining, and meaningful (Hotimah, 2020). Learning with the PjBL approach is the main focus, and its process involves complex techniques. At the presage level, it considers the characteristics of students as informants and, in a teaching context, involves syllabus factors and the selection of project methods. During the process stage, it involves informants studying the implementation of PjBL. In project-based task execution, students work to discover the meaning embodied in project assignments, making project work meaningful for their own experiences and in real life. They integrate components or aspects of the task into a unified whole and relate findings to past knowledge. They also try to build personal theories and hypotheses about the task, adopting a deep learning approach. Meanwhile, the product stage involves the experience of complex interactions in the network (Handrianto & Rahman, 2018).

(Abubakar et al., 2020) prove that project-based learning strategies are effective and can be used to improve student performance. This strategy also enhances students' attitudes toward learning. From the findings of this study, the researchers realized that students achieved better results when taught using project-based learning strategies. Moreover, teaching students using this approach enhances their ability to find and solve problems on their own, guided by their teachers, thereby improving students' skills in self-discovery and the scientific method of problem-solving.

CONCLUSION

The syntax of the problem-based learning model that can be applied to address challenges in basic electricity and electronics learning at SMK Negeri 2 Sukoharjo involves four stages: problem presentation, problem investigation, problem resolution, and procedure evaluation. The problems presented are designed to be accurate, complex, and open-world situations, challenging students' higher-order thinking and creativity. Through this approach, students develop creative thinking skills, including cooperative and interdisciplinary problem-solving. Students learn to work both independently and collaboratively. While engaged in independent learning through PBL, they regularly share, evaluate, and critique each other's work during group meetings. They navigate often conflicting goals and values, work with constraints, and determine the most appropriate actions.

Similarly, the syntax of the project-based learning model that can be utilized to address challenges in working on projects in basic electricity and electronics learning at SMK Negeri 2 Sukoharjo consists of four stages: project startup, solution design, solution development, and presentation.

The results of the Wilcoxon test analysis reveal a difference in scores before problem-based learning compared to scores after problem-based learning. It can be concluded that there has been an effect of problem-based learning on student learning scores. Similarly, the results of the Wilcoxon test analysis indicate a difference in scores before project-based learning compared to scores after project-based learning. This suggests an effect of project-based learning on student learning scores. As evident from the trial analysis of learning development outlined in the lesson plans, it can be inferred that both problem-based learning methods and project-based learning are feasible for improving student learning outcomes.

In conclusion, this research suggests that teachers should move beyond conventional teaching methods towards more creative learning approaches. Creative learning not only stimulates students' enthusiasm but also enhances their performance. The implication is that schools should implement more intensive monitoring to assess and encourage teacher creativity in teaching. Future research could focus on further developing the results of this study by assessing the effectiveness of PBL and PJBL in the implementation of teaching factories.

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