

## Implementation of Product-Based Learning on Welding and Plate Practices II Course Oriented to Infrastructure Needs of the Department of Mechanical Engineering Education UNM

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### ABSTRACT

Product-Based Learning (PBL) enables students not only to learn theory, but also to be directly involved in the production process of real goods or projects, so that the practicum skills needed in the industry can be formed more optimally. This research method used is mixmethode. The results showed that the implementation of PBL in the Welding and Plate Practice II course has great potential to develop student skills that are relevant to industry needs and support the department's infrastructure. The results of PBL implementation also reached a score of 4,304 with a percentage of 48.3% in the "Excellent" category, proving the effectiveness of this method in successfully supporting students' technical skills. Nevertheless, some obstacles such as limited laboratory facilities and lack of cross-disciplinary collaboration and industry involvement are still a challenge

## **INTRODUCTION**

In the world of vocational education, especially in the field of engineering, students' practical skills are one of the main focuses that must be developed. One effective method to improve these skills is through the Product-Based Learning approach, where students not only learn theory, but are also directly involved in the production process of a real product. Product-Based Learning has been shown to improve both hard and soft skills, essential for adapting to the industrial landscape (Chen & Yang, 2019). A study on Problem-Oriented Project-Based Learning (POPBL) revealed significant improvements in students' cognitive abilities, with post-test scores increasing after implementation (Donnelly et al., 2015; Nurtanto et al., 2019). Product-based learning is a combination of two approaches in education, including Project Based Learning and Problem Based Learning approaches combined in one practicum learning activity. With this, Product-Based Learning is a method to provide students with more concrete experience in facing industrial challenges.

The Product-Based Learning methodology is being integrated into engineering curricula to improve transversal competencies and align with the Sustainable Development Goals, making education more relevant to the labor market (Nurdiansah et al., 2021). The Project Based Learning-STEM model effectively enhances 21st century skills among vocational students, showing a marked improvement in competencies required for the modern workplace (Asnur & Ramadhani, 2020). While Product-Based Learning shows promise, challenges remain in optimizing its full implementation across a range of educational settings, requiring adaptation and ongoing support for educators (Ganefri, 2013; Laili et al., 2019).

The Welding and Plate Practice II course in the Department of Mechanical Engineering Education is one of the important courses that requires mastery of welding and plate fabrication skills relevant to the manufacturing industry. However, the implementation of this learning requires adequate infrastructure support. The need for optimal infrastructure is very important so that the learning process can take place effectively, efficiently, and in accordance with industry standards (Prihantoro, 2020; Rohmadi, 2020; Yuan et al., 2022). The availability of sufficient tools and materials, as well as supporting laboratory conditions, are important factors in the successful implementation of the PBL method (Meri & Budiman, 2020; Zuhri & Sinaga, 2022).

Department of Mechanical Engineering Education at Universitas Negeri Makassar has the responsibility to produce graduates who are competent and ready to work. Therefore, it is necessary to review the existing infrastructure to ensure its suitability for practical teaching needs. By implementing PBL in the Welding and Plate Practice II course, it is expected that students can gain more relevant experience, so as to improve their technical competence and also help meet the department's infrastructure needs in producing practical products that support the learning process. In this context, this study was conducted to explore the extent to which the implementation of Product-Based Learning in this course is able to meet the department's infrastructure needs, as well as make a real

contribution to the development of student competencies in the Department of Mechanical Engineering Education.

## LITERATURE REVIEW

Product-based learning (PBL) is an educational approach that emphasizes the creation of real products as a means to improve learning outcomes across a range of disciplines. It integrates theoretical knowledge with practical application, encouraging deep engagement and skill development. Product based learning is a combination of two learning approaches namely: (1) Project Based Learning and (2) Problem Based learning.

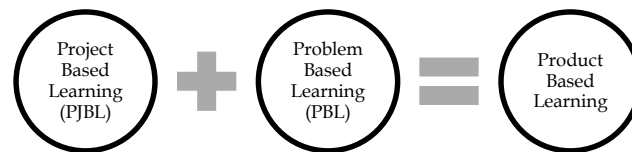


Figure 1. Product-Based Learning Approach Combination Design

In vocational education, PBL encourages active and collaborative learning, and increases student motivation through teamwork and real product achievement (Yulastri et al., 2018). PBL is also highly effective in engineering education, where it incorporates design, marketing and manufacturing elements (Romadin et al., 2021). Industry-supported projects provide real-world experience for students, thus improving reflection and educational outcomes (Lozano et al., 2022; Romadin, 2023). The results showed that Problem Based Learning significantly improved cognitive, affective, and psychomotor learning outcomes in the context of vocational education (Nurtanto et al., 2018).

PBL also promotes learning reuse and curriculum validation through student-created case materials. New product development as a pedagogical innovation highlights the limitations of its application in undergraduate business programs, which may be related to the product-based approach (Oguz-Unver & Arabacioglu, 2014; Wijayati et al., 2019). his approach has been shown to enhance student engagement and entrepreneurial skill development in engineering education (Syaiful et al., 2022; Tseng et al., 2013).

The project-based approach, often coupled with PBL, integrates theoretical knowledge with practical applications, enhances interdisciplinary collaboration, and provides hands-on experience in the development of cognitive products for students. Project Based Learning has proven to be effective in motivating deep learning and increasing positive attitudes towards learning in vocational education. The approach is student-centered, focuses on solving real problems, and enhances motivation, socialization, and self-regulation skills through different types of projects. However, there are challenges in widely adopting PBL, such as resource allocation and curriculum integration, which may limit its application in various educational contexts (Nurtanto et al., 2019; Ruiz-meza, 2021; Yulastri et al., 2018).

From expert observations in the field of vocational education, it can be formulated that PBL is an innovative approach that successfully integrates theory with practice through the creation of real products. PBL not only improves

students' cognitive, affective and psychomotor skills, but also encourages interdisciplinary collaboration, active engagement and teamwork. In engineering and software engineering education, PBL is proven to improve student motivation and learning outcomes, by emphasizing product design and development as part of the learning process. In addition, PBL also supports the development of entrepreneurial skills, especially in the context of vocational education, which provides hands-on experience for students and prepares them for challenges in the world of work.

Although PBL offers many benefits, challenges in its implementation remain, such as limited resources and difficulties in integrating this approach into the existing curriculum. However, research shows that with adequate support, PBL can be an effective method for improving educational outcomes across a range of disciplines. This approach gives students the opportunity to learn independently and take more responsibility, while preparing them to face real-world situations with relevant and applicable skills. The syntax of PBL implementation is described in Figure 2.

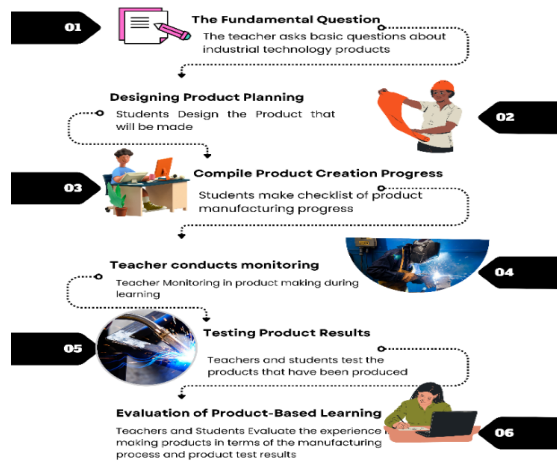


Figure 2. Syntax of Product-Based Learning Model

**METHODOLOGY**

The research method used is a mixed method, with a descriptive qualitative and quantitative approach aimed at revealing phenomena in PBL in the Welding and Plate Practice II course against the Infrastructure Needs of the Mechanical Engineering Education Department.

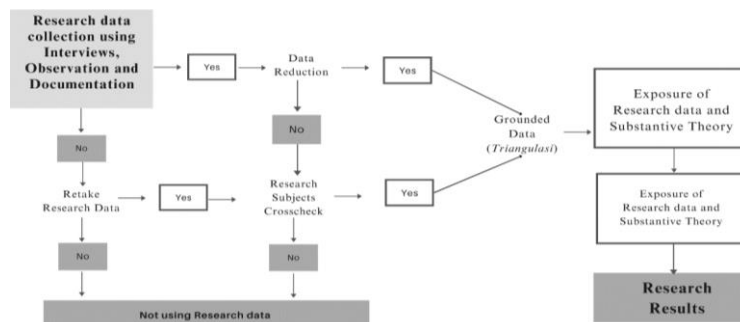


Figure 3. Research Data Collection Procedure

Figure 3 illustrates the implementation of the research, which began with initial observations by the researcher to determine the focus of the research. The research focus was then discussed with relevant theoretical foundations and followed by determining data collection procedures. In a qualitative approach, data is collected from informants who have an important role through interviews, observation, and documentation. The informants and sources used in data collection are described in the instrument grid described in table 1.

Table 1. Research Instrument Grid

No	Research Focus	Focus Indicator Research	Data Collection			Sources
			Sub Focus Indicator	Qualitative	Quantitative	
1	Learning Preparation	PBL Preparation by Lecturers	1. Preparation of teaching materials	✓	-	Head of department, lecturer
			1. Preparation of laboratory equipment	✓		
			1. Learning Syntax Scenario Preparation	-	✓	
			1. Teamteaching Coordination Preparation	✓	-	
			1. Preparation of industrial technology products	✓	-	
			1. Preparations made by students	✓	-	
		PBL preparation conducted by students				Students

No	Research Focus	Focus Indicator Research	Data Collection			Sources	
			Sub Focus Indicator	Qualitative	Quantitative		
		Study of infrastructure needs analysis of Department	1. 7	Analyze the lack of facilities and infrastructure in the Mechanical Engineering department used in learning.	✓	-	Head of department, lecturer
2	Learning Implementation	Learning Implementation Scenario	2. 1	Full description of product based learning scenario	✓	-	
		Conformity of PBL implementation with Syntax	2. 2	Fundamental questions on product based learning activities	-	✓	
			2. 3	Designing the Product	✓	-	
			2. 4	Make a checklist of work progress	✓	-	
			2. 5	Product Monitoring	-	✓	
			2. 6	Product Testing	✓	-	

No	Research Focus	Focus Indicator Research	Data Collection			Sources
			Sub Focus Indicator	Qualitative	Quantitative	
			2. PBL	✓	-	
			7. Evaluation			
3	Learning Evaluation		3. Conduct affective, summative and product assessments	-	✓	
			3. Conduct assessment of product usage	✓	-	

The results of the study were then presented and analyzed using triangulation of sources and methods. Then in the descriptive quantitative approach taken from the questionnaire data of 15 mechanical engineering lecturers who have taught in the Welding and Plate Practice Course II in the Department of Mechanical Engineering, Makassar State University. Descriptive quantitative data were collected using a questionnaire instrument described in table 1. At the end of the study, the conclusions of the research results will be further discussed with relevant literature.

Table 2. Questionnaire Instrument for Product-Based Learning Implementation

No	Question Instrument Grid	Validity Value	Validity Result
1	Does the learning scenario use both project-based learning and problem-based learning approaches?	.923**	Valid
2	Do you apply basic questions (triggering questions) in every lesson?	.866**	Valid
3	Do you monitor the implementation of each lesson?	.875**	Valid
4	Do you assess the affective, cognitive and psychomotor stages?	.779**	Valid

Reliability is measured using Cronbach's Alpha. If the reliability produces a value > 0.6, then the data is considered reliable. The reliability test results obtained 0.9642 then the questionnaire instrument is said to be reliable.

Table 3. Reliability Statistics

Cronbach's Alpha	N of Items
0.942	6

The questionnaire was developed using a Likert Scale with four score levels.

Table 4. Skala Likert

Score	Category
5	Strongly Agree (SS)
4	Agree (S)
3	Neutral (N)
2	Disagree (TS)
1	Strongly Disagree (STS)

Source: (Sugiyono, 2012)

The mean score of the respondents, if explained as a percentage on a scale of 4, can be calculated using the formula P below:

$$P = r/k$$

Notes: P = class interval score, r = range, and k = highest class score.

Example:

$$\text{Range (r)} = \text{highest score} - \text{lowest score} = 5 - 1 = 4$$

$$\text{Class interval (P)} = r/k = 4/5 = 0.8.$$

Table 5. Likert Scale Categories

Average Score	Category
1.00 -1.80	Bad
1.81 - 2.60	Fair
2.61 - 3.40	Neutral
3.40 - 4.20	Good
4.21 - 5.00	Very Good

Source: (Sugiyono, 2012)

## HASIL PENELITIAN

### Learning Preparation

The research results regarding the evaluation of product-based learning preparation are explained in Table 6.

Table 6. Data Exposure of Learning Preparation

No	Research Subfocus	Results of Interviews, Observations and Documentation	Implications	Recommendation
1.	Preparation of teaching tools	Teaching tools in PBL need to be more than	Transformation in designing teaching tools	a. Development of more collaborative

No.	Research Subfocus	Results of Interviews, Observations and Documentation	Implications	Recommendation
		<p>conventional teaching materials. Lecturers must design a project-oriented curriculum by considering real-world problems. The results showed that in many universities, lecturers still adapt text-based learning modules into project-based models. However, many are not optimal in developing assessment rubrics that focus on collaboration skills, problem solving, and product innovation.</p>	<p>that support collaboration, creativity and real problem solving is key to the successful implementation of PBL. Specialized training for lecturers to develop project-based teaching materials should be a priority.</p>	<p>and multidisciplinary teaching tools                      b. Training for lecturers to integrate project-based assessments that assess aspects of innovation, creativity, and theoretical understanding.</p>
2.	Preparation of laboratory equipment	<p>Laboratories are at the core of PBL implementation, especially in the field of technology. However, research results show that laboratories on many campuses</p>	<p>Inadequate laboratories will limit students' ability to produce innovative and relevant technological products. Institutions need to make</p>	<p>a. Investment in laboratory equipment that is more sophisticated and relevant to industry needs.                      b. Increased competency of laboratory technicians to be able to support students in high</p>

No	Research Subfocus	Results of Interviews, Observations and Documentation	Implications	Recommendation
		<p>are still inadequate to support the development of more complex technology-based projects. Limited state-of-the-art equipment and shortages in experienced laboratory technicians are the main obstacles. In addition, some institutions do not have a good laboratory management system, so their use is poorly coordinated.</p>	<p>long-term investments to provide facilities that are in line with the latest technological developments.</p>	<p>technology-based projects. c. Implementation of a more efficient laboratory management system to organize the use and availability of equipment.</p>
3.	Learning Syntax Scenario Preparation	<p>The learning syntax in PBL must be structured to guide students through each stage of product creation, from problem identification to evaluation of results. From the results of the research, it was found that the preparation of syntax that is integrated with</p>	<p>Without a clear learning syntax, students may focus too much on the end result (product) without really understanding the process and underlying theory. Conversely, a syntax that is too rigid can limit student innovation.</p>	<p>a. Development of a learning syntax guide that is balanced between theory and practice, with an emphasis on creativity and innovation. b. Training for lecturers in developing learning syntax that is flexible but still focused on learning objectives.</p>

No.	Research Subfocus	Results of Interviews, Observations and Documentation	Implications	Recommendation
4.	Teamteaching Coordination Preparation	<p>theory and practice is still a challenge for lecturers. Some lecturers have difficulty in balancing theory-based learning with the need to give students creative space in product development.</p> <p>The implementation of PBL often requires collaboration between lecturers from different areas of expertise (team teaching) to provide a holistic learning experience. However, the research found that coordination between lecturers is still not optimal. There are often differences in vision, learning methods, and evaluation between lecturers, which results in</p>	<p>Failure in team teaching can hinder the effectiveness of PBL. Students may feel confused by different approaches and uncoordinated outcomes.</p>	<p>a. Development of a regular coordination forum among lecturers to equalize vision and teaching strategies in PBL.                      b. Development of a more structured multidisciplinary curriculum with clear lecturer roles in supporting each stage of the project.</p>

No .	Research Subfocus	Results of Interviews, Observations and Documentation	Implications	Recommendation
5.	Preparation of industrial technology products	<p>students experiencing confusion in understanding the material as a whole.</p> <p>One of the advantages of PBL is its ability to link education with industry needs. However, this study found that the relationship between universities and industry is still not strong enough. Students often find it difficult to get direct feedback from the industry, and many of the products produced are not up to industry standards due to a lack of understanding of market needs.</p>	<p>Without strong collaboration with industry, students will have difficulty understanding how the products they create can meet real-world needs. The products also tend to be irrelevant to the latest technological developments and industry trends.</p>	<p>a. Establish closer partnerships with industry to provide students with opportunities for direct feedback.</p> <p>b. Organize internship programs or direct project collaboration with industry to ensure the products produced are in line with market needs.</p> <p>c. Universities need to develop strategic policies to facilitate collaboration with various industry sectors.</p>

Research shows that the implementation of Product-Based Learning (PBL) in colleges of technology faces various challenges, despite its great potential to improve the quality of education and industry-relevant skills. Many lecturers still focus on adapting text-based modules into projects without optimizing the assessment of collaboration and innovation. In addition, laboratory facilities are

often inadequate to support complex technological developments, and coordination between lecturers from different disciplines is not optimal, resulting in confusion among students. The PBL learning structure also needs to be refined in order to balance theory with practice and provide creative space for students.

The advantages of PBL in linking education with industry needs are often hampered by the weak relationship between universities and the industrial sector, which causes difficulties for students in getting feedback according to market standards. To optimize PBL, improvements are needed in teaching tools, laboratory facilities, learning syntax, as well as strengthening collaboration between lecturers and industry involvement. With these improvements, PBL can be an effective learning model to prepare students to face the challenges of a complex and dynamic world of work.

### Learning Implementation

The results of the research on the implementation of product-based learning are described in Table 7.

Table 7. Data Exposure of Learning Preparation

No	Research Subfocus	Results of Interviews, Observations and Documentation	Implications	Recommendation
1.	Full Description of Product-Based Learning Scenario	PBL scenarios implemented in various universities generally involve the stages of problem identification, product design, product manufacturing, and final evaluation. However, the scenarios used are not yet well structured and lack integration between theory and practice. Many lecturers	The lack of structured PBL scenarios may hinder students' understanding in integrating theory with practice. This can also affect the effectiveness of learning, as students may not get enough guidance in developing products.	Lecturers need to develop more comprehensive PBL scenarios by including guidelines for each learning stage. There is a need for training for lecturers in designing PBL scenarios that are effective and in accordance with industry standards.

No	Research Subfocus	Results of Interviews, Observations and Documentation	Implications	Recommendation
		still face challenges in developing learning scenarios that are in accordance with the needs of students and industry.		
2.	Designing the Product	The product design stage in PBL provides an opportunity for students to apply the knowledge and skills acquired. However, the results show that many students struggle to develop designs that meet industry standards due to a lack of understanding of market needs and the latest design techniques.	If the product design does not meet industry standards, it may not be widely used or relevant to market needs. This can reduce the competitiveness of graduates in the world of work.	Universities need to provide additional training in product design that includes the latest design techniques and understanding of industry standards. Collaboration with industry in providing input and feedback on student product designs is also very important.
3.	Creating a Work Progress Checklist	The creation of a work progress checklist on PBL projects helps students to manage tasks and time.	Without a clear checklist, students may struggle to manage their time and prioritize their work. This can	Colleges need to familiarize students and lecturers to use progress checklists consistently. Training on project management and progress monitoring techniques

No.	Research Subfocus	Results of Interviews, Observations and Documentation	Implications	Recommendation
4.	Product Testing	<p>However, many students and lecturers are not accustomed to using checklists as a tool to monitor work progress.</p> <p>The product testing stage is often ignored or done with less comprehensive methods. Many student products are tested only in terms of functionality without considering other aspects such as durability, reliability and safety.</p>	<p>result in delays in project completion and sub-optimal final results.</p> <p>Without comprehensive product testing, project outcomes may not meet industry requirements or desired quality standards. This can affect graduates' readiness to face challenges in the workforce.</p>	<p>can be provided to improve these skills.</p> <p>The product testing process should cover various aspects, including functionality, durability, reliability and safety. Colleges can also work with industry to certify products in accordance with professional standards.</p>
5.	PBL Evaluation	<p>Evaluation in PBL activities often focuses only on the final product, while the learning process does not get enough attention. The assessment rubric used also lacks</p>	<p>Lack of comprehensive evaluation can lead to assessments that do not reflect students' overall abilities. This can affect student motivation and</p>	<p>The PBL assessment rubric needs to be expanded to cover all aspects of the learning process, such as collaboration skills, problem solving, creativity, and individual contribution in the team. Lecturers also need to be trained in using comprehensive and</p>

No .	Research Subfocus	Results of Interviews, Observations and Documentation	Implications	Recommendation
		emphasis on aspects of collaboration, problem-solving skills, and innovation.	the overall quality of learning.	objective assessment rubrics.

Research shows that the implementation of Product-Based Learning (PBL) in higher education faces various challenges in terms of learning scenario structure, product design quality, progress monitoring, and project evaluation. Many PBL scenarios are not well structured, and the fundamental questions used often do not trigger students' critical thinking. In addition, limitations in the use of checklists, non-comprehensive product testing, and less than optimal monitoring also affect the quality of project results. The evaluation of PBL, which tends to focus only on the final result, also ignores important aspects such as collaboration and the learning process.

To improve the effectiveness of PBL, it is recommended that improvements be made in the preparation of learning scenarios that are integrated with practice and theory, the use of technology-based monitoring tools, and assessment rubrics that cover various aspects of the learning process. Collaboration with industry to provide input on product design and testing also needs to be strengthened. Training for lecturers and students in project management, product design, and testing techniques that meet industry standards are important steps in optimizing the application of PBL in higher education.

The products made by students oriented to the needs of laboratory facilities and infrastructure are described in Figure 3 and Figure 4.



Figure 4. Tools Box



Figure 5. Shoe Case

### Evaluation of Learning

The research results regarding the evaluation of product-based learning are explained in Table 8.

Table 8. Data Exposure of Learning Evaluation

No.	Research Subfocus	Results of Interviews, Observations and Documentation	Implications	Recommendation
1.	Conducting Affective, Summative, and Product Assessments	Affective, summative and product assessments in PBL activities aim to evaluate various aspects of learning, from student attitudes and engagement to the final project outcome. Research shows that many lecturers still focus on summative assessment that only assesses the final product, while affective assessment that includes student attitudes, motivation and cooperation receives less attention. Product assessment itself often does not cover all aspects of product quality that are relevant to industry needs.	Assessments that do not include affective dimensions and only focus on the end result can lead to a lack of appreciation of the learning process and the development of non-technical skills, such as teamwork and professional attitudes. This could potentially hinder the development of student character traits needed in the workplace.	The assessment rubric in PBL needs to comprehensively cover affective, summative and product aspects. Affective assessment should be designed to measure student engagement, motivation and cooperation during the project process. In addition, product assessment should include various quality indicators relevant to industry standards, such as durability, functionality and innovation.

No.	Research Subfocus	Results of Interviews, Observations and Documentation	Implications	Recommendation
2	Conducting Assessment of Product Usage	Assessment of product use in PBL is often suboptimal, focusing more on whether the product works rather than how it is used in a real context. Product testing is often conducted in environments that do not reflect end-user conditions, and feedback from potential users or industry is rarely used as part of the evaluation process.	Without an in-depth assessment of the use of the product in a real situation, student project outcomes may not meet the needs of the market or end users. This may reduce the relevance of the developed product in a professional context, as well as inhibit students from understanding the importance of user feedback in the product design and development process.	Product assessment should include trials of use under real or simulated conditions that reflect end-user situations. Collaboration with industry to test the product and provide feedback is important to ensure that the product meets market standards and needs. The evaluation should also include ergonomic aspects, reliability, and user satisfaction for the product to be widely accepted and relevant in the world of work.

Overall, this study emphasizes the importance of a more comprehensive and realistic assessment approach in PBL to ensure that the learning process not only assesses the final outcome, but also develops students' skills and attitudes needed in the professional world.

*Results of Descriptive Analysis of Product Based Learning Implementation*

The results of data collection using a questionnaire on the Implementation of Product Based Learning.

Table 9. Tabulation of Product Based Learning Implementation

No.	Skore									F	Average F	
	SS	(%)	S	(%)	N	(%)	TS	(%)	STS			(%)
1	7	46.6	5	33.3	1	6.6	1	6.6	1	6.6	15	4.278
2	10	66.6	2	13.3	1	6.6	1	6.6	1	6.6	15	4.69

No.	Skore										F	Average F
	SS	(%)	S	(%)	N	(%)	TS	(%)	STS	(%)		
3	5	33.3	6	40	2	13.3	1	6.6	1	6.6	15	3.99
4	7	46.6	5	33.3	1	6.6	1	6.6	1	6.6	15	4.26
Average(%)	48.3		30		8.3		6.6		6.6			0
Total Average Category (Excellent)												4.3045

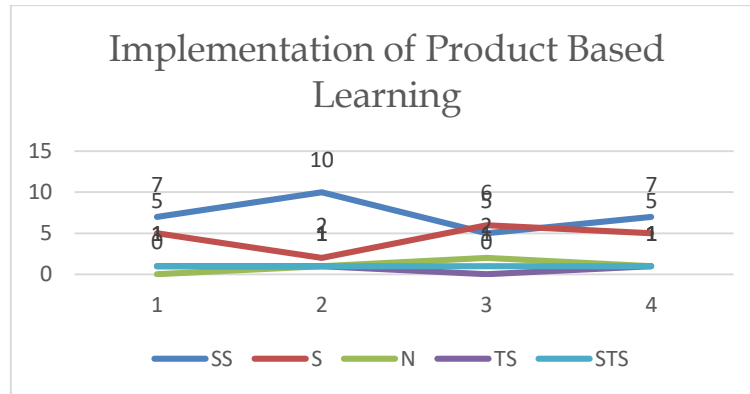


Figure 6. Tabulation of Data Results Implementation of Product Based Learning

Based on the frequency tabulation data in table 9, it can be concluded that the Implementation of Product-Based Learning for Welding and Plate II Practice Courses Against the Infrastructure Needs of the Mechanical Engineering Education Department gets the results of 4,304 with a percentage of 48.3% in the Excellent category. In other words, the implementation is going very well.

### PEMBAHASAN

The results show that the implementation of Product-Based Learning (PBL) in technology colleges faces various challenges despite its great potential in improving students' skills relevant to industry needs. Many lecturers still focus on adapting text-based modules into projects, without optimizing the assessment of collaboration and innovation. In addition, limited laboratory facilities hamper the development of complex technologies, so students lack practical experience that is in line with industry standards. Coordination between lecturers across disciplines is not optimal, which often causes confusion among students regarding integrated learning objectives (Agustina & Putri, 2020; Alfaro et al., 2019; Nurdiansah et al., 2021).

Although PBL is known as a method that is able to connect education with industry needs, the lack of industry sector involvement in the learning process makes it difficult for students to get feedback that is relevant to the labor market. To improve the effectiveness of PBL, it is necessary to improve teaching tools, modernize laboratory facilities, and strengthen collaboration between lecturers and industry (Alfaro et al., 2019; Ramadhan et al., 2020). With this update, PBL is expected to better prepare students to face the challenges of a complex and evolving world of work.

Research on the implementation of Product-Based Learning (PBL) in higher education shows that some aspects of the learning scenario still need improvement. According to (Nurdiansah et al., 2021; Ramadhan et al., 2020;

Romadlon et al., 2021), many PBL scenarios are not systematically structured, making them less able to develop students' critical thinking. This is exacerbated by weaknesses in the use of checklists and progress monitoring, as well as less comprehensive product testing. (Almulla, 2023). As a result, the quality of students' project outcomes is likely to be affected, as they do not get adequate feedback throughout the process. In addition, evaluation that focuses on the end result ignores the important aspects of collaboration and learning process that should be the main concern in the PBL method (Ashfahani et al., 2020; Donnelly et al., 2015).

In order to overcome these problems, the study recommends several steps to improve the implementation of PBL. First, learning scenarios need to be more integrated with theory and practice to match industry needs (Romadin et al., 2021; Yoto et al., 2024). Second, the use of technology in monitoring and testing tools can help optimize student project progress. Assessment rubrics that include collaboration, creativity, and problem-solving processes also need to be developed to provide a comprehensive evaluation (Alfaro et al., 2019). In addition, training for lecturers and students in project management, product design, and testing techniques that meet industry standards will be a strategic step to strengthen the quality of PBL implementation in higher education (Dewi & Sari, 2022; Nurdiansah et al., 2021).

This research highlights the importance of a more comprehensive assessment approach in Product-Based Learning (PBL) to ensure that the evaluation does not only focus on the final product, but also includes the processes and skills that students develop throughout the project. This is in line with the opinion of (Shalihah & Prastiti, 2020) which states that process-based assessment in PBL helps students understand the importance of collaboration, communication, and problem-solving skills relevant to the professional world. Comprehensive assessment includes monitoring the development of students' technical abilities, work attitudes, and professional ethics that are needed in a real work environment (Shalihah & Prastiti, 2020).

The results showed that the implementation of PBL in the Welding and Plate Practice II course in meeting the infrastructure needs of the Mechanical Engineering Education Department obtained a score of 4,304 with a percentage of 48.3% in the "Excellent" category. This shows that the implementation of PBL has been running very well in supporting the development of students' skills and understanding in accordance with industry standards (Putri & Sriwijaya, 2020; Weiss & Belland, 2016). With this achievement, research underlines that the effective implementation of PBL can help develop students' abilities not only in technical aspects, but also in their readiness to face professional demands in the field of mechanical engineering (Hartati et al., 2022; Mohamadi, 2018; Wijayati et al., 2019)

## **KESIMPULAN DAN REKOMENDASI**

The conclusion of this study shows that the implementation of Product-Based Learning (PBL) in higher education has great potential to develop students' skills that are relevant to industry needs and support the infrastructure of the department. Challenges identified include module adaptation that has not been fully optimized, limited laboratory facilities, as well as a lack of collaboration between cross-disciplinary lecturers and industry involvement, leading to a lack of professional feedback for students. Nevertheless, the results of PBL implementation in the Welding and Plate Practice II course obtained a score of 4,304 with a percentage of 48.3% in the "Excellent" category. This proves the effectiveness of PBL in improving students' technical skills. This study recommends improving the quality of learning scenarios, modernizing laboratory facilities, strengthening collaboration with industry, and process-based assessment to increase the relevance and readiness of students in facing the challenges of a dynamic and growing world of work.

## **PENELITIAN LANJUTAN**

Further research could explore the long-term impact of Product-Based Learning on students' practical skills and readiness for industry demands in engineering education.

## **UCAPAN TERIMA KASIH**

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## **DAFTAR PUSTAKA**

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