E-ISSN: 2715-9647
P-ISSN: 2720-9091

JPTIV
http://jurnal.fkip.unila.ac.id/index.php/JPVTI/index
Jurnal Pendidikan Teknologi Informasi dan Vokasional
Volume 6, No. 2, December. 2024
DOI: http://dx.doi.org/10.23960/jpvti

PROJECT-BASED LEARNING STRATEGY FOR ENHANCING MANUFACTURING DRAWING TECHNIQUES COMPETENCY USING CAD

Rahmadani ✉, Erik Fernandes[2], Zulfadli[3]

Fakultas Teknik, Universitas Negeri padang
***Corresponding Author*:** rahmadani9@ft.unp.ac.id

INFORMASI

Artikel History:

Rec. 12- November-2024
Acc. 28- Desember -2024
Pub. 31 Desember, 2024
Page. 197 - 209

Keywords:

- *D3 Mechanical Engineering Program*
- *Project-Based Learning (PjBL)*
- *Skill Improvement*

ABSTRAK

This study aims to evaluate the implementation of the Project-Based Learning (PjBL) model in improving the skills and understanding of students in the Diploma-3 Mechanical Engineering Program. The method used is Classroom Action Research (CAR), conducted in three cycles, each consisting of planning, action, observation, and reflection stages. Each cycle was followed by two face-to-face meetings. Data was collected through tests and analyzed descriptively to measure the improvement in students' learning outcomes. The research findings indicate that the implementation of PjBL is effective in enhancing technical skills, understanding of the material, and collaborative skills among students. The achievement of success indicators improved from 56.67% in Cycle I to 86.67% in Cycle III. PjBL has proven to create more applicable and interactive learning experiences, increase student motivation, and prepare them to face industry challenges. This study concludes that the PjBL model can be more widely applied in vocational education to improve students' practical skills and prepare them to meet the growing demands of the industry.

INTRODUCTION

In the era of globalization, the rapid advancement of science and technology has brought significant changes to various aspects of life. Science emerges as a result of human efforts to meet both physical and spiritual needs (Svari & Arlinayanti, 2024). In this context, institutions not only adapt to technological changes but also reshape their curricula to prepare students for a dynamic global landscape (Ersi Ersi et al., 2023).

As Indonesia enters the 21st century, the country faces the necessity of adapting to the rapid advancements in the digital industry, particularly through the lens of the Fourth Industrial Revolution. This revolution is characterized by the integration of digital, physical, and biological systems, leveraging technologies

Volume 6, No. 2, December. 2024
DOI: http://dx.doi.org/10.23960/jpvti

such as artificial intelligence, robotics, and the Internet of Things (IoT) to enhance manufacturing processes (Gamar et al., 2018; Sudarmanto & Salim, 2019). To build a globally competitive manufacturing sector, Indonesia must prioritize the development of its digital industry, which is crucial for economic growth and competitiveness in the modern era (Novianti & Asmara, 2023). A key component of this strategy involves increasing connectivity and digitalization across various industrial sectors, which will drive efficiency and innovation (Samingan et al., 2024). By embracing these changes, Indonesia can position itself positively in the global market, ensuring that its manufacturing industry thrives amidst the challenges of an evolving digital landscape (Setiawan, 2020).

Indonesia's strategic initiatives to enhance its manufacturing industry, particularly through the development of human resource competencies, are crucial in adapting to the demands of the Fourth Industrial Revolution. The integration of education and industry is essential, ensuring that the workforce is equipped with the necessary skills and innovative capabilities (Fitriani, 2024). Technical drawing plays a vital role in machining processes within the industrial sector, serving as the primary medium for designing and producing components with high precision and quality (Permana et al., 2024). The integration of software such as AutoCAD in medium- to large-scale manufacturing industries enhances the efficiency and accuracy of these processes (Ali et al., 2024), enabling industries, including those in Indonesia, to remain globally competitive. The use of technical drawings, supported by modern technology, ensures that manufacturing processes are accurate and efficient.

In the industrial sector, machining processes are critical to production efficiency, relying heavily on technical drawings to ensure accuracy and high quality in component manufacturing. These drawings serve as the primary medium for conveying design specifications, which are essential for achieving the desired product standards (Deokar et al., 2019). The integration of Computer-Aided Design (CAD) software, particularly AutoCAD, enhances this process by enabling the creation of detailed engineering designs that improve production efficiency (Țîțu & Pop, 2024). In medium- to large-scale manufacturing industries, such as those in Indonesia, the adoption of AutoCAD not only streamlines the design workflow but also supports global market competitiveness (Xiang et al., 2023). As the manufacturing industry continues to evolve, leveraging advanced technologies such as CAD will be essential for maintaining high-quality production and driving economic growth (Durakbasa & Osanna, 2011). Thus, the synergy between technical drawing and CAD software is crucial for the success of modern manufacturing practices.

Education aims to develop competent and competitive human resources by enhancing learners' ability to independently improve their intelligence and skills. At the core of this objective is the learning process, which involves dynamic interactions between learners, educators, and learning resources in an educational environment (Sağocak et al., 2013). One of the effective models in vocational education is Project-Based Learning (PjBL), which engages students in real-world projects, fostering critical thinking, creativity, and collaboration (Adi et al., 2023). This approach is particularly beneficial in fields such as Computer-

Volume 6, No. 2, December. 2024
DOI: http://dx.doi.org/10.23960/jpvti

Aided Design (CAD) in Manufacturing Engineering, where practical skills are essential for workforce readiness (Basri et al., 2023; Mudriadi et al., 2024). By implementing PjBL, educators can significantly enhance student learning outcomes, equipping them with the competencies needed to excel in their future careers. Thus, integrating PjBL into vocational education not only improves academic performance but also prepares students to effectively meet industry demands.

Project-Based Learning (PjBL) is a pedagogical approach that has shown significant promise in enhancing student learning outcomes in vocational education, particularly in fields requiring practical skills such as Computer-Aided Design (CAD) in Manufacturing Engineering. This method involves students engaging in real-world projects, fostering critical thinking, creativity, and collaboration, thereby equipping them with the competencies necessary to excel in their future careers. The integration of PjBL into vocational education not only improves academic performance but also aligns student skills with industry demands, making them more competitive in the workforce. This condition aligns with the findings of Sukamta et al. (2018), who state that PjBL enables students to apply theoretical knowledge in practical settings, which is essential in vocational education. This hands-on experience is particularly beneficial in technical fields such as CAD, where students must develop proficiency in using specific tools and technologies.

While PjBL offers numerous benefits, it is essential to consider the broader context of vocational education. Human resource development through education is a key factor in economic growth and societal advancement. Vocational education must continuously adapt to changing global economic demands by incorporating innovative teaching methods and aligning curricula with industry standards (Siregar & Hasibuan, 2024; Widiansyah, 2018). Additionally, fostering a culture of lifelong learning and continuous skill development is crucial for maintaining competitiveness in the workforce (Zeky, 2022).

Based on the expert opinions presented, it can be concluded that learning outcomes reflect the level of mastery achieved by students. This mastery can manifest in various forms, such as increased knowledge, understanding, attitudes, behavior, skills, competencies, habits, and other aspects that develop within individuals during the learning process.

The purpose of this study is to examine and analyze the implementation of the Project-Based Learning (PjBL) model in enhancing students' competencies in Manufacturing Drawing Techniques using Computer-Aided Design (CAD). This research aims to identify the extent to which the application of the PjBL model influences student learning outcomes, including knowledge, skills, and attitudes that support their readiness to face challenges in the industrial world. Furthermore, this study seeks to contribute to the development of more relevant and effective teaching methods in supporting the needs of Industry 4.0, particularly in the vocational education sector.

METHODOLOGY

Volume 6, No. 2, December. 2024
DOI: http://dx.doi.org/10.23960/jpvti

This study falls under the category of Classroom Action Research (CAR), which aims to enhance the quality of classroom learning through modifications in existing teaching practices. According to Arikunto (2010), CAR is conducted to improve the quality of instructional practices in the classroom by actively involving both teachers and students. This research employs a sample of students from the Diploma-3 Mechanical Engineering Program at Universitas Negeri Padang, using a total sampling technique that includes the entire population of 30 students. The research instruments utilized in this study include learning materials such as the syllabus and Semester Learning Plan (RPS).

The research procedure is carried out in three cycles, each consisting of four stages: planning, action, observation, and reflection. Each cycle includes two face-to-face meetings, aiming to monitor and evaluate the improvement in student learning outcomes at each stage. Data collection is conducted using tests to measure the improvement in student learning outcomes, which are analyzed using the average formula. The obtained data are then analyzed descriptively to determine changes in learning outcomes and mastery of other skills.

The method used in this study follows the Project-Based Learning (PjBL) model, which involves seven developmental steps that engage students in project-based learning. The instructor plays a role in each stage of the PjBL model, from formulating expected learning outcomes and understanding instructional materials to creating and presenting project reports. Through this model, students are given opportunities to learn actively and practically, develop technical skills, and solve real-world problems relevant to their vocational field. Thus, this study aims to enhance students' skills in project-based learning within the field of Mechanical Engineering.

RESULTS AND DISCUSSION

Results

Based on the research findings presented in the student competency table, it can be concluded that the success indicators for each cycle have been well achieved. This indicates that the implementation of the Project-Based Learning (PjBL) model in this study is effective in enhancing the learning abilities of Diploma-3 Mechanical Engineering students, particularly in the CAD course.

The improvement in students' learning abilities is clearly reflected through the significant progress from Cycle I to Cycle III, where each cycle successfully met the predetermined success indicators. This development illustrates that the PjBL method has a positive impact on enhancing students' skills and knowledge in alignment with the intended learning objectives. As evidence, the data recorded in the following table demonstrate consistent achievements in each cycle, highlighting the effectiveness and success of this approach in improving learning quality.

Table 1. Evaluation of Research Success on Students' Learning

Volume 6, No. 2, December. 2024
DOI: http://dx.doi.org/10.23960/jpvti

Competencies in the CAD Course

Cycle	Action Success Indicator (%)	Research Results (%)	Action Success Description
I	55	56.67%	Successful (17 out of 30 students)
II	80	80.00%	Successful (24 out of 30 students)
III	88	86.67%	Successful (26 out of 30 students)

The results of this study indicate that the implementation of the Project-Based Learning (PjBL) model in the CAD course significantly enhances students' skills and knowledge. This research was conducted in the Diploma-3 Mechanical Engineering Program, focusing on the evaluation of learning success measured through the achievement of success indicators in each cycle. In every cycle, the predetermined success indicators were successfully met, reflecting the effectiveness of the PjBL model in improving students' learning abilities.

In Cycle I, although the student success rate reached 56.67% (17 out of 30 students), this result suggests that the PjBL model began to have a positive impact, albeit with room for improvement. At this stage, the implementation of the learning model was still in its introduction and adaptation phase, which may have influenced students' comprehension and skill development. However, this achievement indicates that students started adapting to the PjBL approach.

In Cycle II, the success rate significantly increased to 80% (24 out of 30 students). This indicates that students gained a better understanding and were able to apply the concepts taught through the projects they worked on. This improvement also suggests that a more structured project-based learning approach, which actively involved students in the learning process, effectively contributed to the development of their skills and knowledge. As the learning progressed, the approach became more effective in deepening students' understanding.

In Cycle III, the success rate reached 86.67% (26 out of 30 students), a remarkable achievement indicating that students had mastered the material more effectively. At this stage, the PjBL method proved highly effective in developing technical skills and enhancing students' understanding of Manufacturing Drawing Techniques. Additionally, the level of student participation and engagement in each project phase increased, contributing to even more optimal results.

Overall, these research findings confirm that implementing the Project-Based Learning (PjBL) model gradually and significantly enhances students' skills and knowledge. The continuous improvement from cycle to cycle demonstrates that the PjBL method successfully creates a more interactive, application-based learning environment that directly impacts learning quality. Thus, PjBL is an excellent alternative for teaching subjects that require practical skills, such as Manufacturing Drawing Techniques.

Volume 6, No. 2, December. 2024
DOI: http://dx.doi.org/10.23960/jpvti

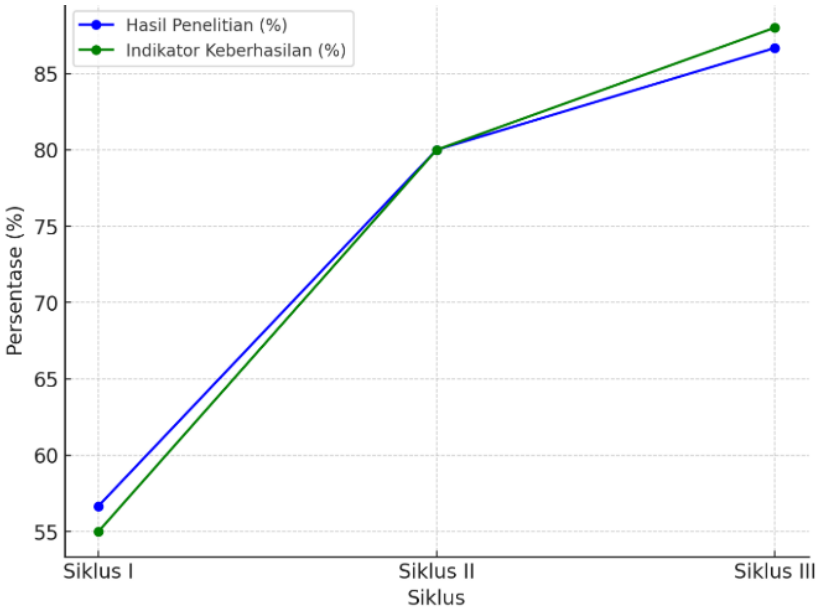

Figure 1. Success Graph of Actions in Each Cycle

Based on the results of the research reflected in the student learning outcomes table, it is evident that each learning cycle demonstrates significant progress in the enhancement of students' skills and understanding. The first cycle shows lower outcomes, but over time, with the implementation of improvements and adjustments made in each subsequent cycle, a clear improvement can be observed. The graph presented in this study illustrates the trend of students' skill development from Cycle I to Cycle III, indicating that the approach used becomes increasingly effective over time.

This study was conducted in the Diploma-3 Mechanical Engineering Program at Universitas Negeri Padang. The implementation of the Project-Based Learning (PjBL) model in this research has proven to have a positive impact on students' learning outcomes. This method enables students to actively engage in the learning process by solving relevant problems and working on real-world projects, leading to the development of enhanced skills.

In the first cycle, although improvement was observed, the results were not yet optimal as students were still adjusting to the new learning method. However, following reflection and improvements in the second and third cycles, students' learning outcomes increasingly showed significant development. This improvement is evident in students' knowledge, skills, and attitudes, with students becoming more active in learning, as well as in their ability to apply manufacturing drawing concepts in real-world contexts.

Table 2 illustrates the achievements made during the research process, showing progressive advancements in each cycle. These accomplishments indicate that the Project-Based Learning method not only enhances theoretical understanding but also provides students with the opportunity to develop practical skills that will be valuable in the industry. Thus, this research provides evidence that the implementation of Project-Based Learning can significantly

Volume 6, No. 2, December. 2024
DOI: http://dx.doi.org/10.23960/jpvti

improve students' learning outcomes and prepare them to face challenges in an increasingly competitive workforce.

Table 2. Evaluation of the Success of Research Actions in Improving Student Learning Outcomes

Cycle	Success Action Indicator (%)	Research Results (%)	Action Success Description
I	50	57.00	Successful
II	60	72.00	Successful
III	75	85.00	Successful

Based on the research results presented in the table and diagram regarding the achievement of success in the research actions for student learning outcomes, it can be concluded that the application of the Project-Based Learning (PjBL) model successfully enhanced students' learning skills. This success is reflected in the achievement of success indicators, which continually increased in each cycle, indicating significant progress in students' learning outcomes over time. The diagram illustrating the improvement in students' skills shows that student learning outcomes continued to improve from Cycle I, II, to III, indicating that this approach became more effective and had a positive impact on students' abilities in the Manufacturing Drawing Techniques subject.

In Cycle I, although the success indicators were achieved, the research findings showed relatively lower results compared to the subsequent cycles. This suggests that while there was improvement, students still required further guidance and deeper understanding to fully grasp the taught material. However, with a more in-depth implementation of PjBL in Cycle II, a significant improvement was observed. At this stage, students became more actively engaged in the learning process by focusing on projects relevant to real-world applications, thereby strengthening their understanding of Manufacturing Drawing Techniques.

Cycle III demonstrated the most optimal results, with both success indicators and research outcomes reaching their highest values. This indicates that the implementation of PjBL in the third cycle effectively encouraged students not only to comprehend theoretical concepts but also to master the practical skills essential in the field of Mechanical Engineering.

The application of Project-Based Learning in this context provides students with the opportunity to learn through direct experience. In the Manufacturing Drawing Techniques course, students not only learn technical concepts but are also encouraged to work on real-world projects that involve the use of tools and techniques relevant to the manufacturing industry. This not only enhances their understanding of theory but also equips them with practical skills that can be applied in the workforce. PjBL also enables students to collaborate in teams, which develops their collaboration and communication skills—key competencies in the professional world.

The success of PjBL in improving the learning outcomes of Diploma-3 Mechanical Engineering students demonstrates that project-based learning can be an effective model for teaching technical skills in vocational education. This

Volume 6, No. 2, December. 2024
DOI: http://dx.doi.org/10.23960/jpvti

approach provides students with hands-on, application-oriented experiences that enhance critical thinking, problem-solving abilities, and practical skills. Thus, the findings of this study provide evidence that Project-Based Learning is a viable method for equipping students with relevant, industry-ready competencies, particularly in the field of manufacturing engineering. Furthermore, this research can serve as a foundation for developing more innovative and effective learning models in the future.

.

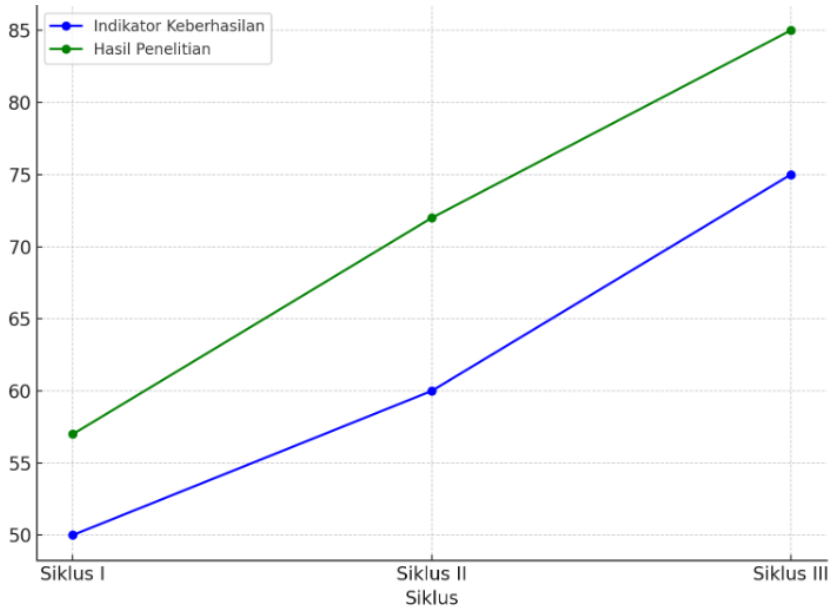

Figure 2. Diagram of Student Success Improvement

Discussion

This study shows significant progress in students' skills in the CAD course after the implementation of the Project-Based Learning (PjBL) model. The results reflect clear improvement in each cycle, in line with previous findings that suggest PjBL enhances technical skills, critical thinking, and problem-solving abilities (Mabrur et al., 2024).

In the first cycle, students' skills were categorized as satisfactory, indicating a basic understanding of the material and drawing skills using AutoCAD software. The second cycle showed improvement to a "good" category, suggesting that students were increasingly mastering basic techniques and applying them in tasks. A more notable improvement occurred in the third cycle, where students' skills reached the "excellent" category. This indicates a deeper understanding of the material and more efficient technical skills (Priambudi, 2022). This improvement aligns with the HappyCAD system, which demonstrates the effectiveness of an interactive learning environment where students engage with 3D models and receive feedback, further enhancing their understanding and application of AutoCAD in engineering graphics (Tsuei & Lai, 2015).

This progress is also consistent with research indicating that PBL motivates

Volume 6, No. 2, December. 2024
DOI: http://dx.doi.org/10.23960/jpvti

students to become more active and engaged in learning (Lestari et al., 2024). Project-based learning offers students the opportunity to work with relevant and challenging material, which increases their motivation to complete tasks and learn in greater depth. Students' involvement in complex projects encourages them to think creatively and improves their collaboration skills, as noted by Rendón & Martínez (2024), who emphasized that PBL hones collaborative and time-management skills.

In the first and second cycles, while there was improvement, changes in the learning process were not as visible, possibly due to students still being in the adaptation phase with the PjBL model, which requires them to be more active, independent, and accountable for their tasks. Significant improvement was evident in the third cycle, where students began to show more noticeable progress in drawing skills and the quality of their work. This suggests that this transition allowed students to develop higher-level thinking skills and problem-solving abilities, which are the primary goals of PjBL (Febrianti & Hamimi, 2024).

Moreover, the PjBL model supports the development of students' critical thinking and problem-solving skills. As Raida & Ardianti (2024) point out, PjBL requires students to identify problems in their projects, plan solutions, and complete tasks with higher quality. The results of this study also show that students became more capable of analyzing and solving problems with greater precision, as demonstrated in the more complex project tasks in the third cycle.

These findings underscore the effectiveness of the PjBL model in enhancing not only technical skills but also student motivation, material understanding, and collaborative abilities. This model, which integrates the principles of project-based learning, fosters an environment where students are engaged in real-world projects, promoting an active and responsible learning approach. Specifically, the PjBL model has proven to significantly improve students' manufacturing drawing skills, particularly in using AutoCAD software (Lockhart, 2011), as evidenced by the progression from the "satisfactory" to "excellent" categories across several cycles. This improvement reflects the model's emphasis on the development of high-level thinking and problem-solving skills, in line with educational objectives to foster independent learning.

The results are also in line with several studies that confirm the successful implementation of PjBL in improving technical skills. For example, in research focusing on digital fabrication, students reported increased proficiency in 2D and 3D modeling, prototyping, and machine operation after participating in open prototyping activities (Soomro et al., 2024). In the context of mechanical drawing, experiential learning methods, similar to PjBL, have been effective in improving students' understanding and practical skills in using CAD software (Nasution et al., 2024). Additionally, collaborative learning, a core component of PjBL, is considered enjoyable and beneficial for skill development, although it may not always align with individual skills development, such as 2D modeling and programming (Soomro et al., 2024). The Peer-PjBL model, which combines project-based learning with peer-to-peer learning, has been shown to significantly enhance students' self-efficacy and creativity, crucial for collaborative and managerial skills (Sutopo et al., 2024).

Volume 6, No. 2, December. 2024
DOI: http://dx.doi.org/10.23960/jpvti

Based on these findings, it can be concluded that the application of the PjBL model significantly improves students' manufacturing drawing skills, particularly in using AutoCAD software. This skill improvement is reflected in the clear progress from the satisfactory category in the first cycle, to good in the second cycle, and finally excellent in the third cycle. This success aligns with the primary goals of PjBL, which include the development of high-level thinking skills and problem-solving abilities.

Thus, the Project-Based Learning model has proven effective in improving the quality of learning, both in terms of technical skills and students' learning attitudes. Therefore, it is recommended that this model be applied more broadly to other subjects to enhance students' practical skills, problem-solving abilities, and collaborative skills comprehensively.

CONCLUSION

This study demonstrates that the implementation of the Project-Based Learning (PjBL) model significantly enhances the skills and understanding of students in the Diploma-3 Mechanical Engineering Program. Over the course of three research cycles, students' learning outcomes showed rapid development, with the success rate steadily increasing in each cycle. Starting from 56.67% in Cycle I, it improved to 80% in Cycle II, and reached 86.67% in Cycle III.

This improvement reflects the effectiveness of PjBL in creating an interactive and applied learning environment, where students can develop technical skills, critical thinking, and problem-solving abilities through real-world projects. Industry-based projects allow students to better master the concepts of manufacturing drawing techniques and the use of AutoCAD software. Furthermore, the application of this model also encourages increased student motivation and collaborative skills when working in groups.

Therefore, the PjBL model has proven effective in improving the quality of vocational education, particularly in enhancing students' practical skills relevant to the workforce. This research recommends the implementation of PjBL not only for the Manufacturing Drawing Techniques course but also for other vocational fields that require technical and collaborative skills, to better prepare students for the challenges of the industrial world.

REFERENCES

Adi, N. H., Riyanda, A. R., Nadia, H., Maulana, F., Ambiyar, A., Verawardina, U., & Lapisa, R. (2023). *Model Pembelajaran Kejuruan*.

Ali, A. S. H. R., Ali, A. M. S., Amin, Y. W. R., & Ali, S. H. R. (2024). *The Important Role of GD&T in Mechanical Drawing, Design and Manufacturing for Students of Engineering Institutes*. 2024-01–2052. https://doi.org/10.4271/2024-01-2052

Arikunto, S. (2010). *Prosedur penelitian suatu pendekatan praktek*. Rineka Cipta.

Basri, I. Y., Giatman, M., Muskhir, M., Effendi, H., Ambiyar, A., Elfina, E., & Yuliardi, T. P. (2023). Improving the Quality of Learning Through Project Based Learning (PjBL) With the STEAM Approach in CAD Courses in the Department of Automotive Engineering Universitas Negeri Padang. *INVOTEK: Jurnal Inovasi Vokasional Dan Teknologi*, *23*(1), 1–10. https://doi.org/10.24036/invotek.v23i1.1068

Deokar, S., Pathak, A., & Warghane, R. (2019). Computer Aided Design and Manufacturing. *Journal of Emerging Technologies and Innovative Research*, *6*(4), 592–597.

Durakbasa, M. N., & Osanna, P. H. (2011). Intelligent Design and Metrology for Higher Quality, Accuracy and Improving Production Efficiency. *Acta Mechanica Slovaca*, *15*(1), 6–11. https://doi.org/10.21496/ams.2011.001

Ersi Ersi, Ahmad Mulyadi, Dwi Noviani, & Hilmin Hilmin. (2023). Pengembangan Kurikulum Pendidikan dan Globalisasi. *Concept: Journal of Social Humanities and Education*, *2*(4), 95–106. https://doi.org/10.55606/concept.v2i4.771

Febrianti, D., & Hamimi, E. (2024). Enhancing creativity through PjBL-STEAM equipped biogeochemical cycle educational kit on ecosystem materials in junior high school. *Research and Development in Education (RaDEn)*, *4*(2), 845–862. https://doi.org/10.22219/raden.v4i2.35186

Fitriani, S. (2024). Teaching Factory and Technopark as a Driver of Enterpreneurship and Innovation: A Lesson Case Study From Indonesian's Vocational Schools. *AL-ISHLAH: Jurnal Pendidikan*, *16*(3). https://doi.org/10.35445/alishlah.v16i3.5247

Gamar, M. M., Al Faruq, M. S., & Lina, L. (2018). Challenging the Indonesian Primary Education in Industrial Revolution 4.0 Era. *Proceedings of the 3rd International Conference on Educational Management and Administration (CoEMA 2018)*. 3rd International Conference on Educational Management and Administration (CoEMA 2018), Malang, Indonesia. https://doi.org/10.2991/coema-18.2018.12

Lestari, A., Tersta, F. W., Firman, F., & Sofyan, S. (2024). Implementation of Project-Based Learning Through the STEM (Science, Technology, Engineering and Math). *International Journal of Education, Culture, and Society*, *2*(3), 175–186. https://doi.org/10.58578/ijecs.v2i3.3410

Lockhart, S. (2011). *Tutorial Guide to AutoCAD 2012*. https://www.amazon.com/Tutorial-Guide-AutoCAD-Shawna-Lockhart/dp/1585036439

Mabrur, M., Huda, N., & Utami, S. (2024). The Effectiveness of Project-Based Learning Assisted by Digital Technology to Improve Problem-Solving and Critical Thinking Skills in SMKN 3 Sampang Students. *Jurnal Indonesia Sosial Sains*, *5*(09), 2450–2457. https://doi.org/10.59141/jiss.v5i10.1468

Mudriadi, W., Yahya, M., & Supriadi. (2024). Effectiveness of Project-oriented Problem-based Learning (POPBL) in Manufacturing Product Design for Vocational Higher Education. *Asian Journal of Education and Social Studies*, *50*(2), 31–42. https://doi.org/10.9734/ajess/2024/v50i21256

Nasution, R., K, A., & Fernanda, Y. (2024). Implementation of experiential learning method in mechanical drawing course to enhance student understanding through real projects. *Journal of Engineering Researcher and Lecturer*, *3*(2), 109–126. https://doi.org/10.58712/jerel.v3i2.127

Novianti, A. G., & Asmara, A. (2023). The Development of Digital Technology and Its Impact on Indonesia's Economic Growth. *International Journal of Research and Review*, *10*(9), 297–319. https://doi.org/10.52403/ijrr.20230932

Permana, P. D., Larasati, Lady, Hati, C. M. P., & Amrina, D. H. (2024). The Influence of Education and Training on Labor Productivity in Indonesia. *Journal of International Conference Proceedings*, *6*(6), 369–379. https://doi.org/10.32535/jicp.v6i6.2705

Priambudi, T. (2022). Pembelajaran Inovatif Abad 21 pada Materi Menggambar Denah Rumah Tinggal Menggunakan Program AutoCAD dengan Model Project Based Learning (PjBL) di SMK Negeri 1 Adiwerna Kabupaten Tegal. *Cakrawala: Jurnal Pendidikan*, 288–297. https://doi.org/10.24905/cakrawala.vi0.194

Raida, S. A., & Ardianti, S. D. (2024). PjBL online in ecological learning to improve student's problem-solving skills. *THABIEA : JOURNAL OF NATURAL SCIENCE TEACHING*, *7*(1), 108. https://doi.org/10.21043/thabiea.v7i1.20193

Rendón, A., & Martínez, F. (2024). Impact of project-based learning on conceptual achievements and motivation of technology students in electricity. *World Journal of Advanced Engineering Technology and Sciences*, *12*(2), 001–008. https://doi.org/10.30574/wjaets.2024.12.2.0262

Sağocak, A. M., Yilmaz, E., & Karahan, N. (2013). *Knowledge, Skills And Creativity In Vocational And Technical Education*. *4*(1), 13–21.

Samingan, M., Prakoso, L. Y., & Suwito, S. (2024). Indonesia's Digital Economic Policy To Increase Economic Resilience. *International Journal Of Humanities Education and Social Sciences (IJHESS)*, *3*(6). https://doi.org/10.55227/ijhess.v3i6.873

Setiawan, A. B. (2020). A Study on the Potential of the Development of Software Applications and Digital Content Industrial Ecosystem in Indonesia. *Jurnal Penelitian Pos Dan Informatika*, *10*(2), 145. https://doi.org/10.17933/jppi.2020.100205

Siregar, E. H., & Hasibuan, W. K. (2024). Pengaruh Pengembangan Sumber Daya Manusia Dan Pendidikan Dalam Rangka Meningkatkan Pertumbuhan Ekonomi. *Mutiara : Jurnal Penelitian Dan Karya Ilmiah*, *2*(1), 312–324. https://doi.org/10.59059/mutiara.v2i1.970

Soomro, S. A., Nanjappan, V., Casakin, H., & Georgiev, G. V. (2024). Fostering technical skills and creativity in the digital fabrication spaces: An open-ended prototyping approach. *International Journal of Technology and Design Education*. https://doi.org/10.1007/s10798-024-09940-3

Sudarmanto, B. A., & Salim, A. (2019). *Makanan tradisional, bahasa, dan revolusi industri 4.0*. Prosiding Seminar Nasional Program Pascasarjana Universitas PGRI Palembang.

Sukamta, S., Florentinus, T. S., Ekosiswoyo, R., & Martono, S. (2018). Project Based Learning Enhances Student Quality in Vocational Education. *Proceedings of the International Conference on Science and Education and Technology 2018 (ISET 2018)*. Proceedings of the International Conference on Science and Education and Technology 2018 (ISET 2018), Semarang, Indonesia. https://doi.org/10.2991/iset-18.2018.96

Sutopo, S., Setiadi, B. R., Nashir, I. M., Saputri, V. H. L., Arifin, A., Prasetya, T. A., Harjanto, C. T., & Sasongko, B. T. (2024). CNC Learning Innovation: Improving Students' Self-Efficacy and Creativity through Peer-PBL. *Jurnal Pendidikan Vokasi*, *14*(2). https://doi.org/10.21831/jpv.v14i2.72409

Svari, N. M. F. D., & Arlinayanti, K. D. (2024). Perubahan Paradigma Pendidikan Melalui Pemanfaatan Teknologi di Era Global. *Metta : Jurnal Ilmu Multidisiplin*, *4*(3), 50–63. https://doi.org/10.37329/metta.v4i3.3407

Țîțu, A. M., & Pop, A. B. (2024). Implementation of CAD/CAM/CAE Systems for Improved Design and Manufacturing Processes in Industrial Organizations. *Proceedings of the International Conference on Business Excellence*, *18*(1), 3069–3078. https://doi.org/10.2478/picbe-2024-0253

Tsuei, M., & Lai, R.-T. (2015). Development of an Online Engineering Drawing Systemto Enhance Junior High School Students' Learning in an Engineering Graphics Course. *International Journal of Engineering Education*, *31*(2), 589–596.

Widiansyah, A. (2018). *Peranan Sumber Daya Pendidikan sebagai Faktor Penentu dalam Manajemen Sistem Pendidikan*. *18*(2), 229–234. https://doi.org/10.31294/JC.V18I2.4347

Xiang, Z., Jinghao, X., & Nazarov, Y. (2023). Application of computer-aided design method to optimize the modeling and design stages for industrial products. *Revista Gestão & Tecnologia*, *23*, 38–52. https://doi.org/10.20397/2177-6652/2023.v23i1.2576

Zeky, M. (2022). Pengembangan Manusia Sebagai Sumber Belajar Pada Berbagai Jenjang Pendidikan. *ADDABANA: Jurnal Pendidikan Agama Islam*, *5*(1), 67–80. https://doi.org/10.47732/adb.v5i1.199