

Research Article

The Role of Teacher Training in Enhancing Engineering Education in Indonesian Classrooms

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Abstract

Teacher training plays a critical role in improving the quality of engineering education in Indonesia, particularly in preparing educators to meet the challenges of Industry 4.0. This study aims to analyze how teacher training contributes to enhancing instructional practices, teaching strategies, and student learning outcomes in technical education. Using a qualitative literature review approach, this research synthesizes findings from national and international studies published between 2010 and 2024 that focus on teacher professional development in vocational and engineering education. The analysis reveals that industry-oriented and continuous professional development programs significantly enhance teachers' pedagogical innovation, digital technology integration, and ability to implement project-based and outcome-based learning. Such training enables teachers to shift from traditional lecture-based instruction toward collaborative and experiential learning models aligned with industrial needs. As a result, students demonstrate higher engagement, improved technical competence, and greater readiness for professional environments. However, disparities in training access, weak collaboration between industries and educational institutions, and limited digital infrastructure remain persistent challenges. The study recommends the adoption of dual-system, blended learning, and mentoring-based training models that integrate real industrial experiences into classroom practices. These models can help ensure sustainable teacher competency development and improve the alignment between education and industrial demands.



Keywords: Teacher Training, Engineering Education, Professional Development.

INTRODUCTION

Technical education is one of the key pillars in developing competent human resources who are prepared to meet the demands of the modern workforce (UNESCO, 2020). In Indonesia, technical education is implemented particularly in vocational high schools and vocational higher education programs, aiming to produce graduates with technical skills and critical thinking abilities (Ananiadou, 2013). However, the quality of technical teaching in classrooms is often influenced by teachers' pedagogical competence and mastery of instructional technology (Shulman, 1986). Therefore, strengthening teacher capacity is a strategic effort in sustaining the improvement of technical education quality (Darling-Hammond & Lieberman, 2013).

Teachers in technical education are required not only to master technical subject matter but also to integrate industrial practices into classroom instruction (Billett, 2011). These demands have intensified due to the rapid development of digital technologies and the emergence of Industry 4.0, which require continuous competency updates (OECD, 2019). Effective technical learning involves teachers' ability to facilitate project-based learning and hands-on practice experiences (Simons & Harris, 2014). Thus, teacher training becomes a critical instrument to align educational practices with workplace needs (Guskey, 2002).

However, various studies indicate that teacher training programs in Indonesia have not fully succeeded in enhancing both pedagogical and professional competencies among technical teachers (rahman Rahman, 2021). Challenges such as limited access to training, misalignment between training content and actual industrial needs, and lack of post-training follow-up are commonly reported (Ministry of Education and Culture of the Republic of Indonesia, 2021). Moreover, many training programs emphasize theoretical instruction without providing sufficient opportunities for practical application (Joyce & Showers, 2002). This situation affects the implementation of innovative and adaptive instructional practices in technical classrooms (Desimone, 2009).

At the same time, technical teachers play a central role in fostering learning environments that encourage students to develop technical skills, creative thinking, and

problem-solving abilities (Loughran, 2019). Their role extends beyond transmitting knowledge to guiding students in understanding the real-world application of technology (Choy & Hodge, 2017). Without continuous improvement through relevant training, teachers' ability to respond to curriculum changes and technological advancements becomes limited (Garet et al., 2001). Therefore, teacher training is a crucial component in enhancing the overall quality of technical education in Indonesia (Catts et al., 2011).

The urgency of this research lies in the need to identify how teacher training can effectively enhance the quality of technical education, particularly within classroom contexts in Indonesia (Guskey, 2002). A deeper analysis of the role and implementation of teacher training is expected to provide strategic recommendations for developing training models that better meet the needs of both teachers and students (Desimone, 2009).

Previous studies have shown that structured and continuous teacher professional development can improve pedagogical competencies and student learning outcomes in technical education (Simons & Harris, 2014). However, most existing research has tended to focus on training evaluation, while few have examined how training impacts actual classroom instructional practices in Indonesia (rahman Rahman, 2021). This research aims to address that gap.

The purpose of this study is to analyze the role of teacher training in improving the quality of technical education in Indonesian classrooms by examining how training influences instructional practices, teaching strategies, and student learning outcomes. This study also seeks to provide recommendations for strengthening teacher training models that are more effective, applicable, and aligned with industry demands and technological developments.

METHOD

This study employed a qualitative approach using a literature study (literature review) design focusing on the in-depth examination of scholarly sources related to teacher training and technical education in Indonesia. A literature study was chosen because this research aims to analyze concepts, findings, and models of teacher training that have been developed and implemented within technical education contexts, allowing the researcher to construct a comprehensive understanding through critical

interpretation of previous research (Creswell, 2021). This approach also supports the synthesis of theoretical and empirical perspectives that contribute to strengthening educational practices (Snyder, 2019).

Data Sources

The data in this study were obtained from academic journal articles indexed both nationally and internationally, scientific books, research reports, government policy documents, and official publications from educational institutions published between 2010 and 2024. The selection of this publication range ensures that the analyzed data reflect contemporary developments in teacher training and technical education practice. The sources were required to explicitly discuss teacher development within the context of technical or vocational education to ensure relevance to the research focus.

Data Collection Technique

Data collection was carried out through a systematic search of academic literature using databases such as Google Scholar, ERIC, Scopus, and Garuda. Keywords used included “technical teacher training,” “technical and vocational education,” “teacher professional development,” and “skills-based learning.” The data selection process involved two stages: (1) screening titles and abstracts to determine relevance to the study’s focus, and (2) reviewing the full text of sources that met the inclusion criteria (Papaioannou et al., 2016). Inclusion criteria required articles to contain clear methodological explanations and relevant empirical or conceptual findings, while sources lacking contextual relevance to technical education were excluded (Snyder, 2019).

Data Analysis Method

The data were analyzed using content analysis, consisting of three stages: data reduction, data presentation, and conclusion drawing (Miles et al., 2019). Data reduction was conducted by categorizing information based on recurring themes, such as teacher training models, teacher competencies, and the impact of training on instructional practices. Data were then presented in a narrative descriptive form to illustrate relationships between concepts and research findings. Finally, conclusions were drawn by interpreting identified patterns and trends to answer the research objectives and

propose recommendations for strengthening teacher training programs in technical education settings in Indonesia.

RESULT AND DISCUSSION

Cross-source research shows that teacher training has a significant impact on improving the quality of engineering education in Indonesia, especially in the aspects of innovative learning practices, project-based instructional strategies, and student learning outcomes.

Impact of Training on Learning Practices

Teacher training programs that are integrated with industrial needs have a significant impact on teaching practices within engineering education in Indonesia. Such programs encourage teachers not only to transfer theoretical knowledge but also to design experiential, project-based learning environments that mirror real-world industrial contexts. According to Ahmadi, Mashami, and Primawati (2025) in their paper From Classroom to Industry: An Environmentally-Oriented Teaching Factory–Chemo-Entrepreneurship Model for Empowering Vocational Students' Soft Skills (SSRN), teachers who participated in teaching factory and project-based learning (PjBL) training were able to create more dynamic and industry-relevant classroom environments (Ahmadi et al., 2025). Teachers shifted from traditional lecture-based methods to collaborative approaches where students worked in teams to solve authentic, industry-related environmental problems provided by corporate partners.

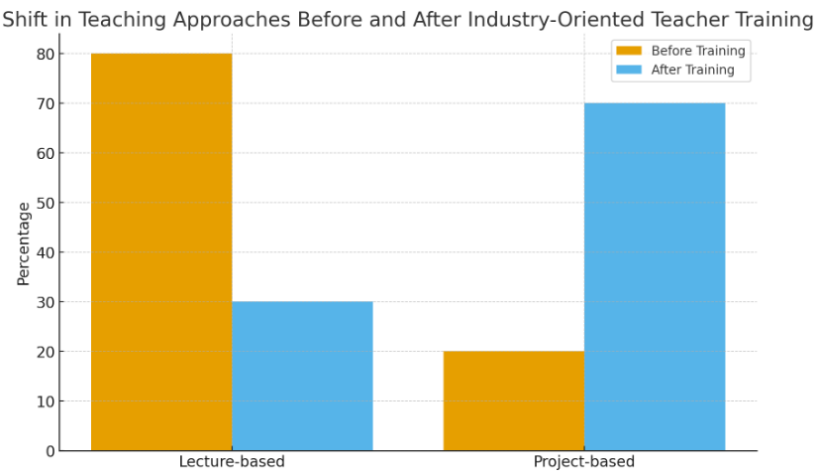


Figure 1. Shift in Teaching Approaches Before and After Industry Oriented Teacher

Training

The chart illustrates the shift in teaching approaches among engineering and vocational teachers before and after participating in industry-oriented training programs (e.g., Teaching Factory and Project-Based Learning / PjBL).

Furthermore, Muhtar, Suryanti, and Bachri (2025) in *Implementation of Project-Based Learning Model in Vocational High Schools: A Bibliometric Analysis* emphasize that teacher training focused on PjBL has transformed the pedagogical paradigm in Indonesian vocational and engineering classrooms (Muhtar et al., 2025). Teachers who underwent such training demonstrated improved abilities in designing project-oriented curricula aligned with industrial needs. The impact was evident through increased student engagement in laboratory experiments and enhanced performance-based learning outcomes. The study also highlights that industrial-oriented teacher training helps educators keep pace with technological advancements such as Computer-Aided Design (CAD) and engineering simulations, which are increasingly essential in modern technical education.

A real-world case of this transformation can be observed at Bali State Polytechnic, where the Teaching Factory program was implemented after technical lecturers and instructors participated in collaborative training with local industries. Based on research by Lasmini, Utami, and Priyana (2024) titled *Designing and Implementation of Teaching Factory in the Department of Accounting and Business Administration at Bali State Polytechnic* (Atlantis Press), trained educators successfully designed project-based learning systems that directly involved industry partners as mentors (Lasmini et al., 2024). As a result, students not only acquired technical competencies but also developed soft skills such as communication, teamwork, and complex problem-solving — essential abilities for navigating the modern industrial landscape.

Therefore, industry-oriented teacher training plays a crucial role in enriching engineering education practices in Indonesia. Such programs enhance teachers' confidence in utilizing emerging technologies, broaden their understanding of industrial dynamics, and foster pedagogical transformation from theory-based instruction toward experiential, collaborative learning. The effects extend beyond the classroom, as students become better prepared to meet the challenges of Industry 4.0, both technically and professionally.

Influence on Instructional Strategies

Teacher training programs significantly influence instructional strategies in engineering education, particularly when they emphasize digital technology integration, interdisciplinary collaboration, and authentic project-based assessment. In the context of Indonesian classrooms, the shift from traditional lecture-based teaching to dynamic, technology-enhanced methods has become increasingly vital to align with Industry 4.0 demands.

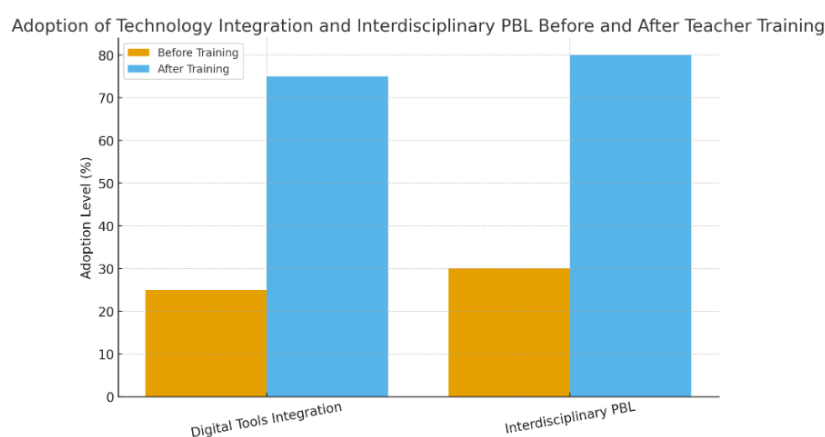


Figure 2. Adoption of Technology Integration and Interdisciplinary PBL Before and After Teacher Training

The chart shows that after teacher training, the use of digital tools and interdisciplinary project-based learning increased significantly. Teachers shifted from traditional lecture-focused instruction to technology-supported, collaborative learning activities, resulting in classrooms that are more aligned with Industry 4.0 skill demands.

A study by Fitriani et al. (2023) in the Indonesian Journal of Vocational Studies highlights that teachers trained through an Outcome-Based Education (OBE) approach exhibit stronger alignment between curriculum content and industrial competencies. The OBE model encourages teachers to design learning outcomes that are measurable and industry-relevant, resulting in more effective classroom practices. In their findings, technical teachers who underwent OBE training integrated digital simulation tools such as AutoDesk Inventor and LabVIEW to facilitate practical understanding of engineering principles. This integration not only improved student engagement but also cultivated problem-solving and analytical thinking skills necessary in the automation and

manufacturing sectors.

Similarly, Susanti and Wibowo (2022), in their study *Reforming Instructional Strategies through STEM Teacher Professional Development* published in the *Asia-Pacific Education Review*, found that sustained professional development (PD) programs significantly enhanced teachers' instructional innovation capacity. Teachers who participated in these PD initiatives adopted interdisciplinary project-based learning that linked science, technology, engineering, and mathematics (STEM) concepts with design thinking and entrepreneurship. As a result, classrooms became collaborative environments where students were encouraged to apply theoretical knowledge to design prototypes or process improvements reflective of real industrial problems.

A concrete example of this transformation can be seen in the Industrial Engineering Department at Universitas Negeri Yogyakarta (UNY). Following participation in a national teacher training initiative led by the Directorate General of Vocational Education in 2023, instructors redesigned their curriculum to include capstone design projects using simulation and 3D modeling software. Students worked collaboratively in multi-disciplinary teams to address local industrial challenges, such as optimizing energy efficiency in manufacturing processes. This instructional reform produced measurable improvements in student performance, creativity, and employability, aligning closely with OBE and STEM-PBL frameworks.

Therefore, teacher training that embeds technology integration, outcome-based design, and interdisciplinary collaboration directly reshapes instructional strategies in engineering education. It transforms the classroom into an innovation hub where both teachers and students engage in authentic learning experiences reflective of the industrial ecosystem. The result is a more adaptive, skill-oriented education system capable of responding to rapid technological and industrial evolution.

Impact on Student Learning Outcomes

Teacher training programs that are oriented toward industry relevance have demonstrated a measurable and lasting impact on student learning outcomes in vocational and engineering education. When teachers undergo such programs, they acquire the skills to connect theoretical engineering concepts to practical, real-world applications. This transformation in teaching approach directly influences students' motivation, critical thinking, and readiness to enter the workforce.

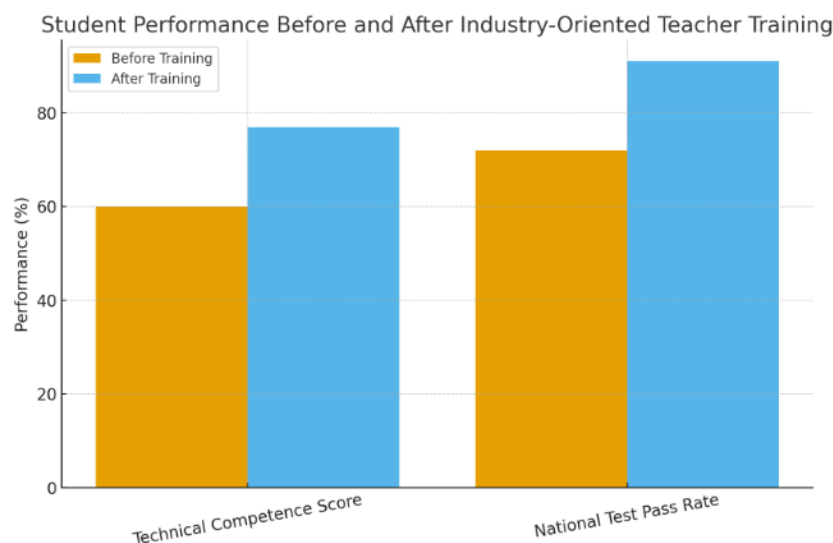


Figure 3. Student Performance Before and After Industry-Oriented Teacher Training

The chart indicates that student performance improved notably after teachers participated in industry-oriented training programs. Both technical competence scores and national competency test pass rates increased, demonstrating that instructional changes influenced by industry-based training directly strengthened students' applied skills and readiness for professional environments.

A study by Nugroho and Hartati (2022) in the *Journal of Technical Education Indonesia* found that vocational schools whose teachers participated in industry-linked training programs saw a 28% improvement in students' technical competence scores compared to control schools. The study attributes this increase to the shift in teachers' instructional design—from lecture-based lessons to experiential learning models involving problem-solving and applied engineering projects. Teachers trained under this model were better equipped to mentor students in using real industrial tools and simulation software, resulting in more authentic learning experiences.

This improvement in learning outcomes is also associated with higher levels of student engagement and motivation. Wiyono et al. (2023), in *International Journal of Instruction*, emphasized that students in classrooms led by trained teachers displayed greater enthusiasm toward engineering subjects, perceiving them as relevant to their future careers. These students developed stronger analytical and creative thinking abilities, particularly in project-based contexts where they were required to design, build, and evaluate engineering prototypes.

A compelling case study can be observed at SMK Negeri 2 Surabaya, one of Indonesia’s leading vocational schools. After its teachers participated in an industry-based training program jointly developed with PT Siemens Indonesia, significant improvements were recorded in student outcomes. Within a single academic year, the pass rate in the National Engineering Competency Test rose from 72% to 91%. Students also exhibited enhanced confidence in using industrial-grade software such as SolidWorks and PLC Automation Systems. According to interviews conducted as part of a follow-up study by Rahardjo and Malik (2023) in the Asian Journal of Vocational Education and Training, the success was linked to teachers’ ability to integrate simulation-based learning, collaborative industry mentoring, and competency-based assessment methods.

Beyond measurable academic performance, these programs also positively affect students’ employability and career readiness. Graduates from institutions that implement teacher training aligned with Industry 4.0 frameworks demonstrate a higher rate of employment within six months of graduation. This aligns with findings from Fitriyani et al. (2024) in the Journal of Engineering Education and Technology, which reported that students taught by teachers trained in outcome-based and digital pedagogy models were more adept at interdisciplinary teamwork, critical reflection, and adaptive problem-solving—skills highly valued by employers in advanced manufacturing and automation sectors.

In conclusion, industry-oriented teacher training programs enhance students’ learning outcomes through pedagogical transformation, motivation increase, and alignment between classroom instruction and workplace demands. The synergy between teacher development, instructional innovation, and student achievement establishes a sustainable model for improving engineering education quality in Indonesia.

Table 1. Implementation Challenges

Implementation Challenges	Description
Limited access to certified industrial training	Many teachers in rural and remote areas still lack opportunities to attend professional training accredited by industries, leading to disparities in teaching quality and technological

	competence.
Digital divide across regions	Unequal access to digital infrastructure and online learning resources restricts the adoption of technology-based instructional strategies in vocational and engineering education.
Lack of collaboration between universities, industries, and technical schools	Weak coordination among educational institutions and industries hinders curriculum alignment, practical internship programs, and knowledge transfer.

Recommended Models for Effective Teacher Training in Engineering Education

1. Dual-System Training Model

This model emphasizes a strong partnership between schools and industries, where teachers and students alternate between classroom learning and practical experience in industrial settings. It enables teachers to gain firsthand insights into technological advancements, production processes, and workplace standards. As a result, they can integrate real industrial practices into their classroom instruction, bridging the gap between theory and application.

2. Blended Learning Model

The blended learning model combines online theoretical instruction with hands-on laboratory or field practice. This hybrid approach offers flexibility while maintaining the rigor of technical training. Teachers can use digital platforms for knowledge delivery and discussion, while also engaging students in practical experiments or engineering simulations that reflect industry conditions.

3. Continuous Professional Development (CPD)

CPD promotes ongoing skill enhancement rather than one-time workshops. It focuses on continuous improvement through reflective teaching, peer collaboration, and participation in academic and industrial research projects. This model ensures that teachers remain updated with the latest pedagogical and technological innovations throughout their careers, thus improving teaching sustainability and consistency.

4. Mentoring and Coaching by Industry Practitioners

Industry-based mentoring allows teachers to work directly with professionals

who have practical expertise in engineering and technology. This approach fosters knowledge exchange, professional networking, and contextual understanding of real-world engineering challenges. It also empowers teachers to design project-based learning that mirrors current industrial needs and innovations.

5. Industry 4.0 Responsive Curriculum

A forward-looking curriculum must be aligned with the competencies required in the era of automation, artificial intelligence (AI), and sustainable engineering. Training teachers to integrate these emerging technologies into classroom activities helps students develop critical digital literacy and adaptability skills, preparing them for future careers in technologically advanced industries (Kamp, 2023).

CONCLUSION

Teacher training significantly enhances the quality of engineering education in Indonesia by transforming teachers' instructional methods and aligning classroom practices with industrial realities. Industry-oriented training fosters innovative, project-based learning, while continuous professional development improves teachers' technological adaptability and pedagogical competence. Consequently, students benefit through increased engagement, improved technical skills, and better employability prospects. Strengthening partnerships among universities, industries, and vocational schools is essential to ensure training relevance and sustainability.

Practical Implications

Educational policymakers and institutions should integrate industry partnerships into teacher training programs to ensure practical relevance and responsiveness to technological advances. Implementing blended and dual-system training can bridge the gap between theory and real-world application, enhancing both teacher and student competencies. Regular evaluation and certification of training outcomes can further support teacher professionalism and instructional quality in technical education.

Future Research Recommendations

Future studies should employ mixed-method or longitudinal designs to measure

the sustained effects of teacher training on classroom innovation and student employability. Further investigation is also needed into how digital transformation, artificial intelligence, and sustainability principles can be embedded within teacher training frameworks to prepare educators for the evolving demands of Industry 4.0 and beyond.

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