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Implementation of Teaching Factory in Indonesian Vocational High Schools: A Bibliometric and Systematic Literature Review

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A B S T R A C T

This study affirms that Teaching Factory (Tefa) is a systemic educational innovation bridging vocational high school learning with industry needs. By embedding authentic production processes into curricula, Tefa supports national economic priorities and global TVET reform principles. Bibliometric analysis identified four clusters: resources and evaluation, competency-based education, operational implementation, and the education–industry–quality link. Publication growth since 2018 reflects strong policy momentum from initiatives such as SMK Revitalization. However, gaps remain in longitudinal employability studies, cost-effectiveness evaluations, and Industry 4.0 integration. Tefa's success depends on teacher development, curriculum alignment, infrastructure readiness, and industry collaboration. With strategic scaling and continuous improvement, Tefa could serve as a benchmark for vocational education reform in Indonesia and other nations.

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INTRODUCTION

Vocational High Schools (Sekolah Menengah Kejuruan or SMKs) play a strategic role in producing graduates who are competent and ready to enter the workforce. SMK graduates have significant potential to contribute to national economic growth. However, the quality of SMK graduates remains a serious concern that requires urgent attention.

According to data from the Central Statistics Agency (BPS) dated November 5, 2020, the unemployment rate among SMK graduates was 13.55%, and in August 2021 it was still as high as 11.13%. Although the labor force continues to grow each year, the increase has not been matched by the skills required in the labor market (Siagian, 2023). The National Labor Force Survey (Sakernas) shows that the Open Unemployment Rate (TPT) for SMK graduates declined slightly to 9.01% in 2024 from 9.31% in the previous year. Nevertheless, SMK graduates still have the highest unemployment rate compared to all other education levels.

The high unemployment contribution from SMK graduates is partly due to their limited technical and soft skills, as well as a mismatch between what is taught in schools and the needs of industry (Dunia Usaha dan Dunia Industri, DUDI) (Imran, 2023). Previous studies also indicate that the competencies of SMK graduates are often inadequate, leading to suboptimal absorption in the labor market (Misbahudin et al., 2022). Contributing factors include curricula that are not sufficiently aligned with industrial needs and the low level of industry involvement in the learning process (Halizah & Resource, 2024).

The government is responsible for improving access, quality, services, and competitiveness in education, as mandated in Article 31(3) of the 1945 Constitution. Various initiatives have been introduced to enhance the quality of graduates, including teacher training programs, the provision of textbooks and teaching tools, and upgrades to school infrastructure. Strategic policies to improve SMKs include:

a. SMK Revitalization Program (Presidential Instruction No. 9 of 2016) aimed at strengthening human resource competitiveness.
b. Centre of Excellence (CoE) Program, launched in July 2020 by the Directorate of SMK, as a follow-up to SMK revitalization efforts.
c. Vocational Education Link and Match Program, introduced in 2017 to strengthen partnerships between schools and industry.
d. SMK Centre of Excellence (SMK PK) program, part of the Merdeka Belajar initiative (Episode 8) launched in 2021.
e. Teaching Factory (Tefa) and Creative and Entrepreneurship Projects to strengthen vocational learning quality.

These initiatives have improved SMK quality and enhanced their public image, making them attractive to students intending to work immediately after graduation. Among these programs, Teaching Factory stands out as a flagship initiative for strengthening vocational education quality by integrating real production processes into teaching and learning activities. The Tefa concept aims

to replicate industry-like working environments within schools, enabling students to experience contextual, interactive, and market-driven learning. Through Tefa, SMK students are trained in settings that closely resemble real industrial environments, providing them with relevant practical experience (Muslim et al., 2019).

Tefa has been implemented in various regions of Indonesia and has proven effective in improving educational quality (Safarinah et al., 2022). Nevertheless, further studies are needed to assess its impact on SMK quality improvement. This study therefore aims to identify and analyze literature on the implementation of Tefa in SMKs using a Systematic Literature Review (SLR) and bibliometric analysis. The results are expected to serve as a reference for the future development of Tefa.

LITERATURE REVIEW

Teaching Factory (Tefa)

Teaching Factory (Tefa) represents a transformative instructional paradigm that seeks to narrow the persistent competency gap between vocational high schools (SMKs) and the increasingly sophisticated requirements of the industrial sector (Kuswantoro, 2014). Unlike conventional classroom-based learning, Tefa embeds teaching and learning processes within simulated industrial environments that mirror real-world production systems. This integration allows students to develop both technical skills and workplace behaviors aligned with industry expectations, a dual focus that is critical in preparing graduates for immediate employment in competitive labor markets (Muslim et al., 2019; Safarinah et al., 2022).

The central pedagogical principle underpinning Tefa is "learning by producing," wherein the production process itself becomes the instructional medium (Paryono & Quito, 2010). This model encourages experiential learning, problem-solving, and adaptive thinking, providing students with opportunities to work on authentic products or services that have tangible market value. By replicating industrial workflows within school settings, Tefa offers an immersive educational experience that goes beyond simulated exercises, fostering a mindset of professionalism and quality consciousness among students.

According to Puslitjakbud (2019), an effective SMK must embody at least nine defining characteristics: readiness to enter the workforce, a demand-driven orientation, mastery of occupational competencies, success in practical workplace performance, close ties with industry, responsiveness to technological advancement, learning by doing, higher operational investment compared to general education, and strong theory–practice integration. Tefa operationalizes these principles by embedding real production requirements—such as quality control systems, efficiency benchmarks, and structured work rotations—into the curriculum (Directorate of Vocational Development, 2017).

Tefa's historical evolution in Indonesia reflects a deliberate policy trajectory aimed at strengthening vocational education. The concept was first introduced in 2000 through the establishment of basic production units in SMKs, which allowed schools to generate revenue while offering practical training opportunities. In 2005, these units were transformed into more formalized industry-based SMK models, strengthening industry–school linkages. By 2011, the Tefa model was fully formalized as a national initiative, with guidelines and implementation standards disseminated to vocational schools nationwide (Ministry of Education and Culture, 2011).

The design of Tefa in Indonesia draws on the Dual System model in Germany and Switzerland, recognized for its integration of classroom instruction with on-the-job training (Rauner & Maclean, 2021). In these systems, students split their time between schools and workplaces, gaining both theoretical knowledge and practical experience. Similarly, Tefa aims to create an ecosystem where schools function as semi-industrial hubs, producing goods or services that meet market standards while serving as training grounds for students.

Crucially, the term "factory" in Tefa does not imply the presence of a literal manufacturing plant within the school premises. Instead, it refers to an industrially simulated learning environment equipped with professional-grade tools, standardized safety protocols, and workflow systems similar to those found in actual industries. In this setting, teachers assume the role of supervisory engineers, quality controllers, and mentors, guiding students through the production process while maintaining industry-level quality standards (Susanti & Arifin, 2020).

Tefa also addresses a persistent challenge in vocational education: the mismatch between school-based training and the competencies demanded by the labor market. By fostering partnerships with industry, Tefa ensures that the skills imparted are current, relevant, and adaptable to evolving market needs. These collaborations often involve joint curriculum development, teacher training in industrial settings, and co-management of school production units (Halizah & Resource, 2024).

Implementation of Tefa requires more than just curriculum modification—it demands significant investments in infrastructure, human resource development, and institutional culture change. Facilities must be modernized to reflect industry standards, and teachers require continuous professional development to stay abreast of technological advancements and industry practices (Imran, 2023). Moreover, institutional policies must promote transparency, accountability, and sustainable financial management of production-based learning activities (Directorate of Vocational Development, 2017). Beyond its immediate benefits for student skill acquisition, Tefa has broader socio-economic implications. It strengthens school–industry–community linkages, promotes entrepreneurial thinking among students, and contributes to local economic development through the commercialization of school-produced goods and services (Safarinah et al., 2022). In the long term, Tefa can serve as a model for aligning education systems

with labor market demands in other developing countries facing similar school-to-work transition challenges.

In conclusion, Tefa is not merely a pedagogical technique but a systemic reform strategy embedded in Indonesia's vocational education policy landscape. By integrating academic instruction with production-based learning in industrially simulated environments, Tefa fosters a holistic skill set that includes technical proficiency, workplace discipline, and entrepreneurial capability. Its success, however, depends on sustained policy support, continuous industry engagement, and rigorous monitoring of learning outcomes to ensure alignment with both national development priorities and global workforce trends (Rauner & Maclean, 2021; Muslim et al., 2019).

Bibliometric Analysis

Bibliometric analysis is a scientific method that employs both quantitative and qualitative techniques to evaluate and interpret patterns in scholarly communication (Bahoo, 2020). At its core, bibliometrics focuses on the measurement of publication outputs, citation frequencies, authorship patterns, and collaboration networks to provide a structured understanding of research activity within a specific domain. By analyzing large datasets of academic publications, bibliometric studies can reveal the intellectual structure of a research field, identify emerging trends, and assess the impact of individual scholars, institutions, or countries.

One of the central strengths of bibliometric analysis lies in its ability to move beyond anecdotal or subjective assessments of a field, offering evidence-based insights grounded in systematically collected publication data (Haddow, 2018). Through citation analysis, for example, researchers can determine which works have exerted the greatest influence on subsequent studies, while co-word analysis can highlight conceptual linkages and thematic clusters. This methodological rigor makes bibliometrics a powerful tool for mapping the development of a research area over time.

In the context of vocational education research in Indonesia, bibliometric analysis plays a strategic role in understanding how the Teaching Factory (Tefa) model has been studied, disseminated, and refined over the years. Since its introduction as a national policy priority, the Tefa model has generated increasing academic interest, particularly in relation to its potential for bridging school–industry skill gaps. A bibliometric approach enables the mapping of publication trends from 2017 to 2025, shedding light on the rate of scholarly output, dominant research themes, and the extent of interdisciplinary engagement.

By identifying key authors, institutions, and journals contributing to Tefa-related literature, bibliometric analysis can also help pinpoint centers of expertise and innovation within Indonesia's vocational education sector. For instance, certain vocational education faculties and polytechnics may emerge as leaders in

both implementing and studying Tefa, thus positioning them as hubs for capacity building and policy experimentation. This information is invaluable for fostering collaborative networks and promoting best practice exchange (Moed, 2017).

Another critical contribution of bibliometric analysis is its capacity to detect underexplored research areas. While certain themes such as curriculum integration, competency development, and industry collaboration may dominate existing literature, other dimensions like digital transformation in Tefa environments, cost-effectiveness studies, and longitudinal impact assessments might receive comparatively less attention. This gap analysis supports the formulation of targeted research agendas, ensuring that future investigations address both academic and practical needs (Aria & Cuccurullo, 2017).

The methodological process of conducting a bibliometric study typically involves several stages: (1) defining the research scope and keywords, (2) selecting relevant databases such as Scopus, Web of Science, Google Scholar, or national repositories, (3) retrieving and cleaning publication data, (4) applying bibliometric indicators such as publication counts, citation frequencies, and h-index values, and (5) visualizing results through network mapping tools like VOSviewer or Biblioshiny (Donthu et al., 2021). For Tefa-related studies, the keywords "Vocational High School" and "Teaching Factory" are particularly relevant for capturing the full scope of related publications.

The visualization of bibliometric data through network mapping can offer powerful insights into the conceptual structure of the field. Co-occurrence maps of keywords, for example, can reveal thematic clusters that reflect distinct research streams—such as teacher professionalization, competency-based education, technological integration, and industry engagement. These clusters, in turn, provide a foundation for deeper qualitative analysis, allowing researchers to interpret the relationships between concepts and their evolution over time (Zupic & Čater, 2015).

For policymakers, bibliometric insights offer more than just an academic overview; they provide a practical evidence base for decision-making. By understanding which areas of Tefa research are mature and which are still emerging, policymakers can allocate resources more effectively, prioritize capacity development programs, and foster industry partnerships that align with research-backed best practices. Moreover, bibliometric data can be used to track the effectiveness of policy interventions over time, ensuring that reforms remain responsive to the evolving needs of both the education and industrial sectors (Bahoo, 2020).

In the Indonesian context, where vocational education reform is closely tied to broader economic development goals, bibliometric mapping of Tefa studies contributes directly to aligning educational policy with industry requirements. This alignment strengthens the employability of SMK graduates and supports national competitiveness in the global labor market. It also ensures that initiatives

like the SMK Revitalization Program and the Centre of Excellence are backed by robust, data-driven evidence rather than anecdotal assumptions (Haddow, 2018).

Ultimately, bibliometric analysis serves as both a diagnostic and strategic planning tool for the continued development of Tefa in Indonesia. By systematically capturing and interpreting the intellectual output of the field, it not only documents the current state of knowledge but also provides actionable guidance for future research, policy, and practice. In this sense, bibliometric studies are indispensable for creating a feedback loop between scholarship, policy formulation, and on-the-ground implementation in vocational education.

Systematic Literature Review (SLR)

Systematic Literature Review (SLR) is a structured and methodologically rigorous approach to synthesizing existing research on a given topic. Unlike traditional narrative reviews, which may be selective and subjective, SLR follows a predefined protocol to ensure transparency, reproducibility, and comprehensiveness (Kitchenham, 2024). It is designed to answer specific research questions by systematically identifying, evaluating, and integrating findings from all relevant studies. This approach minimizes bias and allows for a more reliable assessment of the state of knowledge in a field.

The SLR process begins with the formulation of clear and focused research questions, which serve as the foundation for all subsequent stages of the review (Xiao & Watson, 2019). The research question determines the scope of the literature search, the inclusion and exclusion criteria, and the analytical framework. In the case of Teaching Factory (Tefa) implementation in SMKs, questions might revolve around its effectiveness in enhancing employability, the nature of industry school collaboration, or the integration of Industry 4.0 technologies into vocational learning.

Once the research questions are defined, the next step involves developing a comprehensive search strategy to locate relevant studies. This typically includes identifying appropriate databases such as Scopus, Web of Science, Google Scholar, and national repositories—and constructing search strings using relevant keywords and Boolean operators (Booth et al., 2016). For Tefa-related research, commonly used keywords include "Vocational High School," "Teaching Factory," "competency-based education," and "school–industry partnership."

After retrieving the initial set of studies, researchers apply inclusion and exclusion criteria to filter out irrelevant or low-quality publications. These criteria may relate to the publication date range, language, document type, and methodological rigor (Gough et al., 2017). In this study, for example, only peer-reviewed journal articles, conference papers, and relevant government reports published between 2017 and 2025 were included, ensuring that the findings reflect recent developments in Tefa research.

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework is widely used to guide the screening process and ensure transparency in study selection (Page et al., 2021). PRISMA involves documenting the flow of studies from identification through screening, eligibility assessment, and final inclusion, often using a flow diagram. This systematic process helps readers understand how the final sample of studies was derived and allows for replication of the review.

Data extraction follows the screening stage, where relevant information such as author names, publication year, research objectives, methodologies, key findings, and limitations—is systematically recorded. This information forms the basis for synthesizing findings across studies (Snyder, 2019). In bibliometric-informed SLRs, data extraction also includes bibliographic details such as citation counts, keyword frequencies, and co-authorship networks, which can be analyzed to identify thematic clusters and influential works.

The synthesis phase involves combining the extracted data to answer the research questions. This can be done qualitatively, through thematic synthesis, or quantitatively, through meta-analysis, depending on the nature of the data (Petticrew & Roberts, 2006). For Tefa research, qualitative synthesis might group findings into themes such as curriculum development, teacher capacity building, and industry engagement, while bibliometric analysis might map keyword co-occurrence networks to reveal emerging research topics.

An important strength of the SLR method is its ability to highlight research gaps. By systematically mapping what is known and how it has been studied, SLRs can identify areas that require further investigation. In the context of Tefa, this might include the lack of longitudinal studies assessing long-term graduate outcomes, limited evidence on cost-effectiveness, or insufficient exploration of digital transformation in vocational settings (Grant & Booth, 2009). SLR also serves as a valuable tool for evidence-based policymaking. Policymakers can use the synthesized findings to inform program design, allocate resources, and evaluate the effectiveness of educational reforms. For example, insights from Tefa-related SLRs can guide decisions about scaling the model to more SMKs, adjusting teacher training programs, or enhancing partnerships with industry (Tranfield et al., 2003).

In conclusion, a well-conducted SLR provides a solid foundation for advancing both academic knowledge and practical implementation. By adhering to established protocols, it ensures that the review process is transparent, comprehensive, and reproducible. In the case of Tefa in Indonesia, SLR offers a rigorous mechanism for consolidating fragmented research, identifying best practices, and charting a roadmap for future studies that align with national vocational education priorities and global workforce trends.

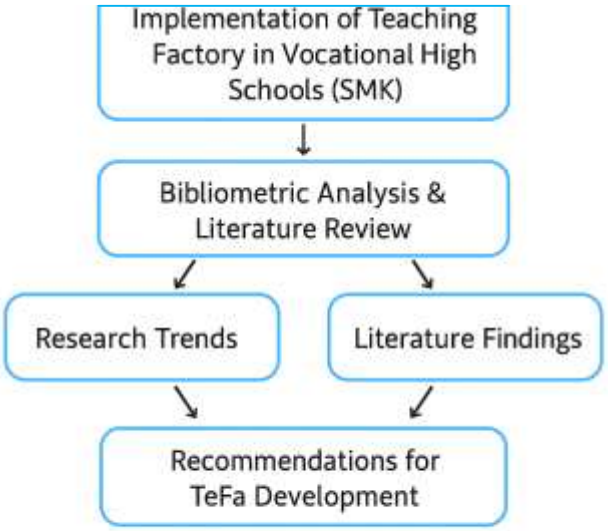

Figure 1.1. Concept Map

METODHOLOGY

This study employed the Systematic Literature Review (SLR) method to conduct a structured and comprehensive analysis of literature on Tefa implementation in Indonesian SMKs. The review aimed to capture research trends and scholarly publications from 2017 to 2025 and to analyze how Tefa has been applied in practice.

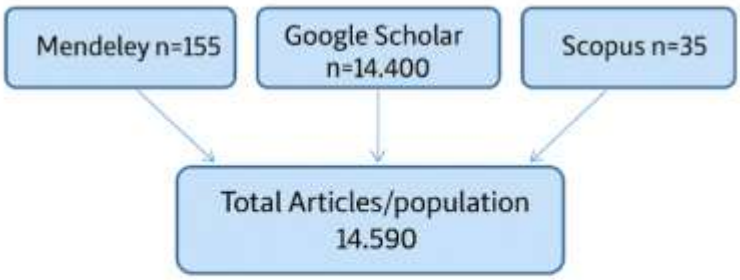

Figure 1.2. Articles Obtained from Digital Library

The SLR design followed four stages:

a. Identification – Articles were searched in three main databases: Mendeley, Google Scholar, and Scopus, using the keywords "Teaching Factory" and "Vocational High School" in titles, abstracts, and keywords. The search yielded 155 articles from Mendeley, 14,400 from Google Scholar, and 35 English-language articles from Scopus, for a total population of 14,590 articles.

b. Screening – Using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, articles were filtered for topic relevance, publication type, and completeness. This process reduced the dataset to 81 articles from Mendeley, 144 from Google Scholar, and 19 from Scopus.

c. Feasibility (Eligibility) – Articles were further filtered based on open access availability, resulting in 65 articles from Mendeley, 18 from Google Scholar, and 9 from Scopus.

d. Inclusion – Final selection was based on inclusion criteria such as topic relevance, methodological appropriateness, and contribution to the research question. The final set comprised 59 articles from Mendeley, 15 from Google Scholar, and 9 from Scopus, for a total of 83 articles.

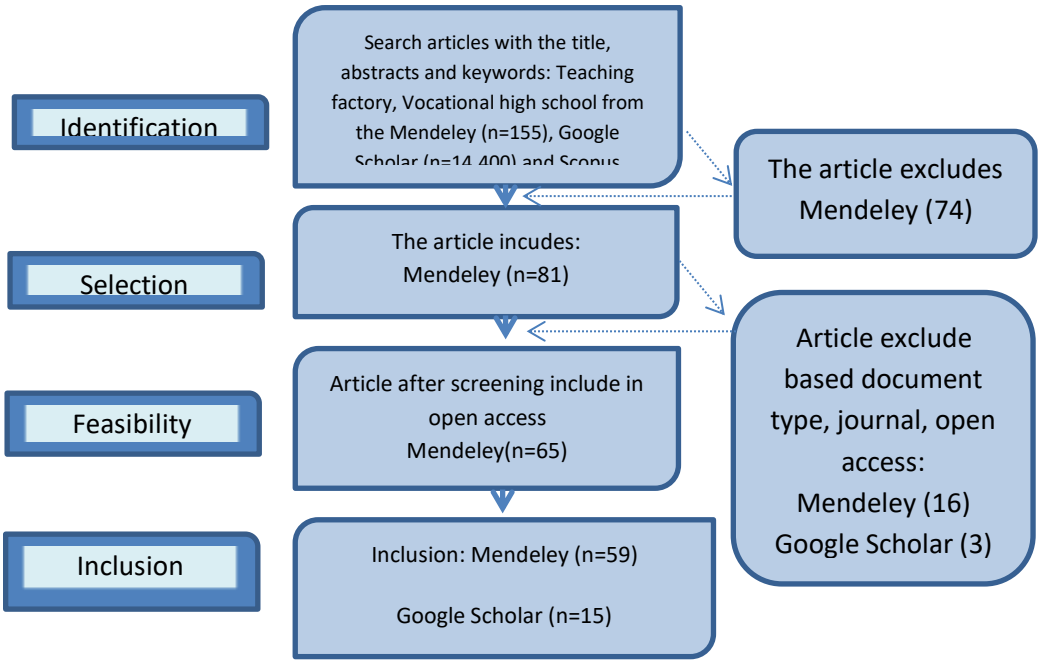

Figure 1.3. PRISMA Research Flow

RESEARCH RESULTS

The bibliometric analysis of 83 selected articles revealed 17 significant keywords that were organized into four interconnected clusters, reflecting the multidimensional nature of Teaching Factory (Tefa) research in Indonesian Vocational High Schools (SMKs). The network visualization, which identified 43 keyword links with a total link strength of 49, indicates a strong thematic interrelationship among research topics. This connectivity suggests that Tefa-related studies do not exist in isolation but rather form part of a broader discourse on vocational education reform, industry school collaboration, and workforce development. Such interlinkages provide an important foundation for

understanding the systemic role of Tefa within Indonesia's Technical and Vocational Education and Training (TVET) ecosystem.

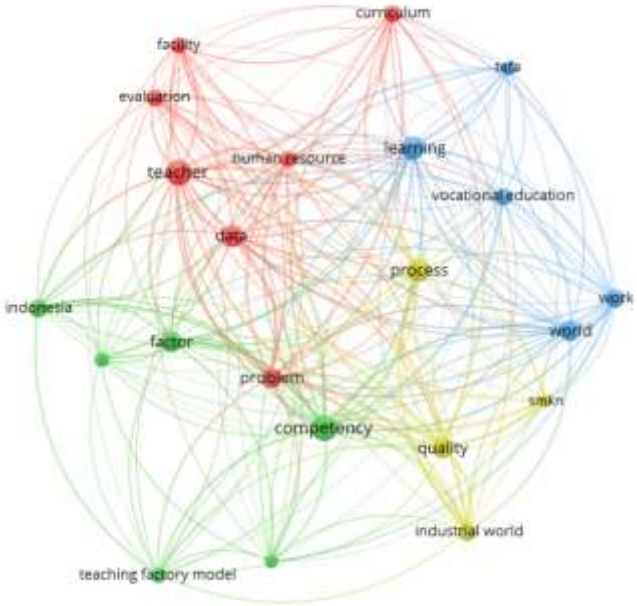

Figure 1.4. Network Visualization

Figure 1.4 above is a visualization of the data network using VOSviewer software from articles related to teaching factory and Vocational High School to identify the research areas and directions on teaching factory in Indonesia based on keyword co-occurrence in the literature. The network shows 17 keywords, 4 distinct clusters, 43 links (relationships between keywords), and a total link strength of 49.

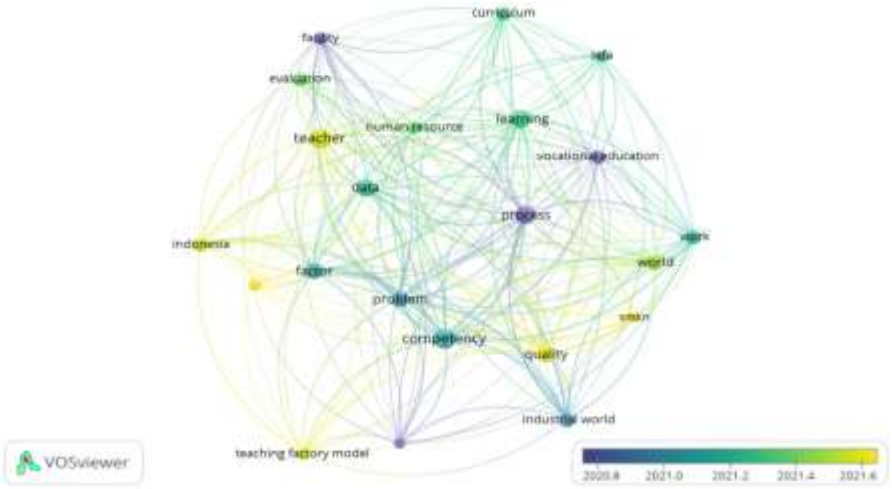

Figure 1.5. Overlay Visualization

Figure 1.5 above is an overlay visualization, showing several phases in the research. The initial phase focuses on facilities, curriculum, vocational education, and processes. The next phase shows a greater emphasis on human resources namely teachers, quality, and other factors reflecting a shift toward quality improvement, the role of teachers, and contextual adaptation.

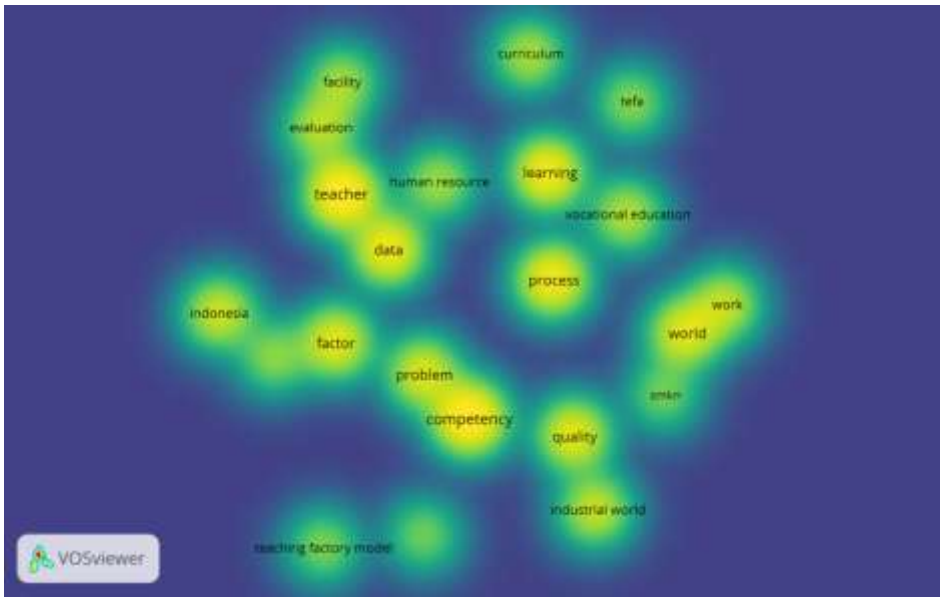

Figure 1.6. Density Visualization

The density visualization shows the highest frequency for the keywords Competence, Teacher, Learning, and Process. This indicates significant attention to competence and teacher capacity in teaching factory learning. Other keywords, such as teaching factory and industry, show a medium density. The clusters are then analyzed as follows:

a. Cluster 1, which includes keywords such as teachers, human resources, infrastructure, curriculum, facilities, and evaluation, underscores the significance of internal school capacities as critical enablers for successful Tefa implementation. Studies in this cluster frequently examine the preparedness of teaching staff, the adequacy of facilities, and the alignment of curricula with industrial standards. This aligns closely with UNESCO's (2016) TVET framework, which emphasizes teacher professionalization, infrastructure modernization, and curriculum adaptability as key pillars for vocational education transformation. The repeated appearance of "evaluation" in this cluster highlights the growing awareness of the need for continuous assessment to ensure that Tefa programs remain relevant and effective in producing industry-ready graduates.
b. Cluster 2 focuses on competency development, SMKs in Indonesia, and the Teaching Factory model itself. This cluster reflects a shift from

content-driven education to competency-based education (CBE), wherein the acquisition of practical skills, problem-solving abilities, and employability competencies is prioritized over rote learning. The concentration of research in this area indicates that Tefa is increasingly viewed as a strategic mechanism for embedding transferable skills into vocational training. Moreover, the alignment of competency development initiatives with national qualification frameworks and ASEAN's Qualifications Reference Framework (AQRF) underscores Indonesia's efforts to position its vocational graduates for regional labor market competitiveness.

c. Cluster 3 centers on the Teaching Factory model, application, and implementation, addressing the operational dimension of Tefa. Research in this cluster examines practical aspects such as implementation fidelity, adaptation to local school contexts, and integration with industry-standard production processes. Many studies identify operational bottlenecks such as insufficient industry engagement, limited funding for facilities, and variability in teacher competency and propose scalable solutions tailored to different SMK profiles, whether urban, semi-urban, or rural. The presence of "application" as a keyword suggests that the discourse is moving beyond conceptual frameworks toward applied models that can be replicated across diverse educational environments.
d. Cluster 4 encompasses industry, quality, processes, challenges, and opportunities, thereby representing the interface between SMKs and the labor market. This cluster illustrates that Tefa cannot be effectively implemented without robust external partnerships. The recurring emphasis on "quality" highlights policy-driven pressure to improve graduate outcomes and meet the demands of Industry 4.0 and, increasingly, Industry 5.0. The presence of "challenges" and "opportunities" reflects a nuanced understanding among researchers that Tefa operates within a complex, dynamic environment, where industrial market trends, technological disruptions, and policy changes can either facilitate or hinder program success.

A temporal analysis of publication trends reveals a notable increase in research output from 2018 onwards, coinciding with major government-led initiatives such as the SMK Revitalization Program, the Link and Match policy, and the SMK Centre of Excellence (SMK PK) program. This pattern suggests a symbiotic relationship between policy reform and academic research, where new policy initiatives stimulate scholarly inquiry, and research findings, in turn, inform further policy adjustments. The spike in publications also reflects heightened awareness among educators, policymakers, and researchers of the urgent need to address the persistent employability gap among SMK graduates.

The most frequently addressed themes across the publications include Tefa implementation strategies, competency-based training models, and sustainable partnerships with industry. These thematic concentrations reflect national priorities in vocational education, particularly the emphasis on ensuring that graduates possess both technical expertise and soft skills demanded by employers. Importantly, the bibliometric mapping shows that these themes are not siloed; rather, they intersect with other clusters, indicating that effective Tefa implementation requires a holistic approach that integrates internal school reforms with external stakeholder engagement.

From a broader perspective, the interconnectedness of the four clusters reveals that Tefa functions not as a standalone initiative but as part of an integrated reform agenda aimed at transforming Indonesia's vocational education landscape. This multi-cluster synergy underscores the need for coordinated strategies that address teacher capacity, curriculum relevance, infrastructure adequacy, and sustained industry collaboration simultaneously. Such a comprehensive approach ensures that Tefa remains adaptable, scalable, and responsive to evolving market conditions, both domestically and in the context of regional economic integration.

Finally, the bibliometric findings highlight critical research gaps that warrant attention. These include the absence of longitudinal impact studies to track graduate outcomes over time, limited cost–benefit analyses to assess financial sustainability, and insufficient exploration of digital transformation in Tefa environments. Addressing these gaps will not only strengthen the evidence base for Tefa policy and practice but also enhance its potential as a model for vocational education reform in other developing countries facing similar school-to-work transition challenges.

DISCUSSION

This study demonstrates that research on the implementation of Teaching Factory (Tefa) in Indonesian Vocational High Schools (SMKs) has experienced substantial growth since 2018, coinciding with major national policy interventions such as the SMK Revitalization Program, Link and Match initiatives, and the SMK Centre of Excellence (SMK PK) program. The bibliometric mapping of 83 selected articles revealed four thematic clusters that together offer a comprehensive understanding of Tefa's role in vocational education reform. The first two clusters reflect internal school capacities teacher quality, infrastructure, curriculum alignment, and competency development while the latter two emphasize external linkages, including industry collaboration, quality assurance mechanisms, and the identification of challenges and opportunities within the labor market. These findings confirm earlier research by Muslim et al. (2019) and Safarinah et al. (2022), which highlighted Tefa's strategic position in bridging the gap between school-based training and industry requirements.

The keyword network analysis, with 43 connections and a total link strength of 49, indicates that Tefa-related research is characterized by high thematic

interconnectivity. This suggests that successful implementation requires an integrated approach that simultaneously addresses pedagogical, infrastructural, and industrial factors. Studies in Cluster 1 and Cluster 2 often emphasize the foundational role of teacher competency enhancement, curriculum reform, and resource adequacy, all of which align with UNESCO's TVET reform principles and ASEAN's regional qualifications frameworks. In contrast, Clusters 3 and 4 capture the operational and market-oriented aspects of Tefa, examining implementation fidelity, industry partnership models, and responsiveness to evolving economic demands.

Despite this positive trajectory, several persistent challenges emerge from the literature. Industry engagement, although widely recognized as critical, remains uneven and often dependent on short-term agreements rather than long-term institutional partnerships. Similarly, curriculum adaptation struggles to keep pace with technological advances associated with Industry 4.0 and the emerging Industry 5.0 paradigm, potentially limiting the relevance of graduate competencies. Teacher professional development programs also face barriers in equipping educators with up-to-date industrial skills, particularly in rural or resource-limited contexts (Imran, 2023). Addressing these gaps will require systematic policy support, targeted investment, and the development of scalable best practices that can be adapted across diverse SMK profiles.

The increase in Tefa-related publications post-2018 also reflects a shift toward evidence-based policymaking in Indonesia's vocational sector. Researchers have begun to explore more complex themes, such as competency-based assessment, entrepreneurship integration, and the use of digital tools to simulate industrial environments. This aligns with global trends advocating for hybrid models of vocational education that combine technical skill acquisition with entrepreneurial and adaptive capabilities, preparing graduates for both employment and self-employment in dynamic labor markets. Integrating digital transformation into Tefa environments through IoT, AI, and automation remains an underexplored yet critical frontier for future research and practice.

In conclusion, the bibliometric evidence positions Tefa not only as an instructional model but as a systemic educational reform strategy with the potential to transform vocational education in Indonesia. Its effectiveness depends on the alignment of internal school readiness with external industrial partnerships, sustained curriculum modernization, and continuous teacher professionalization. If these conditions are met, Tefa could serve as a benchmark for vocational education reform in other developing economies seeking to enhance school-to-work transitions. Future research should prioritize longitudinal impact evaluations, cost-effectiveness studies, and cross-sectoral innovation frameworks to ensure that Tefa remains responsive, inclusive, and future-oriented in addressing workforce readiness challenges.

CONCLUSION

This study provides strong bibliometric evidence that the Teaching Factory (Tefa) model has evolved into a strategic pillar of vocational education reform in Indonesia, particularly within Vocational High Schools (SMKs). Analysis of 83 publications from 2017 to 2025 revealed a steady growth in scholarly output, with a marked acceleration from 2018 onwards coinciding with major policy interventions such as the SMK Revitalization Program, the Link and Match initiative, and the SMK Centre of Excellence (SMK PK) program. The four identified thematic clusters internal school capacities, competency development, operational implementation, and industry engagement illustrate that Tefa is not a standalone pedagogical approach but a systemic reform strategy requiring holistic alignment between school-based resources and external industrial partnerships.

In conclusion, Tefa holds significant potential as a transformative model for aligning vocational education with labor market demands in Indonesia. Its continued success will depend on the alignment of internal capacities teacher quality, infrastructure, curriculum with robust and sustained external engagement from industry. By addressing the identified gaps and implementing the recommended strategies, Indonesia can not only enhance the employability of its SMK graduates but also position Tefa as a model for vocational education reform in other developing economies. Sustained collaboration between policymakers, educators, researchers, and industry actors will be essential to ensuring that Tefa remains responsive, inclusive, and capable of preparing graduates for the evolving demands of the 21st century workforce.

RECOMMENDATION

Despite the positive trends, this review also highlights persistent challenges in sustaining industry involvement, modernizing curricula in line with rapid technological change, and equipping teachers with up-to-date industrial skills. While national policies have emphasized the importance of industry collaboration, the literature indicates that many partnerships remain ad hoc and short-term, limiting the continuity and depth of engagement. Furthermore, the slow pace of curriculum adaptation to Industry 4.0 and the emerging Industry 5.0 paradigm risks creating a widening gap between graduate competencies and market expectations (Imran, 2023). These gaps underscore the necessity for targeted interventions and the institutionalization of best practices across diverse SMK contexts.

Given these findings, several recommendations emerge for policymakers, educators, and industry stakeholders. First, long-term, mutually beneficial partnerships between SMKs and industries must be prioritized through formal agreements, shared resource investments, and co-managed training programs. Second, curriculum frameworks should be reviewed periodically in collaboration with industry experts to ensure relevance to emerging technologies and labor market needs. Third, continuous professional development for SMK teachers

should be institutionalized, with incentives for industry placements and participation in upskilling programs focused on digital technologies, automation, and sustainable production methods.

For researchers, this study highlights the need for more longitudinal studies tracking graduate employability, workplace performance, and career trajectories to measure the long-term impact of Tefa. Additionally, future investigations should expand into underexplored areas such as the integration of digital transformation in Tefa environments, cost–benefit analyses of production-based learning, and the role of entrepreneurship education in strengthening vocational graduates' adaptability. A stronger evidence base in these areas would enable policymakers to design more effective interventions and allow schools to implement Tefa in ways that are both contextually relevant and economically sustainable.

ADVANCED RESEARCH

Future research on the Teaching Factory (Tefa) model should focus on evaluating its long-term impact on graduate employability, career progression, and adaptability to rapidly changing labor market demands. Comparative studies across different regions and industries are needed to assess the consistency and scalability of Tefa implementation, while longitudinal research can provide deeper insights into how sustained industry partnerships influence educational outcomes. In addition, exploring the integration of emerging technologies, digital skills, and green economy competencies within Tefa could strengthen its relevance in preparing students for future-oriented professions. Finally, studies examining policy effectiveness, stakeholder collaboration, and institutional challenges will be essential to refine the model and support its adoption in broader vocational education contexts.

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