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Evaluating the impact of the teaching factory model on Vocational High School student competencies in the SMK Centre of excellence program

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Abstract. The study analyzes the impact of the Teaching Factory learning model on enhancing Vocational High School (SMK) students' competencies under the SMK Center of Excellence (SMK PK) Program. The model bridges education and industry by providing practice-based learning tailored to job market demands. Using a quantitative pre-test and post-test method combined with PLS-SEM, data was gathered through observations, questionnaires, and interviews with students, teachers, and industry partners. Results reveal a significant improvement in technical skills, work readiness, and soft skills, including problem-solving, teamwork, and discipline. Industry collaboration strengthened curriculum relevance and training quality, enhancing graduates' employability. Aligned with SDG 4 (quality education), the study highlights the model's success in preparing students for the workforce and recommends its broader application to elevate vocational education competitiveness in Indonesia.

1 Introduction

According to data from Statistics Indonesia (BPS) in July 2024, the National Labor Force Survey (Sakernas) recorded a total workforce of 149.38 million individuals as of February 2024 [1]. Among this population, the Open Unemployment Rate stood at 4.82%, equivalent to 7.02 million people, while the under-employment rate remained relatively high at 8.52%. When analyzed by age group, the highest unemployment rate was observed among youth aged 15–24, reaching 16.42%. This demographic predominantly represents individuals at the high school education level.

The unemployment age pyramid highlights the challenges the younger generation faces

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in entering the labor market, particularly in the context of globalization and demands from Industrial Revolution 4.0, which requires a workforce with both advanced skills and comprehensive knowledge [2]. This issue is closely tied to the government's policy agenda (RPJMN 2025–2029, which prioritizes human resource development as a key pillar in achieving Indonesia Emas 2045. Strengthening human resource development is essential to address these challenges. Within this framework, vocational education, whether at the secondary or tertiary level, plays a pivotal role in preparing a skilled and competitive workforce. However, a critical challenge faced by vocational education lies in bridging the gap between graduate competencies and the demands of the industry, which hinders the alignment of educational outcomes with workforce needs.

To address the gap between vocational education and industry demands, an innovative learning model is required, such as the Teaching Factory (TEFA) learning model. Conceptually, TEFA is a vocational high school learning model based on production or service activities that adhere to industry standards and procedures, implemented in an environment designed to replicate real industrial settings. According to Chryssolouris *et al.* (2016) , the Teaching Factory paradigm integrates an education model with the necessary ICT configurations to facilitate interactions between industry and students or academia [3]. Over recent years, this model has gained recognition as an effective approach to enhancing the competencies of vocational high school students. At its core, the TEFA model transfers the industrial production environment into classroom practice, enabling students to engage in learning activities that mirror daily industrial operations [4]. With the growing diversification of vocational expertise programs, this practice space can extend beyond traditional settings to include environments such as livestock pens or open agricultural fields, providing students with authentic, industry-aligned learning experiences.

Numerous studies have demonstrated that the TEFA model positively impacts the development of student competencies, encompassing both technical proficiency and interpersonal skills [2, 5, 6]. In line with this, the Directorate of Vocational High Schools under the Ministry of Education, Culture, Research, and Technology of Indonesia launched the Center of Excellence Vocational High School (SMK PK) program in 2020. One of the program's primary objectives is to enhance student competencies, enabling graduates to pursue employment, further education, or entrepreneurship. Despite its potential, the implementation of TEFA in SMK PK schools encounters various challenges, including limited infrastructure, the need for improved teacher quality, and insufficient collaboration with industry partners [7]. These challenges underscore the need for more comprehensive research to evaluate the effectiveness of the TEFA model in enhancing student competencies and addressing the evolving demands of the workforce at SMK PK institutions.

This study aims to evaluate the impact of implementing the TEFA learning model on the development of student competencies, encompassing both hard skills and soft skills. The findings of this research are expected to provide valuable insights for optimizing the implementation of the TEFA model in vocational schools and serve as a foundational reference for shaping future vocational education policies to enhance the alignment between education and industry needs.

2 Methods

2.1 Time and location

This study was conducted from August to October 2024, involving a sample of seven vocational schools participating in the SMK PK program initiated by the Directorate of Vocational Schools. The selected schools include SMKN 2 Cilaku (Cianjur), SMKN 4

Bogor, SMKS 1 Triple J Bogor, SMKN 1 Leuwiliang, SMKN Gorontalo Utara, SMKN 1 Gandapura-Bireun, SMK Negeri Pringsurat, and SMKN 2 Kisaran. These schools were chosen due to their implementation of the program, which aligns with the objectives.

2.2 Data and resources

The population in this research consisted of students, teachers, and alumni from vocational schools involved in the Center of Excellence Vocational School program that implemented TEFA learning model. The research sample, comprising 532 respondents, was selected using a purposive sampling technique. Data collection employed a structured questionnaire designed to assess two main aspects: the implementation of the TEFA model and the development of student competencies. The implementation of the TEFA model was measured using indicators such as the alignment of learning with industry needs, the involvement of industry practitioners, and the use of representative practice facilities. Meanwhile, student competency development was assessed through dimensions of knowledge acquisition, technical skills, and work attitudes. The questionnaire was structured using a 5-point Likert scale, ranging from “Strongly Disagree” (1) to “Strongly Agree” (5). Data collection begins with the preparation of a questionnaire based on predetermined indicators, validation of the questionnaire through validity and reliability tests, and limited trials on a small number of respondents, followed by distribution of the questionnaire to respondents who have met the sample criteria. Furthermore, the collection of questionnaires that have been filled out completely by respondents.

2.3 Data analysis methods

Descriptive statistics and the Structural Equation Modeling (SEM) analytic method are two quantitative methods used in this study. SEM has the ability to assess the relationship between variables [8, 9]. The distribution of respondents' responses of the application of the Teaching Factory model and the growth of student skills was ascertained by analyzing the data. The association between the TEFA learning model's implementation and the competency development of Vocational High School students enrolled in the Center of Excellence Vocational School program was examined using the SEM model with Smart Partial Least Squares (PLS) software. The presence of TEFA in vocational high schools serves as the study's independent variable, while the community's growth in hard and soft skills is one of the variables tracked.

3 Results and discussion

3.1 Respondent demographics, engagement, and respondent understanding of teaching factory

The 513 respondents involved in this study have characteristics as outlined in Table 1. Based on the data presented, most responses were contributed by teachers and students from vocational schools, while alumni accounted for 1.8% of the total respondents. Further details regarding the stratification of student and teacher groups are illustrated in Fig 1 and 2, providing a more comprehensive view of the distribution across different classes and categories.

Table 1. Respondent characteristics.

Variable	Respondent
Gender	
- Female	54.6%
- Male	45.5%
Age	16-58 years old
Occupation	
- Teacher	48.7%
- Student	49.5%
- Graduate	1.8%

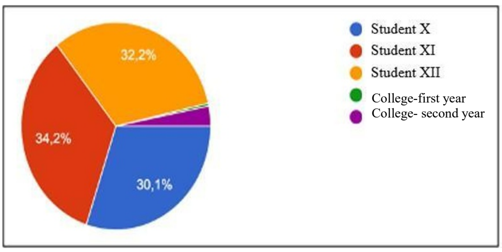

Fig. 1. Student and alumni respondent clusters

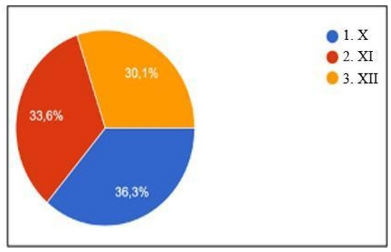

Fig. 2. Teacher respondent cluster

Understanding the general condition of the Teaching Factory (TEFA) is crucial in this study, as it provides a foundation for evaluating the extent to which TEFA-based learning processes are implemented in vocational high schools (SMK) and serves as an indicator for enhancing the competencies of students and alumni. Additionally, assessing the condition of TEFA in each SMK is essential, given that each school has unique characteristics that may influence the success of TEFA implementation. Based on data from respondents, the presence of TEFA in their SMKs and the school's participation in the SMK PK program were reported. A total of 65.8% confirmed that their schools participated in the SMK PK program. However, some were unsure whether their schools participated, and a small portion (8.8%) stated that their schools did not (Fig 3).

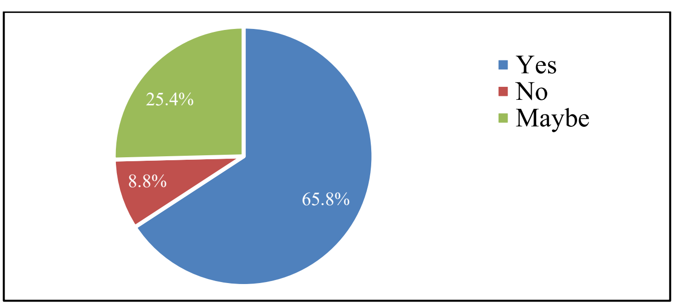

Fig. 3. The school's involvement in the SMK PK Program

Furthermore, the leading TEFA fields across schools vary, encompassing TEFA in agriculture, food processing or culinary arts, informatics, and hospitality. It is important to note that the prominent TEFA fields are closely aligned with the expertise areas of the SMK PK program, which focuses on specific TEFA specializations. This observation is further supported by the research findings presented in Fig 4.

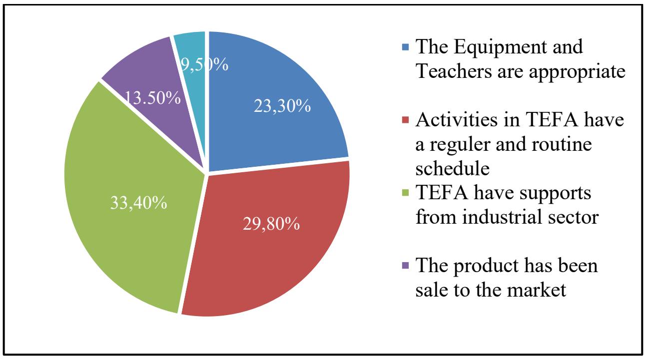

Fig. 4. The criteria for TEFA are considered prominent

As illustrated in Fig 4, several key factors strongly influence the development and excellence of a TEFA in SMK. The most dominant factor, cited by 33.4% of respondents, is the support and collaboration established with industry partners. This is followed by routine and structured activities within the TEFA, indicating that the production of goods or services is conducted consistently (29.8%). Additionally, the availability of comprehensive TEFA equipment and the competence of teachers are significant factors, accounting for 23.3% of responses. Through the SMK PK program, SMK have been provided opportunities to revitalize their TEFA facilities, including constructing dedicated TEFA spaces, equipping them with industry-standard tools, and enhancing teacher expertise through internship programs in industries relevant to the specific TEFA field. These efforts collectively contribute to strengthening the implementation and success of the TEFA model.

Overall, the SMK PK program has significantly encouraged active production activities within the Teaching Factory (TEFA) at participating vocational schools. Based on the study's findings, the duration of TEFA operations at these schools varies, with 28% of respondents indicating activities have been ongoing for more than one year, 22% reporting a duration of six months to one year, and 37% noting that TEFA activities have started within the past six months. The remaining respondents were uncertain about the exact commencement of TEFA operations. The readiness of a TEFA in vocational schools is supported by several critical factors, including the availability of facilities and infrastructure, partnerships with industry, the competence of teaching staff, a production-based curriculum, school management support, student preparedness, adequate funding, and continuous evaluation mechanisms. The distribution of the duration of TEFA activities across vocational schools is illustrated in Fig 5.

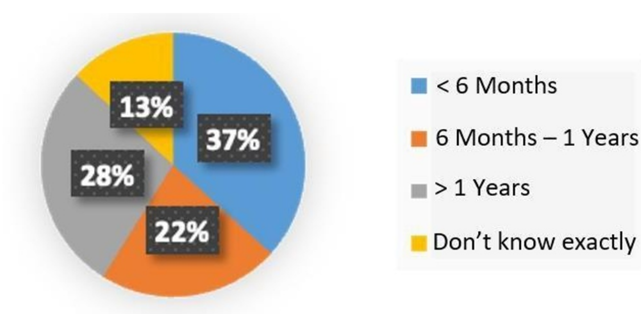

Fig. 5. Duration of TEFA activities at SMK

Descriptive data were obtained the results of quantitative questionnaire calculations and descriptive analysis of interview results. The following are the results obtained based on the answers to the questionnaire from respondents related to the teaching factory concept in vocational schools.

Based on Table 2, respondents from the vocational school community generally demonstrated a good understanding of the Teaching Factory concept. This is evident from the responses to Question 1, where scores predominantly ranged from 3 to 5. Respondents also assessed that the activities conducted in TEFA at vocational schools align with their needs and are supported by adequate facilities that enhance the learning process. Furthermore, the condition of TEFA in vocational schools is perceived to closely resemble actual industry environments.

Table 2. Assessment of TEFA in Schools

Questions	Score (%)				
	1	2	3	4	5
1. To what extent do you comprehend the concept of the Teaching Factory (TEFA)?	8.2	10.8	**33.1**	24.5	23.5
2. To what extent do the Teaching Factory activities at your school align with your needs?	4.4	5.8	29.3	29.2	**31.3**
3. To what extent are the facilities provided in the Teaching Factory (e.g., equipment, practical rooms, and other resources) adequate to support your learning process?	4.8	6.6	24.3	29.4	**35**
4. To what extent do you perceive that the facilities in the Teaching Factory reflect the actual conditions found in companies or industries?	4.6	6.6	32.4	**32.6**	23.8

One of the primary objectives of TEFA is to bridge the gap between education and the workforce. According to the Ministry of Education, Culture, Research, and Technology (2020), the TeFa learning environment should mirror real work conditions, allowing students to acclimate to the demands and expectations of the industrial sector. The respondents' perception that TeFa conditions are close to industrial standards indicates significant progress toward achieving this goal. Sudiyono (2019) further explains that TEFA aims to create a learning atmosphere that replicates the real-world workplace, enabling students to develop both technical and non-technical competencies required by the industry [4].

These findings align with Al'Abri *et al.* (2022) [10], who state that a successful TEFA program must address the needs of both students and industry while being supported by adequate learning facilities. The positive perceptions of respondents regarding the alignment of TEFA activities with industry need to underscore the program's adherence to established theories and best practices. Moreover, the adequacy of facilities is a critical factor in the successful implementation of TEFA. As Setyawan *et al.* (2016) [11] emphasize, providing industry-standard tools and creating a realistic work environment are essential for effective learning. This corresponds with respondents' feedback that the facilities in vocational schools adequately support the learning process, further validating the effectiveness of TEFA implementation.

3.2 The impact of teaching factory on competency development

The Structural Equation Modeling (SEM) analysis is designed to validate the indicators and relationships identified in the theoretical framework while determining the predictive value of the proposed structure. This is achieved by examining the relationships between the four identified variables: SMK, TEFA, hard competencies, and soft competencies. Cronbach's alpha was used to evaluate the questionnaire's reliability, while content and convergent validity were used to evaluate its validity. Validity is confirmed when the T-value exceeds 1.96 and the P-value is less than 0.05. The R^2 criterion, representing the coefficient of determination, was utilized to evaluate the model's ability to explain and predict the dependent variable based on the independent variables. Factor loading, which measures the strength of the relationship between latent and observed variables, is considered optimal with values above 0.4. The overall fit of the model, encompassing both the measurement and structural models, was assessed using the Goodness-of-Fit (GOF) criterion to ensure the model's adequacy [10].

The reliability test of the instrument indicates that the instrument used to evaluate the impact of the Teaching Factory learning model on the competencies of SMK Center of Excellence students demonstrates high reliability and validity. All constructs including Hard Competence, SMK, Soft Competence, and TEFA achieved excellent reliability scores, as indicated by Cronbach's Alpha, ρ_A, and Composite Reliability ranging from 0.823 to 0.960 (Table 3). These results confirm that the research instrument is robust and suitable for assessing the impact of the TEFA model on vocational students' competency development.

Table 3. Results of PLS-SEM Analysis of TEFA in Schools

	Cronbach's Alpha	**ρ_A**	**Composite Reliability**	**AVE**
Hard Competence	0.959	0.959	0.964	0.729
SMK	0.941	0.942	0.952	0.738
Soft Competence	0.957	0.958	0.962	0.680
TEFA	0.741	0.800	0.832	0.518

The results of the PLS-SEM analysis regarding the impact of TEFA on the development of SMK students' competencies indicate that implementation of the TEFA learning model has a positive and significant effect (P-Value ≤ 0.05) on competency development. The analysis highlights those variables such as technical skills, soft skills, learning motivation, and teamwork skills are significantly enhanced through this model. The relationships among these variables are visually represented in the figure below, illustrating the positive impact of the Teaching Factory model on student outcomes in vocational education. Overall, the results highlight that implementing TEFA in vocational education significantly enhances students' skills, employability, and readiness for real-world industry challenges.

Based on the model presented in Fig 6, the analysis reveals that students participating in Teaching Factory-based Learning demonstrate a significant improvement in technical skills relevant to their areas of study. The path coefficient indicates a strong and positive relationship between the implementation of the TEFA model and the enhancement of technical skills. Regarding soft skills, the application of this model also significantly contributes to the development of students' abilities in communication, collaboration, and leadership. The analysis further identifies soft skills as a mediating variable, strengthening the relationship between the learning model and the overall competency of students.

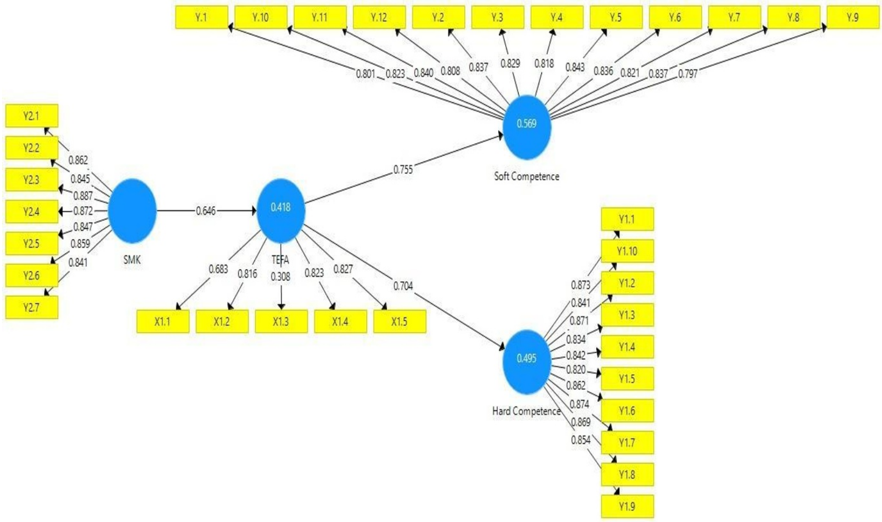

Fig. 6. Model of inter-variable relationships

For the learning motivation variable, the PLS-SEM results indicate a substantial increase in students' motivation to learn following the implementation of the TEFA model, which positively influences their academic and practical outcomes. In terms of teamwork abilities, the analysis shows that students involved in collaborative projects within the Teaching Factory framework exhibit notable improvements in teamwork skills, a critical attribute for their readiness to enter the workforce.

Overall, this study recommends broader integration of the Teaching Factory learning model into the vocational high school curriculum. The findings demonstrate that the model effectively enhances student competencies, both technical and non-technical, aligning with the skills demanded by the industry and preparing students for successful careers.

Table 4. Fit model

	Saturated Model	**Estimated Model**
R	0.040	0.186
d_ULS	0.964	20.00
d_G	0.734	1.000
Chi-Square	1.858	2.581
NFI	0.878	0.830

Furthermore, related to the results of path analysis using SEM, focusing on the relationship between latent variables related to SMK and the competencies produced through TEFA, it is shown in Table 6. It appears that a strong positive correlation exists between SMK and TEFA. This means that improving the quality of SMK contributes to the development of TEFA. Likewise, the relationship between TEFA and student competence and SMK and student competence shows strong and reliable results. All four have a significant positive relationship with a very low p value (0.000).

Table 6. Significance testing of latent pathways

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
SMK->TEFA	0.646	0.65	0.036	18.205	0.000
TEFA->Hard Competence	0.704	0.706	0.031	22.589	0.000
TEFA->Soft Competence	0.755	0.767	0.026	28.880	0.000
SMK->Hard Competence	0.455	0.460	0.043	10.592	0.000
SMK->Soft Competence	0.488	0.492	0.040	12.071	0.000

The R-Square (R^2) and Adjusted R-Square (R^2 Adjusted) values are key metrics for evaluating the explanatory power and fit of a model. These values indicate how well the independent variables in the model explain the variance in the dependent variable(s). The model explains almost half of the variance in Hard Competence, which is a decent result, and the adjusted R^2 confirms that the model does not overestimate its explanatory power (Table 7).

Table 7. R Square Value

	R Square	R Square Adjusted
Hard Competence	0.495	0.494
Soft Competence	0.569	0.568
TEFA	0.418	0.416

The model explains for a significant proportion of the variance in Soft Competence, as indicated by a strong R^2 value. This suggests a good model fit, with the adjusted R^2 confirming that the explanatory power is robust and not overestimated. For the TEFA construct, the model explains a moderate proportion of the variance, reflecting a slightly lower explanatory power compared to the other constructs. Nevertheless, the result remains reasonable, suggesting that the model provides a satisfactory explanation, albeit with room for improvement. In the case of Hard Competence, the model explains approximately 49.5% of the variance, indicating a moderate level of success in capturing the factors influencing this construct. This demonstrates the model's ability to provide a fair explanation of outcomes related to Hard Competence. Regarding Soft Competence, the model explains 56.9% of the variance, representing a relatively strong explanatory power. This indicates that the model effectively captures the key factors driving Soft Competence development.

For the TEFA construction, the model accounts for 41.8% of the variance, which is moderate. While this shows the model's ability to provide a reasonable explanation, it also suggests that other unexamined factors may influence the implementation and outcomes of the TEFA construct. Overall, the model demonstrates varying degrees of explanatory power across the constructs, with stronger performance in Soft and Hard Competence compared to TEFA.

3.3 Managerial Implications

In general, the implementation process of the TEFA in SMK can be conceptualized as illustrated in Figure 7 below. Additionally, the managerial implications derived from the analysis of TEFA development in SMK encompass several key aspects that require effective management to achieve educational objectives that are both impactful and aligned with industry needs. To achieve effective implementation, several key managerial implications must be considered. These include aligning the curriculum with industry standards to ensure relevance, managing infrastructure and facilities to create an industry-simulated learning environment, and enhancing teacher capacity through professional development programs and industry exposure. Additionally, fostering strong collaboration with industry partners is essential for facilitating internships, apprenticeships, and job placements [10]. Equally important is the implementation of structured assessment methods to evaluate technical and soft skills, ensuring that students are well-prepared for the workforce. Sustainable funding strategies, supported by government initiatives and industry partnerships, are also crucial for maintaining and expanding TEFA programs. Lastly, establishing a robust monitoring and evaluation system is necessary to assess the effectiveness of TEFA implementation and drive continuous improvement.

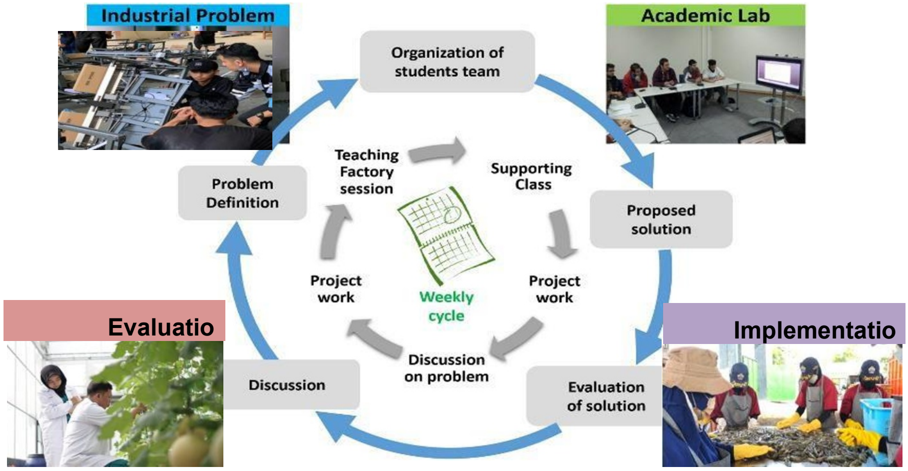

Fig. 7. Teaching Factory cycle for knowledge transfer (modeified Chryssolouris, Mavrikios, Rentzos (2016) [2])

To ensure the successful implementation of the TEFA model in SMK, several strategic steps are necessary [12]. First, curriculum development must integrate the TEFA learning model to align with industry demands, creating a more relevant and competency-focused educational framework. Additionally, professional training for teachers is vital to equip them with the skills needed to manage project-based learning effectively, thereby enhancing students' technical and soft skills. Strong partnerships with industry are equally important, as these collaborations can provide essential resources, facilities, and real-world experiences for students, making learning more applicable to workplace realities.

Furthermore, continuous evaluation systems should be established to assess the effectiveness of the TEFA model. Feedback from students, teachers, and industry partners can guide ongoing improvements to the learning process. Adequate facilities and infrastructure are also critical; management must ensure the availability of industry-standard equipment to support quality learning experience. Finally, promoting SMK programs that implement the TEFA model to the public and prospective students is necessary to increase the attractiveness of vocational education and attract students who are eager to learn in innovative and practical environments. By taking these measures, vocational high schools can create a more effective and relevant learning environment, preparing students with the competencies needed to succeed in the workforce.

4 Conclusion

The Teaching Factory (TEFA) as a learning model in SMK aims to provide students with the technical and practical skills required by industry. This study successfully analyzed the impact of implementing the TEFA model on the development of student competencies across several vocational schools participating in the SMK PK Program. By equipping students with relevant technical and soft skills, TEFA bridges the gap between education and industry demands, ensuring graduates are better prepared for the workforce.

Analysis using PLS-SEM demonstrated the significant association between the variables of SMK, TEFA, and competency at 0.05 significance level. The loading factors confirmed that all defined indicators meet the criteria for measuring latent variables. Moreover, regression coefficients exceeding 1.96 indicate a positive and significant relationship between these variables and constructs. The findings reveal that the TEFA learning model significantly enhances students' technical and soft skills and the effectiveness of practice-based and project-based learning methods. It also boosts students' learning motivation, a key factor in achieving better learning outcomes, and strengthens teamwork skills, which are essential in the workplace.

This study underscores the importance of integrating the TEFA learning model more broadly into vocational school curricula to support the government's vision of creating excellent schools. Students will be better equipped to face the challenges of the industrial world and fulfill the demand for a skilled and competent workforce. Overall, the implementation of the TEFA model not only enhances students' competencies but also prepares them to contribute meaningfully to a dynamic and evolving labor market.

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