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Production-based teaching factory learning model: Enhancing soft skills and simulating the industrial environment

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Abstract. According to the Central Statistics Agency, the high unemployment rate among vocational school graduates is caused by the mismatch between their technical competencies and professional character with industry needs. Vocational schools aim to prepare graduates with excellent skills and character for the business and industrial world. This study aims to create a teaching factory learning model at SMK 1 Perguruan Cikini using the Research and development method with the 4D model (define, design, develop, and disseminate). The study resulted in a 4P+QD teaching factory model, which consisted of divisions such as project sales, PPIC, production, purchasing, quality control, delivery, and after-sales. The model was validated by two expert lecturers, resulting in an average score of 3.54 ("Very Valid"). Evaluations by two productive subject teachers yielded a score of 3.71 ("Very Valid"), while assessments from the teaching factory coordinator and industry practitioners resulted in a score of 3.33 ("Valid"). The model was also tested on students, who evaluated the development of character traits such as honesty, discipline, responsibility, cooperation, adaptability, and creativity, with an average score of 3.47 ("Valid"). This learning model can serve as a reference for vocational high schools (SMK) seeking to implement production unit-based or teaching factory learning processes.

Introduction

Human resource development is a fundamental pillar of national development. The Indonesian government continues to prioritize efforts aimed at enhancing the quality of human capital. In alignment with this objective, Indonesia's education policy seeks to expand access to quality education, foster synergy among government, industry, and higher education institutions, and strengthen collaborative linkages with the industrial sector (Indrawati & Kuncoro, 2021). Vocational High Schools (*Sekolah Menengah Kejuruan*, SMK) represent an educational pathway designed to equip graduates with both strong character and advanced competencies tailored to the demands of business and industry. This form of education emphasizes the development of practical, industry-relevant skills, enabling students to transition directly into the workforce. Consequently, vocational education graduates are generally better prepared to address the specific challenges and requirements of targeted occupational fields (Zhang, 2024).

Despite its potential, the synergy between SMK and the Business and Industrial World (*Dunia Usaha dan Dunia Industri*, DUDI) remains suboptimal, contributing to the low employment absorption rate among SMK graduates. This issue stems primarily from a misalignment between the competencies provided through SMK curricula and the actual demands of the labor market (Hidayat, 2023). Many SMK graduates still lack the intermediate and advanced skill sets required by industry (Sariwulan et al., 2020). Additionally, numerous partnerships between vocational schools and industry actors remain superficial and symbolic, failing to foster sustainable and effective collaboration (Syauqi et al., 2022). A persistent focus on increasing student enrollment, often at the expense of educational quality, further exacerbates the skill mismatch and limits graduates' ability to compete in the labor market (Song & Xu, 2024).

Data from the Open Unemployment Rate (*Tingkat Pengangguran Terbuka*, TPT) by educational attainment indicate that all graduate groups have experienced an upward trend in unemployment, mirroring the national increase in TPT. Among these groups, Vocational High School (SMK) graduates exhibit the highest unemployment rate, reaching 13.55 percent (Badan Pusat Statistik (BPS), 2024). In response, the Indonesian government developed a roadmap for SMK development for the period 2010–2014. This roadmap emphasised the enhancement of students' adaptive capacities, the cultivation of entrepreneurial spirit, the improvement of language and ICT proficiencies, and the implementation of the Teaching Factory (TF) program. The following section presents a synthesis of research findings related to these strategic initiatives.

Through the Directorate General of Vocational Education (*Direktorat Jenderal Pendidikan Vokasi*) under the Ministry of Education, Culture, Research, and Technology (*Kemendikbud Ristek*), the government introduced the *SMK Pusat Keunggulan* (Centre of Excellence) program, aimed at elevating the quality and performance of vocational education. The program's key initiatives include: (a) accelerating teacher upskilling and reskilling; (b) implementing a curriculum grounded in Problem-Based Learning (PBL) and soft skills development; (c) delivering leadership training for school principals; (d) improving educational infrastructure; and (e) institutionalising the teaching factory program.

The Teaching Factory (TF) initiative is designed to integrate academic instruction with industrial practices by engaging students in real-world, production-oriented activities. To be fully effective, the TF program must be further enhanced to fulfill the competency standards required at intermediate and advanced levels. Empirical studies indicate that both school management and the industrial learning environment significantly influence the employability of SMK graduates. The TF model aims to bridge the persistent gap between education and the labor market by offering immersive, hands-on experiences. While prior studies affirm the program's positive impact on employment absorption, they also highlight the need for further refinement to meet higher-level competency demands (Sariwulan et al., 2020). Accordingly, adjustments to the vocational curriculum, particularly those that align with local economic sectors and industrial needs, are deemed essential. Strengthening institutional collaboration between SMKs and industry partners, along with bolstering support from local governments, are also recommended strategies to enhance graduate employability and workforce competitiveness (Anam et al., 2023).

Despite the challenges associated with integrating practical learning into academic curricula, the teaching factory model has emerged as an effective pedagogical solution. This model facilitates the acquisition of technical competencies required in industrial settings while offering students a more authentic and contextually relevant learning environment. Through this approach, students engage directly in real-world industrial practices while simultaneously applying and reinforcing theoretical knowledge acquired in the classroom. This integration strengthens the connection between theory and practice, thereby enhancing students' preparedness for an increasingly dynamic and technology-oriented labor market (Radovic, 2022).

In the context of the Fourth Industrial Revolution, characterized by rapid digital transformation and the proliferation of automation technologies, the relevance and urgency of implementing the teaching factory model have intensified. The incorporation of digital technologies into instructional processes allows students to cultivate future-oriented skills such as programming, data analysis, and systems management (Widana & Ratnaya, 2021). Moreover, the adoption of hybrid learning models, which combine face-to-face instruction with online modalities, expands students' access to diverse educational resources and promotes greater flexibility, both of which are vital in addressing global challenges posed by industrial and technological shifts (Yondri et al., 2020).

Conceptually, the teaching factory represents an educational framework that merges real-world manufacturing experiences with academic learning through the application of Industry 4.0 technologies. This approach seeks to enhance student competencies by fostering immersive and interactive learning experiences. Its relevance is amplified in the Industry 4.0 era, where digitalisation and technological innovation are reshaping both production processes and pedagogical methodologies (Mourtzis et al., 2022). Furthermore, the teaching factory promotes collaborative engagement between academic institutions and industry partners, enabling students to participate in real-world projects and gain practical insights into contemporary industrial practices. This collaboration significantly narrows the gap between theoretical instruction and practical application, ultimately equipping students to navigate the complexities of the modern workforce (Kim et al., 2020; Purnadewi & Widana, 2023).

The integration of practical experiences with academic instruction in a teaching factory setting has been shown to improve students' comprehension of complex concepts and enhance their problem-solving abilities. This pedagogical approach fosters creativity and innovation by encouraging students to explore new ideas and experiment with emerging technologies (Rüdele & Wolf, 2024). Nevertheless, the implementation of the teaching factory model presents several challenges. These include substantial investments in technological infrastructure and the need for comprehensive faculty training to utilise digital tools effectively. Furthermore, maintaining cybersecurity and ensuring data privacy within digitally mediated learning environments are critical concerns (Fuertes et al., 2021).

Interview findings from SMK 1 Perguruan Cikini revealed that many graduates continue to fall short of the competency standards demanded by industry. According to the Vice Principal for Industrial Relations and Community Engagement, this gap is primarily attributed to the inadequate implementation of a learning system that effectively aligns educational content with actual industrial requirements, a concept widely referred to as "link and match." As a designated *Vocational School of Excellence*, SMK 1 Perguruan Cikini has formed collaborative partnerships with several industry stakeholders. One notable initiative involves PT Glory Mitra Sukses (GMS), which supports production activities related to personal computer (PC) assembly conducted within the school. This initiative aims to provide students with contextual, hands-on learning experiences that reflect real-world industrial processes. Consequently, the development of a pedagogically sound and industry-relevant learning model is deemed essential to support and optimise such production-based learning (Suryaningsih et al., 2025).

In light of these identified challenges and opportunities, the present study proposes to develop a learning model entitled *"Production-Based Teaching Factory Learning Model: Enhancing Soft Skills and Simulating the Industrial Environment."* The objective of this research is to design and validate a teaching factory model applicable to PC assembly activities at SMK 1 Perguruan Cikini.

Furthermore, this model is envisioned to serve as a scalable reference for other vocational institutions seeking to implement production-oriented teaching factory frameworks.

Method

This study used the Research and Development (R&D) method with the 4D Model developed by Thiagarajan, Semmel, and Semmel in 1974. It was a systematic instructional design framework consisting of four stages: Define, Design, Develop, and Disseminate, as outlined below:

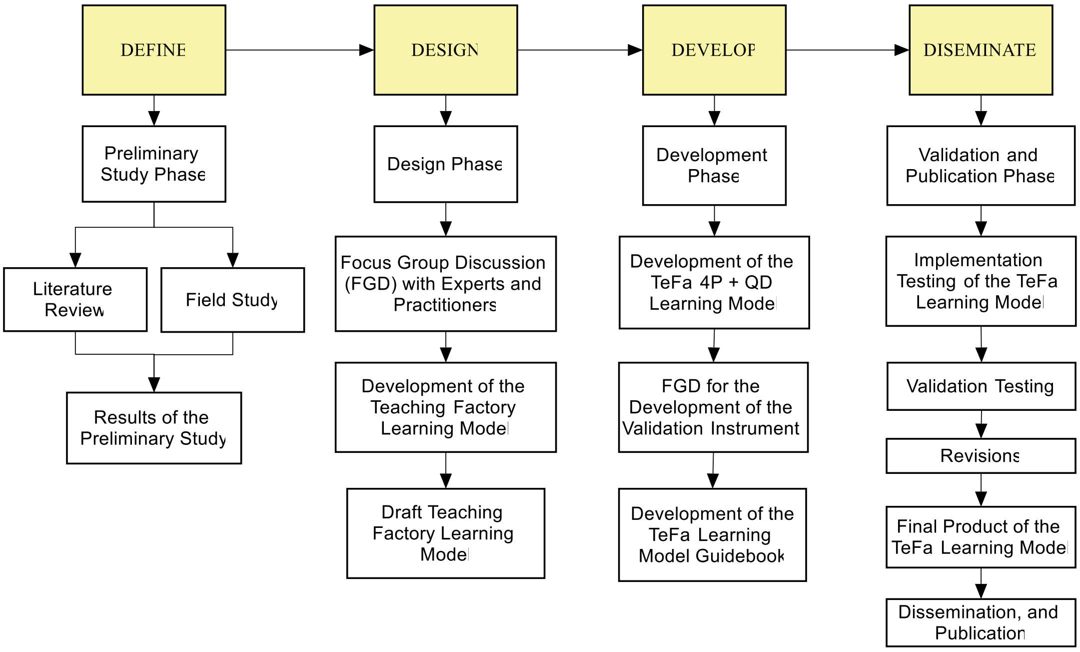

Image 1. Research Stages

Define

The define stage focused on identifying the needs and goals of the educational program within the context of the teaching factory. This included aligning intended learning outcomes with industry requirements and pinpointing key competencies essential for Industry 4.0, such as critical thinking and collaborative problem-solving (Wahjusaputri & Bunyamin, 2022). At this stage, the researcher undertook two primary activities: (1) conducting a comprehensive literature review to explore relevant theoretical foundations for model development; and (2) performing field research through observations and interviews to diagnose existing challenges, formulate research objectives, consult with school leadership, and ensure alignment between learning objectives and industry expectations.

Design

In the design phase, the instructional framework was constructed to develop a teaching factory model that integrates project-based and production-based learning approaches, aiming to replicate real-world industrial scenarios. This involved designing a curriculum that balances theoretical knowledge with hands-on practice (Yondri et al., 2020). A Focus Group Discussion (FGD) was conducted with stakeholders from SMK 1 Perguruan Cikini, including the principal, vice principals, vocational teachers specialising in Computer Network and Telecommunication Engineering, and industry representatives, to design the teaching factory model collaboratively. The FGD was held at Politeknik ATMI Cikarang and supplemented with an industrial visit to observe established production-based learning models. Insights from these activities informed the refinement and drafting of the Teaching Factory Learning Model.

Development

The development phase entailed the creation, refinement, and validation of educational materials and instructional strategies (Maksum et al., 2023). During this phase, the researcher developed the teaching factory model and conducted an FGD aimed at designing validation instruments. These instruments were subsequently used by expert lecturers, vocational teachers, teaching factory coordinators, and industry practitioners to assess the model. The finalised model was documented in the form of a guidebook, ensuring that it adheres to educational quality standards and is ready for implementation.

Disseminate

The dissemination phase involved the implementation of the finalised model in an actual educational setting, accompanied by an evaluation of its effectiveness. This process included field trials and iterative revisions based on stakeholder feedback (Kautsar et al., 2022). The initial stage involved experts' validation of the assessment instruments. This was followed by classroom implementation, in which the teaching factory model was applied through a computer assembly learning activity. The trial was conducted with students from Class X TKJ A and Class X TKJ B (Computer and Network Engineering)

Following the field trial, the developed learning model was subjected to a validation process involving a panel of experts, including university lecturers and vocational teachers as academic specialists, as well as industry practitioners serving as experts in production and service contexts. The validation aimed to assess the effectiveness of the model and to collect student feedback on character development outcomes following participation in the teaching factory-based learning activities.

Data collection was conducted using structured questionnaires consisting of closed-ended statements. For expert respondents, a four-point Likert scale was utilized with the following scoring criteria: 1 = not valid at all, 2 = not valid, 3 = valid, and 4 = highly valid. For student respondents, the questionnaire employed a four-point scale as well, comprising: strongly disagree, disagree, agree, and strongly agree.

The data were analysed through a combination of qualitative and quantitative methods. Descriptive qualitative analysis was applied to data obtained from interviews, field observations, and documentation, while quantitative data from the questionnaires were tabulated and analysed statistically. Table 1 presents the scoring rubric used to categorise the validation results, based on the average score for each assessment criterion (Azwar, 2012).

Table 1. Validation Assessment Criteria

Interval	Category
3.5 – 4.0	Very Valid
2.5 – 3.5	Valid
1.5 – 2.5	Less Valid
0.5 – 1.5	Not Valid

Following the evaluation process, the researchers revised the instructional model based on feedback provided by the validation experts to enhance its design and effectiveness. After several iterative refinement cycles, a finalised version of the teaching factory learning model was produced, representing a fully developed and pedagogically sound instructional framework.

Results and Discussion

Based on interviews with various stakeholders, including the principal, vice principal for curriculum, vice principal for industrial relations, and vice principal for facilities and infrastructure, who also serves as the Teaching Factory coordinator, it was determined that there is a significant need for the development of a Teaching Factory learning model at SMK 1 Perguruan Cikini. During the design phase, the researcher conducted a series of discussions in the form of a Focus Group Discussion (FGD) with the management team of SMK 1 Perguruan Cikini. This team consisted of the principal, vice principals, productive teachers from the Computer Network and Telecommunication Engineering expertise program, and industry practitioners. The discussion was held at Politeknik ATMI Cikarang, in conjunction with an Industrial Visit aimed at observing the well-established Teaching Factory learning model implemented at Politeknik ATMI. Informed by the findings from the FGD, the researcher subsequently refined and further developed the model, leading to the creation of a Draft Design for the Teaching Factory Learning Model. This model served as an alternative pedagogical approach and includes components such as a Production-Based Teaching Factory Learning Model Guidebook and a Computer Assembly Teaching Module for the Computer and Telecommunication Engineering subject.

Image 2. Interview and FGD

Based on literature reviews, preliminary research interviews, and the Focus Group Discussion (FGD), a Teaching Factory learning model was developed and named *Teaching Factory 4P+QD*. The designation "4P+QD" was derived from the structure of the division/team, which included the following components: Project Sales, PPIC (Production Planning and Inventory Control), Production, Purchasing, Quality Control, Delivery, and After-Sales. This model not only incorporated production- and service-oriented learning processes, but also emphasised the development of essential character traits that are vital for students' preparedness for the workforce. Through the 4P+QD model, students are actively encouraged to cultivate key qualities such as honesty, discipline, responsibility, cooperation, adaptability, and creativity. These traits were integrated into each stage of the learning process, thereby fostering both technical skills and personal growth. A visual representation of the 4P+QD learning model is provided below:

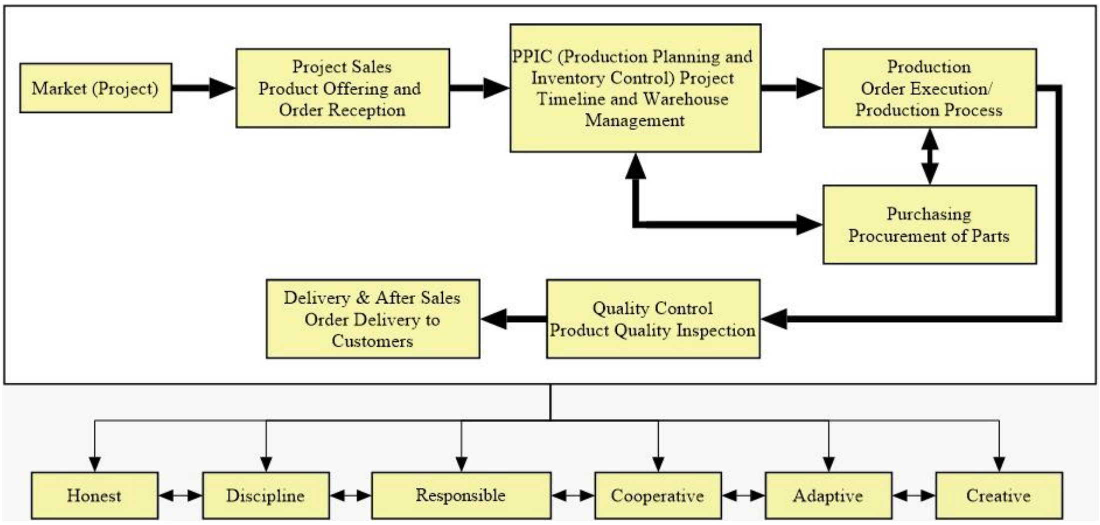

Image 3. Teaching Factory 4P+QD Learning Model

Project Sales

The Project Sales division was responsible for receiving orders from customers or companies seeking to purchase products or utilise services offered by the teaching factory. During the teaching factory learning simulation, students were required to analyze customer needs and determine which products or services could be developed and delivered within the scope of the teaching factory.

Image 4. Documentation of the Product Offering Simulation Process

PPIC (Production Planning & Inventory Control)

In the teaching factory learning simulation, students assigned to the PPIC division were responsible for planning project execution schedules, overseeing product manufacturing, or managing service utilisation. The PPIC division played a key role in scheduling and tracking ongoing projects, monitoring their progress, and categorising projects into three stages: incoming, in progress, or completed.

Table 2. PPIC Division Planning Results

No	Project	Status	Start	Due Date	Finish
1	Merakit PC	Start	08/06/2024	22/06/2024	
2	Sablon Manual	Process	01/07/2024	05/07/2024	08/07/2024
3	Sablon DTF	Finish	03/06/2024	14/03/2024	14/03/2024
4	Configurasi Router	Process	24/06/2024	22/07/2024	

Production

Within the teaching factory learning simulation, students in the Production division were tasked with manufacturing products. Each student received specific instructions from mentors or teachers that were aligned with their designated roles. The production process was divided into several stages, with each student assigned to a particular task. For example, in a PC assembly project, each student was responsible for a specific stage of the assembly process.

Image 5. PC Assembly Process by the Production Division

Purchasing

In the teaching factory learning simulation, students assigned to the Purchasing division were responsible for planning and managing the procurement of materials required for production. Those in the purchasing division were expected to collaborate closely with the PPIC and Production divisions to ensure the availability and appropriate utilisation of necessary components.

Table 3. Purchasing Division Planning Results

No	Part	Type	Quantity	Price	Amount
1	Processor (CPU)	Intel Core i5-11600K	1	Rp3,750,000	Rp3,750,000
2	Motherboard	ASUS ROG Strix B560-F Gaming	1	Rp3,000,000	Rp3,000,000
3	(Graphics Card)	NVIDIA GeForce RTX 3060	1	Rp5,250,000	Rp5,250,000
4	RAM (Memory)	Corsair Vengeance LPX 16GB DDR4	1	Rp1,500,000	Rp1,500,000
5	(Storage) SSD	Samsung 970 EVO Plus 500GB M.2	1	Rp1,500,000	Rp1,500,000
6	Power Supply (PSU)	EVGA SuperNOVA 650 G+ 80 Plus	1	Rp1,350,000	Rp1,350,000

7	*Kasing* (Case)	Fractal Design Meshify C	1	Rp1.200.000	Rp1.200.000
8	CPU Cooler	Cooler Master Hyper 212 RGB	1	Rp600.000	Rp600.000
9	Network Card	-	1	Rp300.000	Rp300.000
10	Optical Drive	-	1	Rp375.000	Rp375.000
	Total				Rp18.825.000

Quality Control
In the context of the teaching factory learning simulation, students assigned to the Quality Control (QC) division are responsible for evaluating the final products to ensure they conform to customer specifications. This process includes the assessment of computer performance, operating system functionality, software installations, and other relevant technical aspects. The primary objective was to guarantee that the products meet predefined quality standards prior to delivery.

Delivery and After-Sales
The Delivery and After-Sales division played a vital role in the teaching factory learning simulation. Students in this division were trained to deliver accurate and professional presentations of the final product to customers. Their responsibilities included not only communicating detailed technical specifications but also providing comprehensive information regarding warranty policies, after-sales services, and other customer support mechanisms. This stage of the simulation emphasised the development of soft skills, particularly effective communication, accountability, and a customer-oriented mindset, by engaging students in client-facing interactions that replicated real-world industry practices.

During the implementation phase of the model, a practical project was conducted in which students assembled a personal computer (PC). The finished product underwent a series of rigorous performance and functionality tests to verify its operational reliability and compliance with quality standards. Upon successful inspection, the product was deemed fully functional and ready for deployment. This personal computer served as a tangible output of the production-based learning process embedded within the comprehensive Teaching Factory learning model.

Validation Results of the Instrument
The validation of the learning model assessment was conducted by two expert lecturers, two vocational teachers, a teaching factory coordinator, and a representative from the industry. The following is the assessment table obtained from each validator:

Table 4. Assessment Table of Expert Lecturers' Validation

No	Assessment Aspect	Average Score Validator 1	Average Score Validator 2	Average Validator Score
1	A. General	3.50	3.70	3.60
2	I. Project Sales	3.75	3.75	3.75
3	II. PPIC	3.40	4.00	3.70
4	III. Production	3.74	3.00	3.37
5	IV. Purchasing	3.67	3.00	3.34
6	V. Quality Control	4.00	3.00	3.50
7	VI. Delivery & After Sales	4.00	3.00	3.50
Average				3.54

Based on the validation data obtained from two expert lecturers, mean scores were recorded for each assessment dimension. The *General* aspect received an average score of 3.60, followed by *Project Sales* with 3.75, *PPIC (Production Planning and Inventory Control)* with 3.70, *Production* with 3.37, *Purchasing* with 3.34, *Quality Control* with 3.50, and *Delivery and After-Sales* also with 3.50. Accordingly, the overall average score was calculated at 3.54, which was categorised as *Very Valid.*

Table 5. Validation Assessment Table of Productive Teachers

No	Assessment Aspect	Average Score Validator 1	Average Score Validator 2	Average Validator Score
1	A. General	3.60	3.60	3.60
2	I. Project Sales	3.75	3.50	3.63
3	II. PPIC	3.60	3.80	3.70
4	III. Production	3.79	3.79	3.79
5	IV. Purchasing	3.67	3.67	3.67
6	V. Quality Control	3.80	4.00	3.90
7	VI. Delivery & After Sales	3.67	3.67	3.67
Average				3.71

Similarly, validation conducted by two productive subject teachers yielded the following average scores: *General* (3.60), *Project Sales* (3.63), *PPIC* (3.70), *Production* (3.79), *Purchasing* (3.67), *Quality Control* (3.90), and *Delivery and After-Sales* (3.67). The overall mean score was 3.71, also falling within the *Very Valid* category.

Table 6. Validation Assessment Table by Teaching Factory Coordinator and Industry Representative

No	Assessment Aspect	Average Score TEFA Coordinator	Average Score Industry Partner (DUDI)	Average Validator Score
1	A. General	3.40	3.10	3.25
2	I. Project Sales	3.75	3.75	3.75
3	II. PPIC	3.40	3.20	3.30
4	III. Production	3.16	3.89	3.53
5	IV. Purchasing	3.67	3.00	3.34
6	V. Quality Control	3.00	3.00	3.00
7	VI. Delivery & After Sales	3.00	3.33	3.17
Average				3.33

Furthermore, validation feedback from the Teaching Factory coordinator and an industry practitioner produced the following average scores: *General* (3.25), *Project Sales* (3.75), *PPIC* (3.30), *Production* (3.53), *Purchasing* (3.34), *Quality Control* (3.00), and *Delivery and After-Sales* (3.17). The resulting overall average score was 3.33, placing it within the *Valid* category.

Following the implementation of the learning model and the integration of character education, students were invited to provide feedback on their experiences during the teaching and learning activities. The evaluation focused not only on the effectiveness of the instructional approach but also on their comprehension of the internalised character values developed throughout the process. The subsequent section presents the average student evaluation table and corresponding chart derived from their responses:

Table 7. Average Student Assessment Data

NO	Student Assessment Aspects	Average Score Grade X TJKT B	Average Score Grade X TJKT C
1	A. General	3.44	3.46
2	I. Honest	3.47	3.53
3	II. Discipline	3.48	3.55
4	III. Responsible	3.45	3.51
5	IV. Cooperative	3.42	3.57
6	V. Adaptive	3.41	3.46
7	VI. Creative	3.39	3.49
Average Score Per Class		3.44	3.51
Overall Average Score		3.47	

Based on student assessment data collected following their participation in the hands-on learning activity of assembling a personal computer (PC) through the Teaching Factory learning model, the average scores for Grade X TJKT B by assessment aspect are as follows: the *General* aspect received a mean score of 3.44. In the domain of character development, *Honesty* scored 3.44, *Discipline* 3.47, *Responsibility* 3.45, *Cooperation* 3.42, *Adaptability* 3.41, and *Creativity* 3.39. The overall average score for Grade X TJKT B was 3.44, which was categorised as *Good.*

Similarly, the assessment results for Grade X TJKT C revealed the following average scores: the *General* aspect received 3.46. For character development, *Honesty* scored 3.53, *Discipline* 3.55, *Responsibility* 3.51, *Cooperation* 3.57, *Adaptability* 3.46, and *Creativity* 3.49. The total average score for Grade X TJKT C was 3.51, which also fell within the *Good* category.

Discussions held between the management of the Special Job Market Exchange (*Bursa Kerja Khusus* or BKK) of DKI Jakarta and Mr. Wikan Sakarinto, who served as the Director General of Vocational Education from 2020 to 2022, revealed that although the Teaching Factory (TEFA) model has been widely implemented in vocational schools, its application has not fully realized its intended potential. In practice, students have often been limited to supporting roles within production activities, rather than being actively involved in the core TEFA work system. Ideally, TEFA should engage students in comprehensive industrial workflows, including market research, production planning, execution, and the delivery of finished products to customers.

Empirical studies have similarly shown that structured implementation of the TEFA model positively influences students' competency development. However, several challenges remain. For instance, Rohaeni et al. (2021) reported that students often exhibit limited understanding of entrepreneurial principles and are not substantially involved in the core stages of production. Additionally, research by Wijanarka et al. (2023) emphasise that successful TEFA implementation hinges on robust industry collaboration and strategic planning and evaluation aligned with real market demands. While TEFA-based learning significantly contributes to improving students' job readiness, aspects such as product marketing and the cultivation of an entrepreneurial mindset continue to require targeted intervention to achieve more comprehensive educational outcomes (Prianto et al., 2021).

The implementation of the Teaching Factory (TEFA) model across various vocational schools (*Sekolah Menengah Kejuruan* or SMK) in Indonesia demonstrates considerable potential in enhancing students' work readiness. Nevertheless, several systemic and operational challenges remain. At SMKN 2 Singaraja, for instance, TEFA implementation has shown promising outcomes in terms of facilities, infrastructure, and the integration of industry partners in planning processes. However, teacher supervision, crucial for practical guidance, has been constrained by scheduling conflicts, thereby limiting the full potential of student readiness (Dwijayanthi & Rijanto, 2022). Similarly, at SMK Negeri 5 Surakarta, although the TEFA model reached an implementation effectiveness level of 70.29%, industry collaboration remains an area requiring further development to improve program quality (Saputro et al., 2021). Broader challenges, including insufficient human resources, inadequate infrastructure, and weak industry linkages, further hinder the optimal application of the TEFA approach (Saputro et al., 2023). Within this context, career planning initiatives beginning with early TEFA exposure, structured training, and targeted mentoring are essential to ensuring students' preparedness for real-world production environments (Irawan et al., 2024).

In response to these findings, the 4P+QD Teaching Factory Learning Model was developed as a comprehensive framework to address existing limitations while strengthening holistic competency development. This model comprises several integrated divisions: the *Project Sales* division receives and manages customer orders; the *Production Planning and Inventory Control* (PPIC) division schedules and monitors project implementation and resource utilization; the *Production* division executes manufacturing tasks in accordance with standard operating procedures (SOPs), emphasizing occupational health and safety (K3); the *Purchasing* division is responsible for procuring the required materials and coordinating with PPIC and production units; the *Quality Control* division evaluates finished products to ensure conformity with TEFA standards and customer requirements; and finally, the *Delivery and After-Sales* division manages product handover, customer service, satisfaction evaluation, and warranty claim procedures for defective units.

The 4P+QD model introduces a novel paradigm in TEFA-based learning by simulating an authentic industrial environment in which students are assigned job roles that reflect real-world responsibilities. A key innovation in this model is its emphasis on cross-functional competency development. Unlike conventional TEFA implementations, which often confine students to tasks within their areas of specialization, particularly in the production domain, the 4P+QD model adopts a rotational system. This approach is grounded in the recommendations of Mr. Wikan Sakarinto, who underscored the importance of developing student competencies across the entire spectrum of TEFA operations, not just in production-related roles.

Through structured rotation, students engage in experiential learning across all departments—Project Sales, PPIC, Production, Purchasing, Quality Control, and Delivery & After-Sales—allowing them to acquire a holistic understanding of organisational workflows. This exposure facilitates the exploration of various functions and encourages students to identify their personal strengths and vocational interests. Furthermore, the immersive nature of the 4P+QD model cultivates critical employability skills such as problem-solving, communication, adaptability, and teamwork. By directly confronting authentic production challenges within a simulated business unit, students build confidence and gain the practical knowledge necessary for a seamless transition into the workforce.

Conclusion

This study culminated in the development of the 4P+QD Teaching Factory Learning Model. This structured instructional framework integrates six key operational divisions, namely Project Sales, Production Planning and Inventory Control (PPIC), Production, Purchasing, Quality Control, and Delivery and After-Sales. Each division corresponded to a core business function and was associated with specific job roles that inform the design of instructional syntax within the model. The framework was intended not only to deliver technical competencies but also to foster the development of essential soft skills, including honesty, discipline, responsibility, teamwork, adaptability, and creativity. By simulating authentic industrial environments within the school context, the 4P+QD model enabled students to engage in practical workflows that mirror contemporary industry practices.

A quantitative validation process was conducted to evaluate the model's validity and practicality, involving multiple stakeholders. Two subject-matter expert lecturers assessed the learning model and assigned it an average score of 3.54, which was classified as "Very Valid" according to the applied evaluation criteria. Similarly, vocational subject teachers, who were directly involved in the facilitation of hands-on learning, provided a higher average score of 3.71, also falling within the "Very Valid" category. Furthermore, validation by TEFA coordinators and industry practitioners from PT Usaha Jayamas Bhakti yielded an average score of 3.33, which was considered "Valid."

In addition to expert validation, the model's impact on student development was assessed through student self-evaluations focused on soft skills acquisition. The evaluation examined critical character competencies such as honesty, discipline, responsibility, cooperation, adaptability, and creativity. The aggregated student responses resulted in an average score of 3.47, which corresponded to the "Good" category. These findings collectively suggest that the 4P+QD Teaching Factory Learning Model is both pedagogically sound and practically feasible. It aligns with current industry expectations while also addressing the need for holistic student development, particularly in fostering non-technical competencies that are crucial in the 21st-century workforce.

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