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# Evaluation of the industry 4.0-based vocational high school development program

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**Abstract.** The Directorate of Vocational High Schools (SMK) of the Ministry of Education, Culture, Research, and Technology has allocated government assistance funds for vocational high schools developed in accordance with Industry 4.0 for the 2021-2024 period. This program is designed to enhance the quality of graduates in line with the industrial world's needs, particularly in Special Economic Zones (SEZs) and Industrial Zones (IZs). Using the CIPP model to examine the impact of the Industry 4.0-based vocational high school development program, a proportional random sampling method was employed to select 63 schools as respondents. Data was collected through questionnaires, observations, and in-depth interview guides. Analysis of data from various sources concluded that there were positive impacts from the development of vocational secondary schools, including: digitization of the educational process; preparation for the adjustment of competencies required by in-dustry through the adjustment of the Industry 4.0-based curriculum; activation of the Learning Management System; optimization of the role of industry practitioners to im-prove the competencies of teachers and educators in schools; and renewal of practice room facilities and practice equipment. It is recommended that this program be continued and its distribution expanded outside SEZs and IZs.

## Introduction

Vocational education needs to equip its graduates with a variety of more general skills, namely life and career skills, learning and innovation skills, and skills in utilising information, media, and technology. Life and career skills have the following components: (1) flexibility and adaptability, (2) initiative and self-management, (3) social and intercultural interaction, (4) productivity and accountability in managing projects and producing products, and (5) leadership and responsibility. Furthermore, learning and innovation skills have the following components (Widana et al., 2019): (1) critical thinking and problem-solving, (2) communication and collaboration skills, and (3) creativity and innovation. Meanwhile, information and technology media skills have the following components: (1) information literacy, (2) media literacy, and (3) ICT literacy. The provision of these skills is packaged under the term 21st Century Skills (Zhong et al., 2022).

The focus of skills in 21st-century education is currently known as the 4Cs (Zeng et al., 2025), which include creativity, critical thinking, communication, and collaboration. Not only student character but also collaboration between stakeholders in schools and parents will improve student character and future life development. The vocational high school curriculum must adapt to the increasingly competitive business and industrial climate. Lase (2019) states that students are prepared with a curriculum that includes artificial intelligence, the internet of things (IoT), wearables (augmented reality and virtual reality), advanced robotics, and 3D printing.

A distinctive aspect of vocational education emphasises practical knowledge and skills relevant to the demands of the workforce to cultivate the habit of thinking and working with workplace-like qualities (Morris et al., 2024), particularly in the commercial and industrial fields or sectors (McGrath & Yamada, 2023; Zylfija & Shaqiri, 2023), an industry-based curriculum approach is the best vocational training strategy (Suseno, 2023). Basic principles of the vocational education process include: (a) community participation (the world of work) is crucial in developing vocational education programs; (b) articulation and coordination are essential components of vocational education; and (c) continuous assessment and evaluation (Ruan, 2023; Widana et al., 2023).

To enhance the competitiveness of Indonesian human resources, revitalisation of vocational high schools is necessary through refining and aligning the curriculum with competencies tailored to the needs of graduate users; improving the competencies of educators and education personnel; enhancing collaboration between ministries/institutions, local governments, and the business/industry sector; increasing access to graduate certification; and other programs. The management and implementation of vocational secondary education must be able to deliver educational programs tailored to the types of employment (Stenzinger et al., 2023; Jatmika et al., 2025). Meanwhile, the Graduate Competency Standards for vocational education emphasise skills that enhance students' competencies, enabling them to live independently and pursue further education in their respective vocational fields (Stenzinger et al., 2023).

Vocational education makes a significant contribution to societal development and a country's economic growth (Sun et al., 2025). Meanwhile, Liu et al. (2024) argue that vocational education is a key factor in economic development, competitiveness, and even social stability in many countries, including developed ones. Vocational secondary education in Indonesia still falls short of the ideal in producing graduates who are readily absorbed into the job market. Data from the 2022 National Labour Force Survey by the Central Bureau of Statistics (BPS) shows that the Open Unemployment Rate (TPT) for Vocational High School graduates remains the highest compared to graduates of other educational levels. However, the TPT rate decreased from 13.55% in 2020 to 11.13% in 2021 and then again to 9.42% in 2022.

The Directorate of Vocational High Schools of the Ministry of Education, Culture, Research, and Technology has allocated government assistance funds for vocational high schools developed based on Industry 4.0 from 2021 to 2024. The development of industry-based vocational high schools is expected to enhance graduate quality in line with the needs of the industrial world, particularly in National Priority Areas, such as Special Economic Zones (KEK) and Industrial Zones (KI), which are Key National Development Priorities.

**Table 1**. Special Economic Zones (SEZs) in Indonesia

| KEK based on the Industrial Sector | Quantity | Name of KEK Area |
|---|---|---|
| Industry KEK | 12 areas | • Gresik<br>• Kendal<br>• Sei Mangkei<br>• Arun Lhokseumawe<br>• Galang Batang<br>• Morotai<br>• Palu<br>• Sorong<br>• MBTK<br>• Bitung<br>• Tanjung Sauh<br>• Setangga |
| Tourism KEK | 7 areas | • Mandalika<br>• Lido<br>• Tanjung Lesung<br>• Kura Kura Bali<br>• Tanjung Kelayang<br>• Likupang<br>• Sanur (Pariwisata-kesehatan) |
| Digital KEK | 2 areas | • Nongsa<br>• Singhasari |
| Other Services KEK | 1 area | • *Batam Aero Technic* |

The SMK 4.0 development assistance program is part of a primary vocational education and training project outlined in the 2020-2024 National Medium-Term Development Plan (RPJMN), related to accelerating the development of superior human resources. This is intended to support a modern economic structure based on industry, which requires a skilled labour force with specialised expertise and specific skills. The areas of expertise being developed have been aligned with the major Industry 4.0 projects in five priority sub-sectors: 1) food and drink, 2) Textiles and Clothes, 3) Automotive, and 4) Chemistry and pharmacy.

The success of the 4.0-based vocational high school program will contribute to the absorption of graduates into the workforce and industry, ensuring they are well-targeted, relevant to their learning, and adapt to the situations and conditions in each region (Gaona et al., 2024). The success of a program can serve as a benchmark for other programs.

To ensure program quality and determine the appropriateness and impact of vocational high school development programs, an impact evaluation of the implementation of Industry 4.0-based vocational high school development programs is necessary. Impact evaluation is a type of evaluation that assesses the long-term impact of a program, policy, or intervention on its intended beneficiaries (Zhou et al., 2024), primarily concerns the outcomes of interventions (programs, projects, policy measures, reforms) (Atanasov, 2025), meant as positive and negative, intended and unintended, direct and indirect, primary and secondary impacts produced by an intervention (Meng et al., 2024).

Government assistance to improve the quality of education varies greatly, including: School Operational Assistance (BOS) for vocational schools, where there are discrepancies between its use and government policy, a lack of preparedness on the part of administrators, and a lack of clarity regarding the legal basis for the use (Sutrisnawati et al., 2021). TEFA Implementation Assistance has been appropriate in several aspects, such as non-physical development (preparation of TEFA tools, human resource development, coordination with relevant agencies or industries, analysis and determination of material needs) and physical development (procurement of practice materials, procurement and repair of equipment, rehabilitation of workshops/labs or practice support rooms and other related physical activities) (Rukmana, et al., 2021), Assistance in Strengthening Work Culture, all vocational schools receiving assistance have implemented all components of the program well (Nasyaliyah et al., 2023).

Research on the impact evaluation of Industry 4.0-based vocational high school development programs in special economic zones (SEZs) and industrial estates is highly urgent, given the rapid technological developments affecting the industrial world. The Industry 4.0-based vocational school development assistance program was rolled out from 2021 to 2024. This evaluation will provide a clear picture of the success and effectiveness of existing programs, offering practical recommendations for further improvement and development. Special economic zones and industrial estates have significant potential to support the development of quality vocational education relevant to the world of work, ultimately increasing Indonesia's competitiveness.

The research question for this study is how the Industry 4.0-based vocational school assistance program affects the quality of learning, graduate absorption, and the optimal role of school principals. The purpose of this evaluation is to assess the impact of the Industry 4.0-based vocational school development assistance program in terms of context, input, process, product, and impact in special economic zones (SEZs) and industrial estates. This evaluation aims to provide an overview of the Industry 4.0-based vocational school development assistance program, including the results of the interventions carried out, as well as their impact on the fulfilment of practical teaching factory facilities and infrastructure, school cooperation with the industrial world, and graduate employment rates.

## Method

This research is a program evaluation study with a descriptive approach. The objective of this study is to describe the impact of an Industry 4.0-based vocational high school development program on vocational high school quality. Carmel et al., (2023) identified nine key issues for conducting impact evaluation: (1) Identify the intervention (type and scope), (2) Determine the objectives of the intervention being assessed, (3) Carefully describe the theory linking the intervention to the outcomes, (4) Address attribution issues, (5) Build on existing knowledge relevant to the intervention's impact, (6) Use a mixed-methods approach: the logic of comparative advantage of methods, (7) Determine whether impact evaluation is feasible and worth the cost, (8) Start early to get the data, and (9) Early planning is essential.

The research was conducted from October to December 2024. This research begins by describing how the industry-based vocational high school development program is implemented. Therefore, this evaluation utilises the evaluation model proposed by Olweean & Rebeca Guzman (2024), which consists of the CIPP framework (context, input, process, and product).

**Table 2.** Criteria of the CIPP Evaluation Indicator

| Indicator of the CIPP | Component Criteria |
|---|---|
| Context | Concept and legality |
| Input | 1. Supporting resources<br>2. Human resources<br>3. Implementation strategy |
| Process | Program Implementation:<br>1. Strengthening industry 4.0-based learning<br>2. Building practice facilities/laboratories<br>3. Industry 4.0 practice equipment |
| Product | 1. Achievement of goals<br>2. Positive impact |

Product evaluation attempts to identify and assess both planned and unplanned outputs and benefits, in both the short and long term. Therefore, impact evaluation falls within the product evaluation domain, namely, gathering and assessing data on programs that reach their intended audiences (Khofifah et al., 2025).

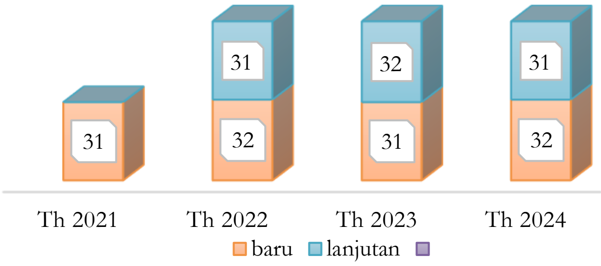


**Image 1.** Number of Recipients of SMK 4.0 Development Assistance 2021 to 2024

The target of this evaluation is vocational high schools (SMK) receiving assistance for vocational school development based on Industry 4.0 from 2021 to 2023. Considering the geographical distribution of aid recipients, the proportional random sampling method was used to determine the target. This evaluation identified 63 vocational high schools from 19 provinces in Indonesia as recipients of the 2021 and 2023 programs.

The evaluation instrument was based on theoretical studies and the legal basis for implementing the industry-based vocational school development program. The evaluation instrument prioritised questions that reflected actual activities, rather than being based on respondents' assumptions. Therefore, the items in the impact evaluation instrument were structured based on performance or prioritising valid evidence. The instrument has been verified through expert validation from various fields, including education experts, vocational education practitioners, academics, and the internal Directorate of vocational High schools.

The indicators contained in the monitoring and evaluation instrument for the 4.0 Vocational School Development Program are as follows.

**Table 3.** Impact Evaluation Data Grid

| No | Impact Evaluation Aspects | Client Activity Portrait Evaluation |
|---|---|---|
| 1 | Suitability of aid allocation | Using the findings of the aid allocation to strengthen learning, fulfil practical equipment, and build/rehabilitate/renovate/redesign industrial practice spaces. |
| 2 | Graduate absorption | Using the findings of the real number of graduates with employment status, entrepreneurship, and continuing studies. |
| 3 | Collaboration with the business world and the world of work | Utilising findings from school collaboration packages with industry and professional partners, including:<br>– Curriculum alignment.<br>– Project-based learning.<br>– Guest teachers.<br>– Internships/Industrial Internships.<br>– Competency certification for teachers and graduates. |

| No | Impact Evaluation Aspects | Client Activity Portrait Evaluation |
|---|---|---|
| | | – Technology updates and training for teachers.<br>– Teaching Factory.<br>– Commitment to graduate retention.<br>– Scholarships or donations |
| 4 | Updating the Industry 4.0-based Learning Process | Using findings from aligned curriculum components:<br>– Learning methods<br>– Teaching materials<br>– Practical tools<br>– Student worksheets<br>– Teaching Factory implementation<br>– Project-based learning implementation |
| 5 | Improving the Quality of Educators | Using the findings of the increase in the number of intern teachers in industry, the number of teachers certified in their competency according to their field of expertise |
| 6 | Utilization of Physical Assistance and Equipment | Use of physical aids and equipment:<br>– Information technology-based equipment has been used in learning.<br>– Information technology 4.0-based equipment is used for training and production processes.<br>– Possession of practical tools and practice rooms that meet industry standard needs.<br>– The specifications of the tools and practice rooms at your school match the standards of your partner's workplace. |
| 7 | The Role of the Principal | Utilising the findings of the principal's strategic role:<br>– Mapping the learning needs of the school community (students, teachers, and educational staff) to improve the quality of workplace-based learning.<br>– Mentoring vocational teachers to develop competencies/expertise concentrations.<br>– Mentoring teachers to improve the quality of workplace-based learning.<br>– Encouraging the school community (students, teachers, and educational staff) to master required competencies.<br>– Providing opportunities for the school community (students, teachers, and educational staff) to develop competencies outside of school, particularly in the workplace. |

Data was collected through a questionnaire on the e-Monev application (a special application developed by the Directorate General of Higher Education). This self-assessment of performance achievements was conducted by vocational schools receiving assistance. An in-depth interview guide was also used to gather information on the impact of program implementation and identify potential problems before they caused further impacts, allowing for swift program improvements. Respondents to the reflection activity included school principals, business partners, graduating students, and parents of graduating students.

Descriptive quantitative data analysis included graphs to illustrate the success of the Industry 4.0-based vocational school development program. Descriptive statistical analysis used percentages to assess the achievement of success indicators for the Industry-based vocational school development program. Qualitative data consisted of descriptive narratives from respondents regarding program obstacles and follow-up, as well as responses from supporting documents in the form of in-depth interviews.

## Results and Discussion

### Context

The Ministry of Education, Culture, Research, and Technology, through the Directorate of Vocational Schools, has allocated government assistance funds for the development of vocational schools based on Industry 4.0. This is in accordance with Presidential Regulation No. 18 of 2020, which mandates that strategic vocational education and training development programs are necessary to increase the skilled workforce that can support the development of Industry 4.0, especially in national priority areas, namely Special Economic Zones (KEK) and Industrial Zones (KI).

This Industry 4.0-based vocational high school development program aims to: 1) improve the quality of learning in vocational high schools by providing infrastructure assistance to produce qualified graduates in accordance with the standards required by the workforce; 2) build a new image for vocational high schools by creating a quality vocational practical learning process; 3) enable them to become driving schools for the development of other vocational high schools; and 4) equip vocational high school students with Industry 4.0-based skills. Assistance focuses on developing competency skills through the learning reinforcement process, and/or providing practical equipment, and/or developing Industry 4.0-based student practice spaces (Chagas et al., 2024).

### Input

The targets of the Government Assistance for the Development of Industry 4.0-Based Vocational High Schools are: (1) vocational high schools that meet the requirements for applying for Government Assistance for the Development of Industry 4.0-Based Vocational High Schools, (2) vocational high schools designated by a decision of the Director General of Vocational Education based on vocational education priority programs.

Field findings indicate that several key individuals are involved in supporting the implementation of industry 4.0-based vocational school development. School principals play an important role in monitoring the successful realisation of assistance. Principals monitor and control programs implemented in accordance with Standard Operating Procedures (SOPs), the production processes within the educational unit, and conduct evaluations based on the SOPs. Principals monitor the school environment, the TEFA process in delivering learning and planning, and conduct open and closed evaluations.

The workshop on aligning the Industry 4.0-based vocational school curriculum with the industry also involved resource persons from various vocational school education experts, including education practitioners, industry practitioners, lecturers from Vocational Education Quality Assurance Development Centres, internal vocational school directorates, and academics. Government Regulation No. 41 of 2015 stipulates that the implementation of competency-based industrial vocational education must be equipped with a Professional Certification Institute, a teaching factory, and a Competency Testing Centre. Therefore, every vocational high school must be able to implement the teaching factory learning model in its school.

**Proces**

The implementation of the Government Assistance Program for the Development of Industry 4.0-Based Vocational High Schools is to improve the quality of teachers and learning in vocational high schools, in collaboration with partners in the world of work on an ongoing basis through: 1) Strengthening work-based learning processes, 2) Providing vocational high school practical equipment that meets industry standards; and 3) Construction/rehabilitation/renovation/redesign of student practice rooms and their furnishings, including planning and supervision costs.

Learning reinforcement is the starting point for encouraging the development of industry-based vocational high schools in accordance with program development objectives. Learning reinforcement interventions for industry-based vocational high schools are related to the alignment of the curriculum, syllabus, and learning modules with Industry 4.0. These learning reinforcement interventions are also expected to enable vocational high school teachers and education personnel to adapt to technological developments in their vocational fields. Furthermore, adjustments are being made to the curriculum, and the latest technology-based learning methods are being applied in classes to ensure their relevance to Industry 4.0 technology. This is an anticipatory measure that encourages graduates to continue developing and adapting to future trends, as jobs previously filled by humans are expected to disappear and be replaced by technology, machines, robots, or artificial intelligence. Vocational school graduates are encouraged to have innovative abilities, creativity in creating new products and Industry 4.0-based skills through strengthening the following technologies:

**Table 4.** Technology 4.0 Interventions in Vocational Schools Receiving Assistance

| | |
|---|---|
| Efforts to strengthen technology 4.0 in vocational schools | (a) Develop a curriculum that is appropriate to the needs of Industry 4.0, including mastery of digital technology, programming, and graphic design. |
| | (b) Holding training and workshops for teachers and students so that they can master new technology and apply it in learning. |
| | (c) Establishing cooperation with industries around vocational schools to provide students with direct experience of the world of work and the latest technology. |
| | (d) Encourage students to develop creativity and innovation in the use of technology by holding competitions or other activities that can stimulate students' creativity. |
| | (e) Strengthening Technology 4.0 in Vocational Schools, so that students are better prepared to face the challenges of an increasingly sophisticated and digital world of work in the future. |
| | (f) Provide adequate facilities and hardware such as computers, laptops, printers and other mobile devices. |

**Product**

Through interventions to strengthen Industry 4.0-based vocational school learning, related to the alignment of Industry 4.0-based curricula, syllabi, and learning modules, vocational school teachers and educational staff can keep pace with technological developments and adjust their curricula and learning methods to remain relevant. The output of this activity not only aligns the curriculum but also the latest learning methods in line with digital technology in the learning process. Teachers become more open to digital technology, which helps facilitate the implementation of an Industry 4.0-based independent curriculum. Utilising digital technology in educational activities through the use of a Learning Management System (LMS) and more tactical and practical learning approaches to foster the development of students' vocational skills.

Furthermore, the strengthening of vocational school learning also includes various workshop themes to support learning. Therefore, vocational schools receiving Industry 4.0-based assistance can provide quality education, at the very least, freeing them from the major educational sins (bullying, intolerance, and sexual violence) that have been prevalent in schools.

Provision of modern learning facilities and infrastructure relevant to Industry 4.0 technology in Industry 4.0-based vocational high schools. Support for modern learning facilities and infrastructure relevant to Industry 4.0 technology. Procurement of modern, industry-standard practical equipment. Construction of representative student practice spaces.

**Impact**

The development of Industry 4.0-based vocational schools has led to improved educational quality, aligning with the needs of the surrounding industry. These positive impacts include:

Learning quality improvement activities conducted by Industry 4.0-based vocational schools have had a positive impact through workshops on developing teaching materials and strengthening digital-based learning media. Regarding the updated learning components in SMK 4.0, the following points are discussed:

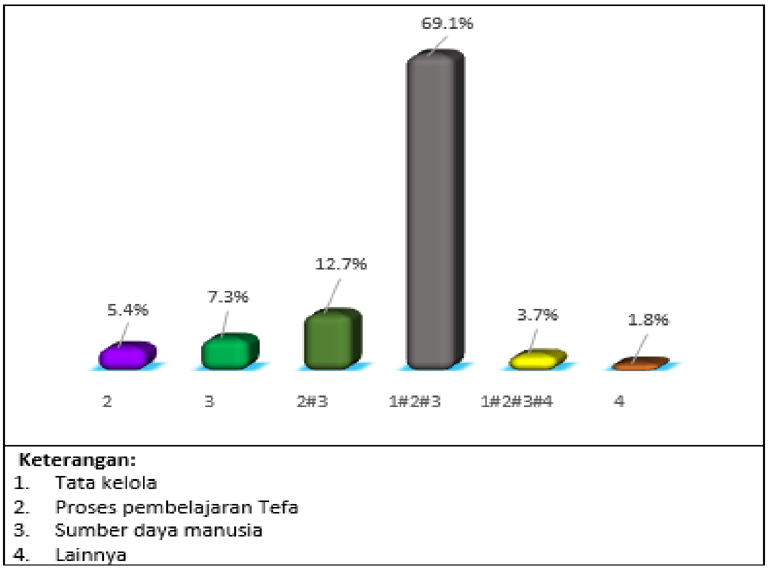


**Image 2.** Updated Learning Components

The most significant percentage, 69% of vocational high schools, stated that the updated learning components included governance, the TEFA learning process, and resources. Furthermore, 12.7% of vocational high schools updated the TEFA learning process and human resources. 7.3% updated the human resources component, and 5.4% updated the TEFA learning process.

The successful implementation of TEFA and PjBL in schools is indeed a shared success for the school community, with the principal playing an optimal role (Evi Yupani & Widana, 2023). The role of the principal in encouraging the implementation of TEFA based on Industry 4.0 is shown in the following image.

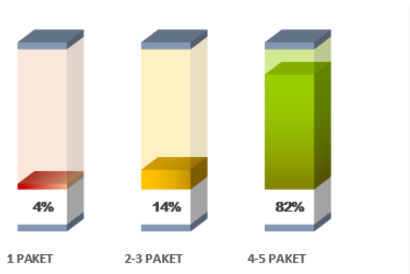


**Image 3.** The role of the principal in encouraging the formation of TEFA

Principals can implement five support packages for the school community to implement TEFA and PjBL, including: (1) needs mapping, (2) mentoring vocational teachers, (3) mentoring all teachers, (4) encouraging all school members to master specific competencies, and (5) providing facilities for developing the competencies of school members. The most significant percentage (82%) were principals who had implemented four to five support packages to encourage the implementation of TEFA based on Industry 4.0. In 14% of vocational high schools (SMK), principals implemented two to three packages, and the lowest percentage, 4%, had only implemented one support package to encourage the implementation of TEFA based on Industry 4.0.

Industry 4.0-based vocational schools organise link and match activities with the world of work. This creates alignment between vocational schools and the world of work, both in physical aspects (equipment) and non-physical aspects (curriculum, work culture, internships). Aligning the curriculum with educational partners using the following curriculum components.

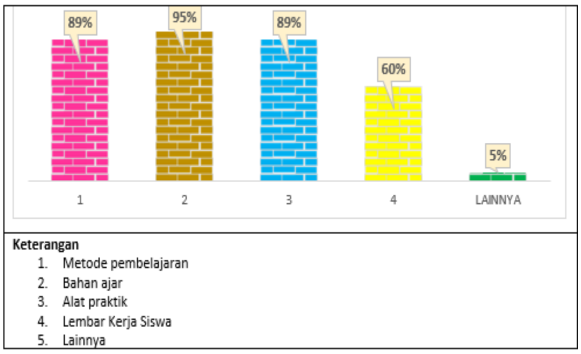


**Image 4.** Curriculum Alignment Components with DUDIKA Partners

The image above shows that the highest percentage of vocational high schools has aligned the curriculum components in the form of teaching materials (95%), while vocational high schools (SMK) have aligned the components in the form of learning methods and practical tools (89% and 89%, respectively). This demonstrates that the results of the curriculum components that have been aligned with DUDIKA relate to learning methods, teaching materials, practical tools, and student worksheets.

Support for modern learning facilities and infrastructure relevant to Industry 4.0 technology. Procurement of modern, industry-standard practical equipment. Construction of representative student practice spaces.

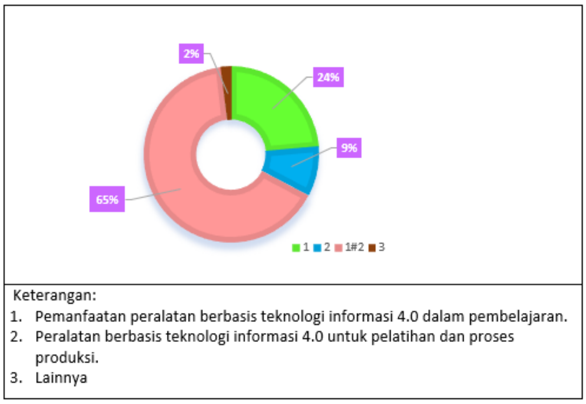


**Image 5.** Utilization of Equipment Assistance

The graph shows that all school respondents stated they had utilised equipment assistance for TEFA 4.0 development at their schools. Regarding the type of equipment assistance, 65.5% of vocational high schools (SMK) used information technology-based equipment in learning, specifically IT 4.0-based equipment for training and production processes. Furthermore, 23.6% of vocational high schools used IT 4.0-based equipment in learning, and 9.1% utilised IT 4.0-based equipment for training and production processes.

An internal tracer study revealed that many SMK graduates are employed and earn salaries below the minimum wage.

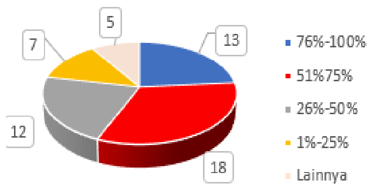


**Image 6.** The number of vocational schools whose graduates work according to the minimum wage

The image above shows that of the vocational high schools respondents, 13 have 76%-100% of employed graduates earning the minimum wage, 18 have 51%-75% of employed graduates earning the minimum wage, 12 have 26%-50% of employed graduates earning the minimum wage, and 5 have graduates who do not earn the minimum wage.

Building the image of vocational high schools as modern educational institutions relevant to industrial developments is undoubtedly not an instantaneous process. It requires a strong driving force to transform the old into a new, more sustainable one.

The collaboration between vocational schools 4.0 and the professional world includes the 8+i collaboration package: (1) Curriculum alignment; (2) Availability of Industry 4.0-based facilities and infrastructure; (3) Teachers from the professional world (guest teachers); (4) Internships/industry work experience; (5) Competency certification for teachers and graduates from the professional world; (6) Teachers receiving technology updates and training from the professional world; (7) Teaching factories; (8) Commitment to graduate absorption by the professional world; and (9) Scholarships or donations from the professional world.

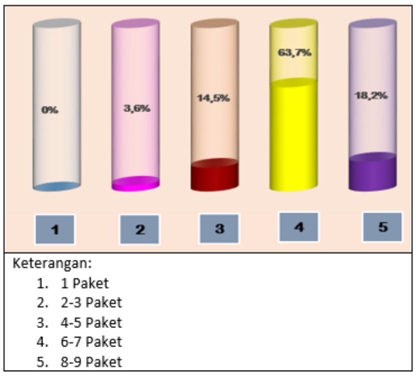


**Image 7.** A package of collaboration
between vocational schools and the world of work

The image above illustrates the most significant percentage of collaborations with Dudika, with 18.2% of vocational schools implementing 8-9 collaboration packages, and 14.5% implementing 4-5 collaboration packages. Therefore, it can be concluded that vocational schools have made efforts to implement the 8+i Link and Match approach in developing Industry 4.0-based schools. The relationship between education and industry needs to be continuously improved so that vocational high school graduates have skills that meet evolving industry standards. To date, vocational education programs in vocational high schools continue to face challenges in adapting their curricula to meet the evolving needs of the industry.

The BKK has played a role in helping graduates find employment through various activities, including providing job information in collaboration with industry, the private sector, and the government, as well as offering career guidance. Furthermore, the BKK's level of achievement in assisting with placement into industry or other partners is important. Other supporting factors include educational institutions collaborating with the Ministry of Manpower. Inhibiting factors include barriers and poor communication with unemployed alumni, as well as a mismatch between job openings and the competencies available at vocational high schools.

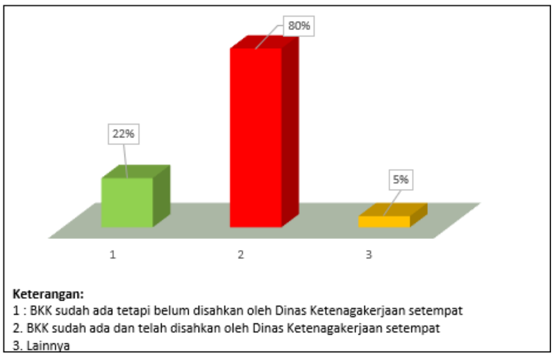


**Image 8.** Vocational School with BKK Status

The graph above shows that 80% of vocational high schools have a Special Job Exchange (BKK) approved by the local Manpower Office. Another 22% have a BKK but have not been approved by the local Manpower Office.

The BKK aims to help graduates find employment in their chosen fields. The BKK's function is to provide facilities for job placement and information services, as well as to establish and develop collaborative relationships with businesses and industry. Job opportunities are vast, but the available human resources do not meet the criteria. Other factors include parents' reluctance to allow their children to work long distances, a weak work ethic among graduates, an inability to adapt to new jobs, and a lack of competency among graduates in finding work. These factors contribute to job failure and the failure to achieve salaries in line with the minimum wage.

The job fairs are organised by the Special Job Exchange (BKK) in collaboration with the local manpower office and partners with the business, industry, and workforce (DUDIKA) sector. These activities aim to provide opportunities for vocational high school graduates to secure decent employment. High appreciation is extended to SMK 4.0 for organising a job fair with the participation or willingness of local provincial and/or district/city officials, including the Secretary of the provincial office, the head of the provincial office, the head of the manpower office, the chief of police, the police sector, the military district commander, the military command, and the smk's industry partners. The creation of a link and match model between the education sector and the workforce is expected to reduce the unemployment rate among vocational school graduates (Husein, 2019).

This is expected to enhance learning quality and align with the competency needs of graduates who have demonstrated mastery of digital technology. This finding aligns with research demonstrating that workshops and learning assistance have been proven to enhance the quality of teaching in the classroom (Mastuti et al., 2022) and to yield improvements in classroom management (Marliani et al., 2025). SMK 4.0 also conducts workshops related to strengthening literacy, numeracy, and character skills, in accordance with the competency concentrations that students are studying. Reinforcement of learning for vocational schools receiving Industry 4.0-based development assistance in 2024, related to curriculum alignment with the industry, is carried out through workshops. Vocational schools strive to ensure that the link and match program runs optimally by collaborating with industry, aligning curricula, providing industrial work experience, and conducting competency tests (Maulina & Yoenanto, 2022). Principals monitor and control programs implemented in accordance with Standard Operating Procedures (SOPs), the production processes within the educational unit, and conduct evaluations based on the SOPs. Principals monitor the school environment, the TEFA process in delivering learning and planning, and conduct open and closed evaluations.

The principal ensures that the environment supports the implementation of the Teaching Factory (Akyuwen, 2023), maintains sustainable cooperative relationships with long-standing industry partners, and expands business with new partners so that the Teaching Factory continues to develop in schools (Sahdu, 2024). To realise the learning conditions in the TEFA program, the chosen learning model is appropriate and aligned with the real-world improvement of student competencies. The application of TEFA-based PjBL aims to align the content taught in educational units with the needs of the business and industrial world, a learning outcome-oriented process (Purnadewi & Widana, 2023). The successful implementation of TEFA and PjBL in schools is indeed a shared success for the school community, with the principal playing an optimal role (Pratama et al., 2025).

Various notes as part of the program impact evaluation address obstacles, challenges, outcomes, and follow-up actions to improve program development outcomes in the future. Notes on the impact evaluation of Industry 4.0-based vocational high schools development for policymakers and stakeholders concerned with program quality are as follows.

**Table 5.** Summary of Obstacles, Challenges, Outcomes, and Follow-up of the Evaluation of the Impact of SMK 4.0 Development

| Factor | Description |
| --- | --- |
| Obstacle | 1. Graduate quality is not yet aligned with the academic field of vocational schools. |
| | 2. Development of an Industry 4.0-Based Vocational School Roadmap. |
| | 3. Competency Certification/LSP. |
| | 4. Improving the Quality of Educators (Productive Teachers, Internship Teachers). |
| | 5. Curriculum Alignment with Industry Partners (Link & Match). |
| | 6. Implementation of Project-Based Learning (PJbL) and TEFA. |
| Challenge | 1. Limited human resources from the professional world in linking and matching collaborations in implementing the SMK 4.0 program. |
| | 2. Coordination and open communication with partners to establish collaborative work experience programs. |
| | 3. Synchronising curriculum development to adapt to developments in the professional world and the global market. |
| | 4. Adjusting practical equipment to meet quality standards. |
| | 5. Timely implementation of activities with industry partners in the implementation of PBJL and TEFA. |
| Outcome | 1. Increasing students' absorption into the workforce. |
| | 2. Synchronising learning tools between vocational schools and the workforce (link and match). |
| | 3. Increasing the number of productive teachers based on Technology 4.0. |
| | 4. Improving project-based and TEFA-based learning support. |
| | 5. Opening the broadest possible access to industry-based partners and the global market. |
| Follow-up | 1. Collaboration (link and match): Open communication regarding collaboration in developing vocational high school programs based on 4.0. |
| | 2. Industrial work experience: Enhancing collaboration by aligning the roles and main tasks of implementing internship programs. |
| | 3. Internship program: Relevant and priority partners for productive teachers. |
| | 4. Industry: Collaboration with other relevant ministries: the Ministry of Industry, the Ministry of Micro, Small, and Medium Enterprises, the Ministry of Tourism, the Ministry of Communication and Information, and other stakeholders. |
| | 5. Curriculum development: Enhancing the development of relevant curricula between vocational high schools and their partners. |

The Impact of research in practice is that industry-based vocational school development programs can provide feedback on good practices in implementing the development of Industry 4.0-based vocational schools, which can be replicated in other vocational schools. Development of learning by establishing partnerships with industry, adjustments to the Industry 4.0-based curriculum, activation of LMS for the implementation of synchronous and asynchronous learning, optimising synergy with the local manpower office, and implementing teaching factories together with other schools, so that there is a real link and match between vocational schools and DUDI.

## Conclusion

The results of the analysis of several data and from various sources of information collected can create a common thread of the impact of the development of industry 4.0-based vocational schools, including: (1) The industry 4.0-based vocational school development program, which is part of the National Education Major Project, has a positive impact on the availability of graduate human resources who are ready to compete in the world of work; (2) The concrete manifestation of SMK partnerships with various 4.0 industries located in KI and KEK, is manifested in various activities: mentoring from the industrial world/education practitioners, Implementation of PKL for students on a regular and continuous basis, and recruitment of prospective workers as an actualization of the MoU with Industry; (3) The Industry 4.0-based SMK development program including: Digitalization of the educational process in SMK, preparing for competency adjustments required by Industry 4.0 through adjustments to the Industry 4.0-based curriculum, activation of LMS for the implementation of synchronous and asynchronous learning, optimizing the role of industry practitioners/education practitioners to upgrade the competencies of teachers & education personnel in SMK, updating practice room facilities and practice equipment; and (4) Indicators of the success of the development of Industry 4.0-based SMK are seen in SMK development activities consisting of strengthening digital-based learning, improving the quality of practice equipment and improving the quality of facilities.

Based on the conclusion of the development of Industry 4.0-based Vocational Schools which shows that the impact generated by Vocational Schools after consistently and continuously carrying out activities as indicators of success of Vocational Schools in carrying out all digital-based activities, the Industry 4.0-based Vocational School development program is worthy of being continued and expanding the reach of the distribution area outside in SEZs and IZs in Indonesia.

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