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From School to Industry : The Relevance of Vocational School Competencies in Machining Technology to Manufacturing Industry Needs

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Abstract: This study aims to analyze the relevance of technical machining skills competencies at SMK Negeri 1 Karawang to labor needs in the manufacturing industry sector. The research method used is a survey with a quantitative approach. The research instrument is a questionnaire given to 68 students in the 12th grade of the technical machining program. The data analysis technique used was descriptive statistical analysis, calculating the percentage of respondents' answers based on the Likert scale to evaluate the alignment of the curriculum and graduates' competencies with industry demands. The research results indicate that the competencies possessed by graduates of SMK Negeri 1 Karawang are highly relevant and aligned with the demands of the job market. This is evident from the curriculum content alignment rate, which reached 85%. Specifically, graduates' competencies in cognitive aspects achieved a percentage of 86%, while psychomotor aspects also scored 86%. Meanwhile, the affective aspect received the highest score at 88%. However, there are still shortcomings in the mastery of soft skills, such as the 5S principles (commonly understood as Sort, Set in order, Shine, Standardize, and Sustain, though adapted here for workplace politeness and courtesy as Smile, Greeting, Politeness, and other relevant workplace behaviors might be more contextually defined) and 5P (Precision, Productivity, Maintenance, Prevention, and Improvement), as well as workplace safety culture (Safety) and work ethics. These findings recommend strengthening soft skills in the curriculum, enhancing collaboration between schools and industry, and conducting regular curriculum evaluations to ensure that graduates' competencies remain aligned with the needs of the job market.

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Introduction

The alignment between the vocational skills taught at vocational high schools (SMK) and the needs of the job market is a critical issue in the development of competent human resources (HR). In the era of globalization and rapid technological advancement, the manufacturing sector has become one of the main pillars of the economy, particularly in industrial areas such as Karawang. SMK Negeri 1 Karawang, located in West Java province, is one of the vocational education institutions that plays a strategic role in producing competent workers, particularly in the field of mechanical engineering. However, a common challenge is how well the competencies of SMK graduates align with the needs of the manufacturing industry, especially in the Karawang area.

According to Hidayati et al. (2021), the mismatch between the competencies of vocational school graduates and the needs of the business world and industry can lead to high unemployment rates and low work productivity. This aligns with data from the Central Statistics Agency (BPS), which shows that the Open Unemployment Rate (OUR) for SMK

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graduates in Indonesia as of August 2024 reached 9% or approximately 1,840,162 individuals. This figure remains the highest compared to other educational levels. Therefore, Sobari et al. (2023) emphasize the importance of industry involvement in developing vocational school curricula to minimize the gap between graduates' competencies and industrial demands. Through partnerships between schools and industries, by aligning curricula with industrial needs, the absorption of vocational school graduates into the workforce can be enhanced.

Several researchers have examined the relevance of the technical machining skills curriculum in SMK to the labor needs of the manufacturing industry. For example, research conducted by Bagyo & Ngadiyono (2020) found that the Computer Aided Design (CAD) curriculum in the 2013 SMK curriculum had a relevance level of 81.67% with the competencies required by industry, indicating that although most of the material was appropriate, there was still room for further adjustment. Additionally, in their research, Yoto et al. (2020) explained that there is a gap between the competencies taught at SMK and those required by the industry, particularly in the use of the latest technologies and soft skills. Meanwhile, Widarto (2019) argued that the SMK curriculum needs to be continuously updated to keep pace with technological advancements and the dynamic demands of the industry.

However, despite existing research on this issue, certain aspects have not been thoroughly examined. One aspect that has received little attention is the specific factors influencing the alignment of technical machining competencies with the needs of the manufacturing industry in a particular region, such as Karawang. This aspect is crucial because each region has distinct industrial characteristics. This study aims to analyze the relevance between the technical machining skills competencies at SMK Negeri 1 Karawang and the labor market needs in the manufacturing sector. The research is expected to provide practical recommendations for both schools and the government to enhance the quality of vocational education, making it more aligned with the demands of the workforce.

Research Method

This study uses a descriptive quantitative approach with a survey method to obtain an overview of the suitability of technical machining skills competencies at SMK Negeri 1 Karawang with the needs of the manufacturing industry. This approach was chosen to objectively measure and describe the level of suitability between the curriculum, graduate competencies, and industry demands based on numerical data collected from respondents. The population in this study was all 136 students in the 12th grade of the Machining Engineering program at SMK Negeri 1 Karawang. Sampling in this study used purposive sampling. This technique is a sampling technique carried out by researchers with certain considerations (Sugiyono, 2015). The number of respondents used in this study was 68 students who had completed the entire learning process and were considered capable of providing relevant assessments of the alignment between their competencies and industry needs.

The instrument used in this study was a closed-ended questionnaire based on a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). This questionnaire consists of two main parts, namely (1) the alignment of curriculum content with industry demands, and (2) graduate competencies divided into three main aspects, namely cognitive (understanding), psychomotor (skills), and affective (attitude). Additionally, secondary data was obtained through curriculum documentation and interviews with school officials and several industry

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representatives in Karawang as supporting evidence. Documentation data was obtained from the curriculum documents implemented at SMK Negeri 1 Karawang, while interviews were conducted with the school's curriculum vice principal and company representatives in Karawang to strengthen relevant data.

The data obtained were analyzed using descriptive statistical methods, specifically percentage statistics. This analytical technique was used to determine the categories of understanding levels and their alignment with the skills learned in relation to the demands of the manufacturing industry. Data from each respondent were collected, calculated, and then analyzed descriptively using the following formula:

$DP = \frac{n}{N} \times 100\%$..... (Warnandes et al., 2011)

Description :

DP : Descriptive Percentage (%)

n : Empirical score (score obtained)

N : Ideal score for each item

To determine the average percentage obtained from the research results, calculations were performed using the following formula:

Average = Σx/N…….…… (Al Kadri et al., 2022)

Description :

Σx : Total value of all samples

N : Number of data units in the sample unit

After that, the data obtained was analyzed statistically and then the level of conformity was examined based on its category according to Table 1, which shows the descriptive analysis percentage categories.

Table 1. Descriptive Analysis Categories Percentage

81% – 100%	Very Relevant
61% – 80%	Relevant
41% – 60%	Quite Relevant
21% – 40%	Irrelevant
1% – 20%	Highly Irrelevant

Results and Discussion

Alignment of Machining Skills Competencies with Labor Requirements in the Manufacturing Industry

The alignment between the competencies taught at vocational schools and the needs of the industrial workforce is a key element in producing graduates who are ready to enter the workforce and relevant to the dynamics of the job market. In this context, the aspects examined include the relevance of the curriculum content and the competencies of graduates in three important aspects, namely cognitive, psychomotor, and affective aspects. The results obtained from this study indicate that, in general, the technical skills competencies in mechanical engineering at SMK Negeri 1 Karawang have a high level of alignment with the labor needs of the manufacturing industry. The overall percentage of results from the four indicators is presented in Figure 1.

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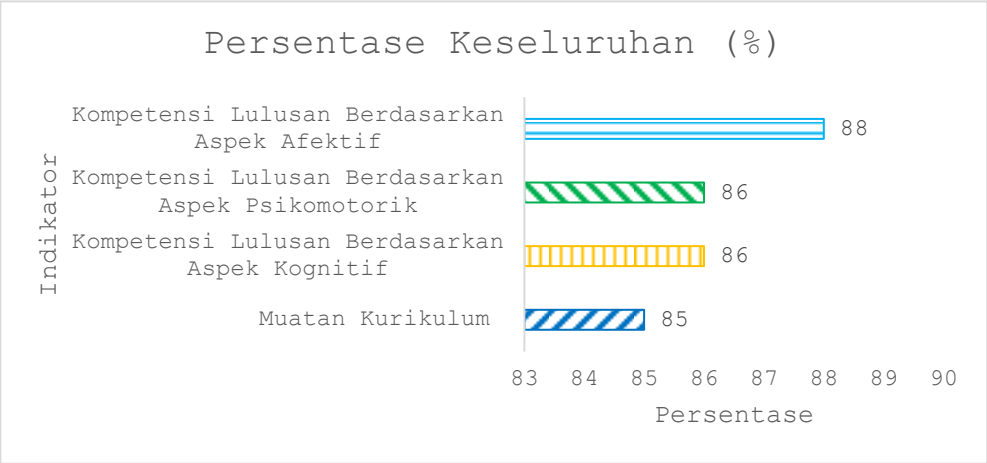

Figure 1 shows that the curriculum content indicator obtained a suitability level of 85%, which means it is classified in the Highly Relevant category. This shows that the applied curriculum structure has met most of the competency needs expected by the manufacturing industry. The current curriculum is an independent curriculum, which gives schools the flexibility to develop a curriculum based on the needs of the world of work. This flexibility allows for a regular process of curriculum synchronization between the school and the industry. Every year, there is a joint evaluation and discussion between the school and industry representatives to adjust the curriculum content to the latest technological developments and workforce competency demands. This is in line with the findings of Fajari et al. (2024) who emphasized the importance of digital technology-based curriculum development in order to keep up with the development of the industrial era 4.0 and digital transformation. A curriculum that is adaptive to technology is an important foundation in preparing vocational students so that they are not left behind in facing the changing needs of the labor market.

Furthermore, Ramadhan et al. (2022) revealed that Field Work Practices (PKL) and mastery of work competencies make a major contribution to student work readiness. Therefore, in addition to improvements in curriculum content, the implementation of practical activities such as PKL, teaching factories, and teacher internships is also used as a real strategy to strengthen the relevance of the curriculum to the world of work. These activities provide direct experience to students in understanding the work culture, technology used, and quality standards in the manufacturing industry. However, the implementation of an industry-based curriculum is not without obstacles. One of the main challenges that is often faced is the limited time from the industry to be actively involved in the process of curriculum development and evaluation. As stated by Fatah (2022), building a solid partnership between schools and industry is not always easy, especially when the industry has time constraints or other priorities that hinder the collaboration process. In addition, Nida et al. (2023) noted that the implementation of PKL often experiences obstacles such as the mismatch of assignments with student competencies and the lack of supervision from the industry, which can affect the effectiveness of the learning process in the field. To overcome these challenges, the school continues to actively approach the industry and seeks to establish mutually beneficial partnerships. In addition, teacher capacity building programmes through training involving the industry are also an important part of this process. Thus, it can be concluded that the mechanical engineering curriculum at SMK Negeri 1 Karawang is quite relevant to the needs of the manufacturing industry. However, continuous curriculum

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development and more intense collaboration with industry are still needed to provide a strong foundation for graduates to have high work readiness amid the dynamics of the industrial world that continues to evolve.

In addition to the suitability of the curriculum content that has been designed to meet the increasingly complex demands of the industry, graduates of SMK Engineering Machining are required to have complete and balanced competencies with 3 (three) main aspects, namely cognitive (knowledge), psychomotor (skills), and affective (attitude) aspects. These three aspects have a complementary role in forming graduates who are ready to work both in terms of mastery of theory, practical skills, and professionalism. Based on the results of the questionnaire presented in Figure 1, the competence of graduates in the cognitive aspect obtained a level of conformity of 86%, which means it is classified into the Very Relevant category. This indicates that the majority of students consider themselves to have a good mastery of basic knowledge. They have understood the basic principles of machining, production processes, material selection, work safety, and the use of measuring instruments and technical drawings.

However, the industry says that although students' theoretical understanding is good, it is not enough to directly address the challenges in the field. Today's manufacturing industry relies heavily on digitalization and computer-based technology such as the use of CAD (Computer Aided Design) software and programming on NC/CNC machines. Many graduates already understand the basic concepts of CNC machine theory, but still lack the ability to compile programs, determine cutting parameters, and operate the machine efficiently. This is in accordance with research conducted by Arif et al. (2022) that the learning outcomes of mechanical engineering graduates are indeed achieved, but increased competence is still needed to match the needs in the field. In addition, Made et al. (2022) recommends implementing a project-based learning method because it is proven to increase material understanding and active student involvement in the engineering learning process.

Then next, based on the results of the questionnaire presented in Figure 1, competencies in the psychomotor aspect obtained a score of 86%, which means that these competencies are included in the Very Relevant category. This competency includes the ability of students to apply technical skills directly both in workshops at school and in the world of work. The percentage shows that students have mastered basic practical skills such as operating lathes, milling and grinding machines and NC/CNC machines. However, there is still a lack of mastery of the latest technology, especially in the operation and programming of NC/CNC machines, as revealed in the research of Wiyogo et al. Industry also emphasizes the importance of skills in reading and making technical drawings, understanding tolerances and measurements in machining, and accuracy in setting work parameters. This is reinforced by the results of interviews with the industry which states that graduates already understand conventional machines, but are still lacking in the practical aspects of computer-based automatic machines. Therefore, increasing practical hours and more intensive cooperation with industry are important so that the skills of graduates can be honed so that they are ready to enter the world of work.

Finally, on graduate competencies based on affective aspects, the graph in Figure 1 shows that this aspect obtained the highest score of 88%. This shows that the competencies possessed based on this aspect are considered Very Relevant. Students assess that they have good discipline, responsibility, and work ethic. Research conducted by Rahayu et al. (2021) and Warnandes et al. (2022) also stated that in general, the industry assessed the attitudes and work ethics of SMK graduates as quite good. However, skills gaps are still found, especially

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in soft skills aspects such as communication, leadership, discipline, and teamwork. Milaningrum and Rahmawaty (2021) even highlighted the mismatch between graduates' competencies and industry demands, especially in the use of information technology and interpersonal skills. This is confirmed by the results of interviews with industry parties who stated that competencies that are still weak are not only in the aspect of technical skills, but also in the work culture in companies such as 5S (Smile, Greeting, Greeting, Polite, Polite), 5P (Precision, Productivity, Maintenance, Prevention, Repair) as well as safety culture and professional ethics. According to the industry, the formation of work attitudes cannot only be left to the industry, but must be instilled since school through habituation and contextual learning. Therefore, the applied curriculum also needs to integrate activities that can shape student character such as group discussions, teamwork simulations, communication training, and industrial work culture habituation programs. Strengthening soft skills is important so that graduates not only have technical skills, but also mentally and socially in adapting to a dynamic work environment.

Factors of Conformity of Competencies Owned by Graduates with Labor Needs in the Manufacturing Industry

The level of suitability is inseparable from various factors that influence the achievement of graduate competencies with the demands of the world of work in the manufacturing industry. In general, these factors are classified into two main categories, namely internal factors and external factors. Internal school factors play an important role in shaping the competencies of graduates in accordance with the needs of the manufacturing industry. One of the main factors is the quality of the teaching staff. Teachers are not only material deliverers, but teachers are also facilitators who guide students in understanding the theory and practice in the field of mechanical engineering. Although many teachers already have adequate experience and competence, they still need to improve their skills, especially in keeping up with the latest industrial technology. This is reinforced by the findings of Fatah et al. (2022), who stated that non-optimal equipment and teacher training are obstacles in the relevance of vocational education to the industrial world.

Teachers' limited access to industry-based training is a challenge in itself. Therefore, there is a need for more collaboration between schools and industry, for example through the provision of teacher internship programs and certified training, so that teaching materials are always up-to-date according to the needs of the manufacturing industry which is developing very rapidly (Hidayati et al., 2021). In addition, practical facilities and equipment are also internal factors that greatly affect graduate competence. The results of interviews with school officials show that most of the practical equipment used is still far behind the latest industrial technology such as automation-based machines. This condition is in line with the findings of Hidayati et al. (2021), which revealed that limited practical facilities are one of the main causes of the mismatch between graduate competencies and industry needs. The school has tried to overcome this by implementing practice-based learning with a composition of 75% practice and 25% theory. This strategy aims to give students more hands-on experience. However, this still faces obstacles, especially due to the limited number of equipment and machines available. Students often have to take turns using the machines, which results in a lack of individual practice hours, so their skills are not maximized.

Apart from within the school, external factors can also have a significant influence on the suitability of graduate competencies with labor needs in the manufacturing industry. One of the most dominant external factors is the advancement of industrial technology which is developing very rapidly. The industrial world has now transformed with the application of

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automation, digitalization, and computer-based manufacturing systems. However, many SMK graduates still experience difficulties in following this development because they are not accustomed to operating the latest technology such as CAD software and NC / CNC machines (Fatah et al., 2022). This condition is exacerbated by the limited practical equipment available in schools that does not support learning industrial technology 4.0. Thus, although students have understood the basic theory, they often experience difficulties when they have to directly operate modern equipment commonly used in industry

Faktor lain yang dapat memengaruhi adalah Tingkat keterlibatan industri dalam Another factor that can influence is the level of industry involvement in vocational education. Some industries have participated through internship programs, teacher training, or curriculum evaluation, but this participation is uneven. Most industries often still experience obstacles such as limited time and energy to guide students during industrial practice (Nida et al., 2023). This has an impact on the low quality of work experience gained by students. According to Sobari et al. (2023), more active industry involvement in curriculum development is needed with the aim of bridging the gap between the world of education and the world of work. More intensive cooperation can help ensure that learning materials and graduate competencies really match the needs of the field. In addition, the dynamic and fast-changing conditions of the job market also influence. The manufacturing industry demands graduates who are not only technically skilled, but also adaptive, communicative, and able to work in teams. According to the company, there are still some graduates who still have difficulty in adjusting to a complex and diverse work environment. They are also considered lacking in discipline, problem solving, and mental readiness to deal with work pressure. Therefore, improving soft skills is an important concern going forward.

Efforts to Improve Alignment of Graduate Competencies with the Needs of the Manufacturing Industry

Based on the various factors that can affect the level of alignment both internally and externally described earlier, a number of efforts need to be implemented to improve the suitability between the competencies of graduates of vocational engineering schools and the needs of the manufacturing industry. These efforts do not only focus on the technical aspects, but also include improving educators' human resources, learning support facilities, and strengthening students' soft skills. The following are some of the efforts that can be made to increase the level of alignment.

Improving Curriculum Synchronization with Industry

One of the fundamental steps that can be taken is to synchronize the curriculum with the needs and latest developments in the manufacturing industry. According to Sobari et al. (2023), curriculum synchronization is the main strategy in improving the relevance of vocational education, especially by involving industry directly in the development of curriculum content. This synchronization can be done periodically through the holding of communication forums between schools and industry partners. The forum is conducted annually which serves as a discussion space and the industry can provide input regarding what competencies are needed both technically and non-technically.

Improving Teacher Competence Through Industrial Training and Internships

Teachers have an important role in bridging theoretical knowledge with the practical needs of the world of work. Therefore, improving teacher competence through industry-based training and internship programs is very important. According to Fatah et al. (2022), teachers who take part in training or internships at the Company will gain insight into the latest technology and production methods, so that they can deliver more contextualized learning to

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students. Teacher upskilling and reskilling programs need to be facilitated systematically by schools and the government through cooperation with industry. This is in line with the SMK Center of Excellent (CoE) program that aims to improve the quality of vocational education in Indonesia through partnerships with industry (Wardani & Raihani, 2024; Sudarma et al., 2023). The program focuses on better development, teacher potential, and infrastructure (Sudarma et al., 2023).

Provision and Utilization of Technology-Based Learning Facilities

Learning facilities and infrastructure that are in accordance with the times are one indicator of school readiness in producing competent graduates. However, in reality, many schools still experience limited practical equipment. To bridge this gap, schools also need to establish cooperation with industrial partners such as in the form of equipment grants, utilization of industrial facilities, and procurement of digital simulations (Sobari et al., 2023)

Increasing the Surety and Quality of Field Work Practices (PKL)

PKL is an important medium for honing students' technical skills and introducing students to industrial work culture. However, the quality and duration of PKL implementation are often an obstacle. Nida et al. (2023) revealed that the placement of students in positions that are less relevant to their skill competencies is one of the main causes of the ineffectiveness of the PKL implementation. For this reason, a firmer policy is needed in regulating the implementation of PKL, including extending its duration, increasing mentoring from the industry and preparing a PKL work program that is structured and in accordance with the student's expertise curriculum.

Strengthening Soft Skills and Mental Readiness of Graduates

Industry needs are not only limited to technical skills, but also include work attitudes, ethics and interpersonal skills. Currently, the industry considers that soft skills such as communication, collaboration, discipline, and adaptability are the most difficult aspects to find from SMK graduates (Mardi., 2021). This is in line with the results of interviews from the industry who said that the competencies that are still lacking in SMK graduates are those related to the work culture in the company such as 5S, 3P, safety culture, morals, and work ethics. Therefore, schools need to integrate soft skills training explicitly into the curriculum. This can be done through collaborative lessons, leadership training, and extra-curricular activities that can encourage the development of character and work ethic.

Strengthening Competency Certification and Cooperation with Certification Bodies

Competency certification is concrete evidence that a graduate has skills in accordance with industry standards. Schools need to work with institutions such as the National Professional Certification Agency (BNSP) to facilitate students to take competency tests regularly. By having certification, graduates have added value in the job market and facilitate the recruitment process in manufacturing companies (Sobari et al., 2023).

Increasing the Role of Industry in Vocational Education

The active role of industry is an important component in the success of vocational education programs. Industry is not only a place for PKL, but can also act as a partner in curriculum preparation, facility providers, and direct teaching in the form of industrial classes. However, according to Fatah et al. (2022), the biggest challenge is building a solid partnership between schools and industry, due to different priorities and teachers' lack of understanding of industry-based curriculum.

Conceptually, these results support the theory of industry-based curriculum relevance that emphasizes the need to synchronize the curriculum with the needs of the world of work to produce graduates who have holistic competencies in cognitive, psychomotor, and

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affective aspects. The findings also emphasize the importance of applying constructivistic and experiential learning approaches in vocational education, which integrate theory, practical skills, and professional attitude development. Meanwhile, practically, the findings provide some important recommendations. For schools, it is necessary to strengthen the teaching of soft skills such as 5S (Smile, Greeting, Greeting, Politeness), 5P (Precision, Productivity, Maintenance, Prevention, Repair), work safety culture, and work ethics through integration in project-based practical activities, group discussions, and work simulations. Intensive collaboration with industry should also be strengthened through curriculum evaluation, provision of practical facilities, and teacher training and internships in industry.

For the industry, the results of this study provide a basis for increasing involvement in curriculum development, providing work practice sites, and providing regular feedback on graduate performance. In addition, the industry is also expected to support the development of competency certification to improve the competitiveness of graduates. As for the government, the results of this study provide a basis for facilitating competency certification programs, training and increasing teacher capacity, providing technology-based facilities, and strengthening the implementation of PKL to be more effective and quality. Thus, the competence of graduates of SMK Mechanical Engineering will be more in line with the needs of the dynamic manufacturing industry.

Conclusion

The results showed that the competence of Mechanical Engineering expertise at SMK Negeri 1 Karawang is generally very relevant to the needs of the world of work in the manufacturing industry. The level of curriculum suitability reached 85%, with graduate competencies in cognitive and psychomotor aspects each at 86%, and the highest affective aspect at 88%. This finding confirms that although graduates have mastered the theory and basic skills, strengthening is still needed, especially in mastering the latest technology (CAD, NC/CNC) and soft skills (5S, 5P, work ethics). Factors such as curriculum updates, practical facilities, teacher competence, and industry involvement play an important role in this suitability. Therefore, strengthening school-industry collaboration, improving teacher training, and providing technology-based facilities are strategic steps so that graduates are increasingly ready to face the growing demands of the industry.

Recommendation

Recommendations based on the findings of this study include:

(1) For Schools (SMK)

Schools are advised to regularly evaluate the curriculum by involving industry practitioners, so that the suitability between learning materials and labor needs is maintained. In addition, strengthening soft skills training should be a priority in the learning process, through integration in extracurricular activities, field work practices, and collaboration-based projects.

(2) For the Manufacturing Industry

Industry needs to increase its role in vocational education through partnership programs such as teaching factories, teacher internships, provision of work practice sites, and curriculum development in accordance with the real needs in the field. The industry is also advised to provide regular feedback to the school regarding the performance of graduates so that the school can make continuous improvements.

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(3) For the Government

The government needs to strengthen the synergy between vocational high schools (SMK) and the industrial world through curriculum synchronization that is relevant to the latest labor market needs. Strategic steps include improving teacher competencies through industry-based training and internships, as well as providing modern practice facilities such as CNC machines and digital simulations. In addition, it is important to extend the duration and ensure the relevance of field work practice (PKL) programs, while integrating the development of soft skills, such as communication, work ethic, and safety culture, in learning. The government is also expected to encourage competency certification for students through cooperation with certification bodies, and increase active collaboration with industry in curriculum development, training, and internship programs. These steps aim to create SMK graduates who are competent and ready to compete in the world of work.

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