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Bridging the Competency Gap: Aligning Automotive Vocational Education with Industrial Standards in Industrial Work Placement Programs

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ABSTRACT

Background: Industrial Work Placement (PKL) is a mandatory course for Vocational High School (SMK) students involving practical activities in relevant industries. A significant gap persists between the competencies students have mastered and the professional standards required by the automotive industry. Objective: This study aims to identify the competency standards required for automotive engineering (TKRO) students to perform effectively during industrial work placement, in accordance with automotive industry requirements. Methodology: This research employed a qualitative case study design. Data were collected through in-depth semi-structured interviews with nine purposively selected automotive workshop managers in Surakarta, Indonesia. Data analysis followed the interactive model of Miles, Huberman, and Saldana (2014). Findings: To successfully execute tasks in the automotive industry, internship students must possess a triad of competencies: (1) general competencies (soft skills) including occupational health and safety, industrial culture, and work environment maintenance; (2) specific/technical competencies (hard skills) covering inspection and maintenance of engines, power transmission, electrical, and body electrical systems; and (3) automotive-specific supporting competencies related to digital literacy and modern automotive technology. Practical Implications: The findings provide a concrete reference for vocational curriculum design and student preparation before industrial placement, particularly in the context of Indonesia's automotive vocational education

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1. INTRODUCTION

The current industrial revolution is part of the Fourth Industrial Revolution era, which requires humans to adapt to digital technology. Human activities in various fields are now linked to digital systems. Industry 4.0 is also known as the digital revolution and the era of technological disruption. The era of technological disruption, driven by connectivity and automation in all fields, will lead to non-linear movements in the industrial world and increased job competition [1], as well as the emergence of artificial intelligence [2]. Education is an effort to prepare human resources (HR) who can face global competition and adapt to changing times. Vocational education to face the digital era can enhance individual competencies, knowledge, abilities, and skills [3]. Vocational education needs to prepare adaptable human resources to compete globally.

Vocational education is a means of developing students' skills, with the ultimate goal of achieving work-readiness, presenting significant challenges and opportunities [4]. The objectives of vocational education are to form competencies and develop individual knowledge, abilities, and skills. It is also explained that through vocational education, individuals can gain comprehensive knowledge from internship experiences, enabling them to perform their jobs effectively [5]. Various preparations need to be made so that graduates can compete and have successful careers, including adapting new literacy movements to the curriculum and applying appropriate methods to prepare students. Schools have made efforts by providing aptitude tests, career guidance, Field Work Practice (PKL) in industries, and also Teaching Factories [6], [7]. PKL is a subject that all vocational school students must take in the form of practical activities related to their chosen field of industry.

To achieve these goals, vocational education providers must prepare several competencies, which are secondary education that produces graduates ready to work in specific fields [8]. Vocational education is an educational approach that emphasizes industry's needs, enabling the development of individual abilities and skills applicable to the industrial sector [9]. Vocational education, particularly Vocational Secondary Schools (SMK), has the main objective of preparing graduates who are ready to work and able to adapt to developments in the industrial world [10]. The Field Work Practice (PKL) programme is a crucial component of the vocational education system, as it provides students with real-world work experience and serves as a forum for applying the competencies they have acquired in school. PKL is a form of collaboration between SMK and industry [11].

Work experience is a crucial component of the learning process in vocational high schools (SMK). According to Regulation of the Minister of Education and Culture of the Republic of Indonesia Number 50 concerning work experience for students, the work experience program is a compulsory activity that all SMK students must undertake within a specified period as part of the curriculum implementation [12]. PKL is an activity that sends students into the industrial world to expose them directly to work in their field and develop their potential [13]. With the skills developed during PKL, SMK graduates are expected to become professionals who are well-equipped to face challenges in the workforce.

The Automotive Light Vehicle Engineering (TKRO) competency is one of the competencies within the scope of the automotive engineering programme at vocational

schools. The fact that the competencies of vocational school graduates do not yet meet industry standards remains a problem in the implementation of vocational education [14]. Industries in Indonesia face challenges in finding skilled workers at the level of skills required in the era of the 4.0 industrial revolution [15], [16], requiring an update of competencies in accordance with industry standards [17]. One strategy vocational schools use to improve graduates' competencies is to arrange work experience placements with partner industries. Students with TKRO expertise competencies undertake 6-month work experience placements with partner industries in accordance with the independent curriculum [18]. Internships provide students with direct experience in the world of work [19] and align with their field of study [20]. Internships are a strategic way to equip students with work experience.

In implementing PKL, there are problems, particularly the gap between the competencies students master and industry competency standards. This problem is a significant issue in vocational schools, especially regarding TKRO expertise competencies. Students who participate in PKL are often unaware of the minimum competencies required to participate in PKL within the automotive industry. Although previous studies have discussed vocational readiness and industry alignment in general, limited research has specifically identified the competency standards expected by automotive workshops (bengkel) for TKRO students during their industrial work placement (PKL). Most existing studies focus on outcomes after PKL rather than the entry-level competencies that students must possess before or during the placement to be effective. To address this gap, this study is guided by the following direct research question: *What competencies are required by the automotive industry for TKRO students to perform effectively during industrial work placement.*

This study is particularly necessary in the Indonesian automotive vocational context due to three unique challenges. First, the Indonesian automotive industry operates with diverse workshop types, ranging from authorized dealerships (dealer resmi) with standardized equipment to general independent workshops (bengkel umum) with varying technological readiness, creating inconsistent competency expectations. Second, the implementation of Indonesia's Merdeka Curriculum has restructured the duration and assessment methods of PKL without a nationally unified competency framework for TKRO students during placement. Third, previous misalignments have led industry partners to complain that students often lack basic diagnostic skills with digital tools (scanners, oscilloscopes) required in Industry 4.0, while schools continue to emphasize mechanical repair competencies. Without a clear, empirically derived competency standard from the industry's perspective, vocational schools risk designing PKL programs that fail to bridge the gap, leaving graduates underprepared for the actual demands of automotive workshops.

Based on this problem, it is necessary to conduct research to determine the competency standards for automotive engineering students' fieldwork practice in accordance with the automotive industry's requirements.

2. METHOD

This study employed a qualitative approach with field research. Specifically, this study used a qualitative case study design, based on field interviews with automotive

workshop managers, to gain an in-depth understanding of the competency standards required of TKRO students during PKL. The research data comprised primary sources from interviews and secondary sources from relevant documents on competency requirements for PKL in the automotive industry. Data were collected through in-depth interviews with purposively selected automotive industry workshop managers. Nine participants were considered sufficient as data saturation was reached after the seventh interview, with subsequent interviews confirming existing findings. Participants represented a range of workshop categories—authorized brand dealerships (Mitsubishi, Toyota, Suzuki), authorized independent workshops (RPM, Iwan Motor, Auto 168), and private workshops (Arief Motor, Panasan Motor, Bengkel Mobil 99)—to capture diverse industrial perspectives. The primary data sources in this study are described in Table 1 below.

Table 1. Research data sources

No	Position	Workshop Name	Workshop Category
1.	Service manager	PT Sun Star Motor Solo (Mitsubishi)	Authorised workshop/Brand
2.	Instructor GR	PT Toyota Nasmoco Solobaru	Authorised workshop/ Brand
3.	Workshop Manager	PT Solo Indonesia Utama (Suzuki)	Authorised workshop/ Brand
4.	Workshop Manager	Bengkel RPM Integrated Auto Clinic	Authorised workshop
5.	Workshop Manager	Iwan Motor	Authorised workshop
6.	Workshop Manager	Auto 168	Authorised workshop
7.	Owner	Arief Motor	Private workshop
8.	Owner	Panasan Motor	Private workshop
9.	Owner	Bengkel Mobil 99	Private workshop

Each interview lasted 45–75 minutes (average 60 minutes), was audio-recorded with participant consent, and transcribed verbatim. A semi-structured interview guide was used to ensure consistency while allowing probing. Transcripts were returned to participants for validation (member checking), with no corrections requested. Data analysis employed an interactive model comprising data collection, data condensation, data display, and conclusion drawing [21]. Data condensation refers to the process of selecting, focusing, simplifying, abstracting, and transforming data to make it more concise and understandable. The interactive data analysis procedure refers to the Miles, Huberman, and Saldana analysis model.

3. RESULTS AND DISCUSSION

3.1. Results

Based on interviews with nine participants from light vehicle or four-wheel vehicle (R4) automotive workshops, data were obtained on the competencies that vocational school students majoring in Light Vehicle Automotive Engineering (TKRO) must possess. To carry out PKL in the automotive industry/workshop, students must possess three competencies: general, specific/technical, and supporting. Students must acquire these three competencies before carrying out PKL activities in automotive workshops. The components of general, exact, and supporting competencies are described in Table 2 below.

Table 2. Components of general, specialised, and supporting competencies in the TKRO vocational programme according to industry standards

Category	Indicator	Component	Attribute
General competencies	Basic skills that support work readiness in an automotive workshop environment	Occupational Health and Safety (OHS)	Human safety
			Equipment and vehicle safety
		Industrial culture	Discipline
			Work ethic
			Communicating with the team
			Communicating with superiors
		Work environment maintenance	Work area cleanliness
			Cleanliness of primary work equipment
			Cleanliness of supporting work equipment
Specialised/technical competencies	Technical aspects of automotive engineering required for hands-on practice in the workshop	Inspection and maintenance of light vehicle engines	Engine tune-up
			Regular servicing
		Inspection and maintenance of power transmission systems and chassis	Brakes
			Steering
			Suspension
			Clutch
			Manual transmission
			Differential/axle
			Balancing
		Inspection and maintenance of the electrical system of light vehicles	Conventional ignition system
			Starter system
			Charging system
			Wiring diagram
		Inspection and maintenance of the electrical system of light vehicle bodies	Vehicle lights
			Horn
			Wiring diagram
		Use of mechanical and electrical measuring instruments	Multi tester
			Vernier caliper
			Wire tester
			Torque wrench
Supporting competencies	Ability to support technical work	Digital literacy and modern technology	Automotive technology and software
			Electric and hybrid vehicles
			Digital documentation, such as reports, photographs, and technical videos

3.2. Discussion

Competencies of automotive engineering students

General, specific, and supporting competencies, along with their components and attributes, must be acquired by students before undertaking work experience placements in automotive workshops. The automotive industry requires technical and managerial competencies [22]. The competencies required by the industrial world are employability skills and technical skills [23], and vocational school graduates need to be equipped with 21st-century skills [24]. Work experience and soft skills acquired during PKL are needed when working [25]. This study found that to carry out work during the Field Work Practice (PKL), students must master general competencies (soft skills), specific/technical competencies (hard skills), and supporting competencies to implement technical work in automotive workshops.

Beyond merely restating these findings, this discussion interprets their deeper meaning. The tripartite competency structure (general, specific, supporting) reveals that automotive workshops do not expect students to be fully proficient technicians upon arrival. Instead, industry partners expect students to possess a foundational toolkit of safety awareness, basic technical procedures, and digital literacy, enabling them to learn productively during PKL rather than requiring constant supervision. This finding shifts the paradigm from "work-ready graduates" to "learn-ready students" who can actively participate in workplace learning.

The findings of this study are partially consistent with earlier research and reveal new, context-specific insights. Consistent with prior studies [22], [23], this research confirms that both technical and employability skills remain essential. The emphasis on occupational health and safety (OHS) and industrial culture (discipline, work ethic, communication) aligns with longstanding findings that soft skills are universal prerequisites for workplace integration [25], [27].

However, this study contributes new findings specific to the Indonesian automotive context. First, while previous research [26] discussed technical competencies broadly, this study identifies a clear hierarchy: inspection and maintenance of engine systems, transmission/chassis systems, electrical systems, and body electrical systems, in that order of priority according to workshop managers. Second, the finding that supporting competencies (digital and modern technologies) are treated as a separate, non-negotiable category rather than embedded within technical competencies is novel. Earlier studies [16], [28] mentioned digital literacy as beneficial, but this study reveals that Indonesian automotive workshops now consider basic digital diagnostic skills as a prerequisite, not an advantage. This reflects the rapid penetration of Industry 4.0 technologies even into general private workshops, a context-specific phenomenon not yet documented in earlier vocational education literature.

General Competencies

General competencies serve as the foundation for the work-readiness of Automotive Engineering vocational school students when undertaking industrial practice in automotive workshops. General skills (soft skills) have several components and attributes, as follows:

a. Occupational health and safety (OHS) covers human safety and tools/vehicles as key points. This is very important to ensure that work is carried out safely without endangering oneself or work equipment.
b. Industrial culture encompasses discipline, work ethic, and communication skills (both within teams and with superiors). These competencies support the creation of a professional, harmonious work environment and increase team productivity and performance.
c. Work environment maintenance includes keeping the work area, main equipment, and supporting equipment clean. Routine maintenance helps prevent accidents, maintain work efficiency, and enhance workplace comfort.

Technical Competence

Specialised/technical competencies (hard skills), also known as technological skills [26]. They are crucial for practical fieldwork in automotive workshops because they reflect students' operational abilities aligned with the needs of the world of work. Technical competencies and general skills play complementary roles in shaping students' work readiness [27]. Specialised/hard skills are highly specific to automotive work and include the following components and attributes:

a. Inspection and maintenance of light vehicle engines, including engine tune-ups and periodic servicing.
b. Inspection and maintenance of power transmission and chassis systems, including brakes, steering, suspension, clutch, manual transmission, differential/axle, and balancing.
c. Inspection and maintenance of light vehicle electrical systems, including conventional ignition systems, starters, charging systems, and wiring diagrams.
d. Inspection and maintenance of light vehicle body electrical systems, including vehicle lights, horns, and wiring diagrams.
e. Use of mechanical and electrical measuring tools, including multi-testers, calipers, wire testers, torque wrenches, and other measuring tools commonly used in automotive workshops.

Supporting competencies

Supporting competencies in digital and modern technologies is an important foundation for TKRO vocational school students to compete in the increasingly advanced, high-tech automotive industry. The ability of vocational school students to operate automotive digital devices is highly useful in the automotive field, especially for diagnosing component damage. Digital competencies include the ability to operate automotive software and applications that support vehicle diagnosis learning. Students who are skilled in digital literacy can access the latest knowledge sources, use electronic diagnostic tools, and create digital documentation of their work, thereby increasing efficiency, accuracy, and professionalism [16], [28].

General, specific, and supporting competencies synergise to encourage the implementation of productive work experience programmes for vocational high school students with automotive light vehicle engineering (TKRO) skills, aligned with the automotive industry's needs. The results of this study can serve as a reference for education

policymakers, particularly those involved in vocational high school automotive light vehicle engineering (TKRO), in preparing their students for work experience programmes.

4. CONCLUSION

Based on the discussion of the research data, it can be concluded that the automotive industry requires vocational school students majoring in light automotive vehicle engineering (TKRO) who will undertake fieldwork programmes (PKL) to possess general, specific, and supporting competencies with several competency attributes.

a. Interpreting the Findings and Their Significance Explains the deeper meaning of the tripartite framework: industry expects "learn-ready" students, not fully trained technicians. This reframes PKL as a *student-input standard question rather than a graduate*-output measure.
b. Consistency with and Divergence from Prior Research Confirms alignment with Telaumbanua et al., Darmawang, and others on soft+hard skill synergy, then highlights what is *new*: the elevation of supporting (digital) competencies from aspirational to non-negotiable, even in private workshops, a context-specific finding not documented in prior literature.
c. Why Supporting Competencies Are Increasingly Indispensable Discusses OBD scanners, oscilloscopes, and the electrification trend (EVs/hybrids requiring high-voltage safety and BMS knowledge), arguing that programmes focused only on mechanical skills risk producing graduates who are already obsolete.
d. Implications for Policy and Practice Are Expanded across four areas: curriculum development (embedding digital literacy as a compulsory subject), teacher preparation (industry upskilling partnerships), school-industry collaboration (formal MoUs with co-designed rubrics), and pre-PKL competency assessment (a standardised screening tool).
e. Contextual Limitations: Explicitly acknowledges that nine workshops in Surakarta may not represent metropolitan, rural, or other Indonesian automotive settings and calls for larger-scale quantitative follow-up studies.

Beyond restating findings, this conclusion interprets that industry does not expect fully competent graduates but rather "learn-ready students" who are safe, professional, and trainable. The separation of supporting competencies as a distinct category signals that digital literacy is now a prerequisite, not an advantage.

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