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Analysis of Automotive Industry Competency Needs for Automotive Engineering Education Students of Medan State University in the 4.0 Era

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Abstract

The advancement of automotive technology in the Industrial Revolution 4.0 era requires vocational education graduates to possess updated competencies aligned with industry standards. This study investigates the gap between the competencies of students in the Automotive Engineering Education Program at Universitas Negeri Medan and the needs of the automotive industry. A descriptive qualitative approach was applied, involving interviews, observations, and document analysis with stakeholders from academia and industry. The findings reveal a significant misalignment, particularly in digital automotive systems, computer-based diagnostics, and soft skills such as communication and problem-solving. The study highlights the need for curriculum revision, integration of industry-based learning practices, and enhanced collaboration between educational institutions and industry partners to ensure graduate readiness in meeting modern automotive demands.

Keywords
Automotive Industry Competencies, Vocational Education, Industry 4.0

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INTRODUCTION

The Fourth Industrial Revolution has profoundly altered the landscape of numerous industrial sectors, including the automotive industry, which is now propelled by digitalization, connectivity, and automation in production processes. Technologies include the Internet of Things (IoT), Artificial Intelligence (AI), and computer-based control systems have become essential elements of contemporary automotive systems [1]. These advancements necessitate a redefinition of the skills required of the industrial worker, encompassing both technical expertise and soft skills such as problem-solving, critical thinking, and technology literacy. Vocational education must be adaptable and sensitive to technology-driven industrial requirements to cultivate pertinent human capital for the changing labor market [2].

In the context of higher vocational education, particularly within the Automotive Engineering Education Program at Medan State University, these challenges are compounded by the dual mandate of preparing students both as skilled technicians and as professional educators. Consequently, the required competencies extend beyond mastery of automotive technology to include teaching capabilities and the integration of emerging technologies into pedagogical practice. Graduates of automotive engineering education programs are expected

to translate industrial competencies into contextual and adaptive learning processes that meet the needs of vocational high schools (SMKs) in the digital era [3].

However, existing research highlights a persistent gap between the competencies of graduates and the actual demands of the automotive industry. Many graduates lack proficiency in modern automotive technologies such as electronic fuel injection systems, anti-lock braking systems (ABS), and diagnostic software [4]. At the same time, the automotive industry increasingly requires job-ready professionals who are capable of operating advanced tools and understanding efficient, automated systems [5]. This competency gap underscores the need for a comprehensive mapping of industry-relevant skills, especially as they pertain to the graduate profiles of automotive engineering education programs.

This study aims to comprehensively analyze the current competency requirements of the automotive industry in relation to the preparedness of students in the Automotive Engineering Education Program at Medan State University in the era of Industry 4.0. Employing a needs analysis approach, the study seeks to bridge the gap between vocational education and industrial expectations. The findings are expected to contribute to curriculum development, industry-based training initiatives, and enhanced graduate relevance to labor market demands. This aligns with previous studies emphasizing that sustained partnerships between academia and industry are essential to achieving effective and continuous link-and-match strategies [6].

Graduate Competency Alignment

Competency theory, as developed by Spencer, defines competency as an underlying characteristic of an individual that encompasses knowledge, skills, values, and attitudes associated with superior job performance [7]. In the context of vocational education, this theory is implemented through the Competency-Based Education and Training (CBET) approach, which emphasizes skill mastery aligned with labor market standards [8]. CBET prioritizes a direct link between learning outcomes and industry requirements, promoting the development of outcome-based curricula that are measurable and aligned with professional competency profiles. This theoretical framework forms the basis for analyzing the relevance of competencies taught in automotive engineering education to those demanded by the contemporary digital automotive industry.

Recent literature underscores that competencies within the automotive industry in the context of Industry 4.0 necessitate a combination of both technical and non-technical skills. The contemporary automotive sector necessitates personnel proficient in the operation of IoT-integrated machinery, adept at diagnosing vehicular issues through electronic diagnostic instruments, and exhibiting robust communication and collaborative abilities [9]. Nonetheless, numerous vocational automotive education institutions have not completely incorporated Industry 4.0 technologies into their instructional methodologies, frequently leading to a disparity in skills for graduates transitioning into the labor market [10]. Additional research highlights the significance of industry-based project learning as a method for cultivating contextual competencies that correspond with the requirements of real-world employment settings [11].

Previous research focusing on graduates of the Automotive Engineering Education Program at Medan State University has revealed notable discrepancies between the competencies of graduates and the expectations of the industry, especially regarding proficiency in digital automotive technologies and essential adaptive skills, including problem-solving and time management [12]. A significant number of students are reported to have insufficient practical experience with contemporary technologies utilized in current automotive workshops and manufacturing facilities [13]. Consequently, enhancing curriculum design via an analysis of industry needs is essential to guarantee that higher vocational education—particularly at Medan State University, yields proficient graduates who are in

accordance with the changing requirements of the automotive industry in the context of Industry 4.0.

In line with the issues discussed previously, this study specifically aims to identify and map the core competencies required by the automotive industry for graduates of automotive engineering education in the industry 4.0 era. It also seeks to evaluate the alignment of those competencies with the curriculum currently implemented within the Automotive Engineering Education Program at Medan State University.

METHOD

This research utilized a qualitative methodology characterized by an exploratory descriptive framework. The objective of this study was to achieve a thorough understanding of the various types and characteristics of competencies necessary for the automotive industry within the framework of the Fourth Industrial Revolution. Additionally, it aimed to evaluate the degree to which these competencies are currently exhibited by students enrolled in the Automotive Engineering Education Program at Medan State University. A qualitative methodology facilitates an in-depth examination of the discrepancies that exist between vocational education and the requirements of the industry.

Data were gathered utilizing semi-structured interviews, direct observation, and document analysis [14][15]. The interviews encompassed key informants categorized into three distinct groups: (1) students enrolled in the automotive engineering education program, (2) academic faculty responsible for instructing core technical courses, and (3) professionals from the automotive industry, which included senior technicians, workshop supervisors, and human resources managers from organizations such as Toyota Auto2000, Daihatsu, Mitsubishi, and various contemporary workshops. Participants were chosen through purposive sampling, determined by their expertise and relevance to the research focus [16].

Document analysis included curriculum guides, course syllabi (RPS), and industry competency standards (such as the Indonesian National Work Competency Standards/SKKNI and internal benchmarks from automotive companies) [17]. Observations were conducted in classroom and laboratory settings to examine how technical and non-technical skills are developed in practice. To ensure data credibility, triangulation was applied across sources and methods [18].

The collected data were analysed using thematic analysis, which involves data reduction, categorization, interpretation, and conclusion drawing. This technique is well suited for exploring perceptions, experiences, and needs within specific social groups [19] [20]. It allowed the researcher to identify key patterns and themes regarding both the technical and soft skills demanded by the modern automotive industry, and to assess how current educational practices at Medan State University align with those expectations. A flowchart of the research process is presented in Figure 1.

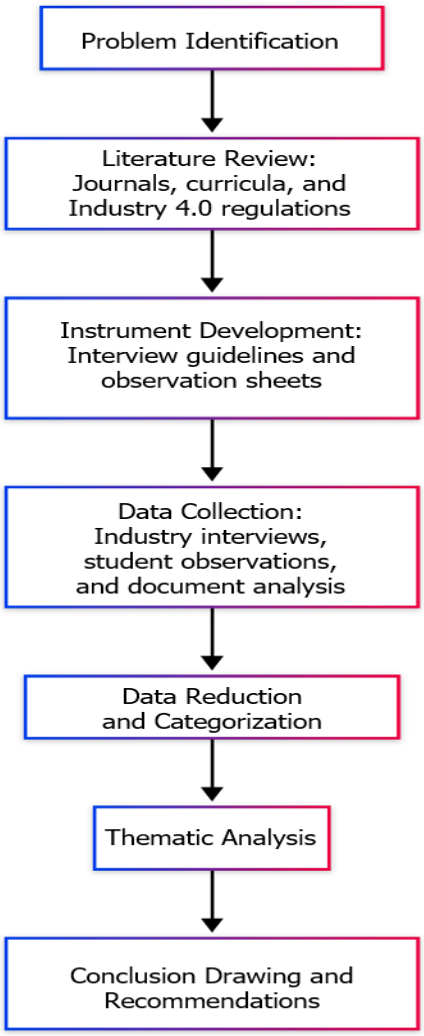

Figure 1. Research Process Flowchart

RESULT AND DISCUSSION

Result

This study explored the alignment between the competencies developed through the Automotive Engineering Education Program at Medan State University and the actual demands of the automotive industry in the context of Industry 4.0. Data was obtained through semi-structured interviews with five automotive industry practitioners from Toyota, Mitsubishi, and Daihatsu, three faculty members responsible for core automotive subjects, and several enrolled students. These sources provided a comprehensive view of the competency expectations from both the supply (education) and demand (industry) perspectives. The results revealed a notable mismatch between the skillsets acquired by students and the advanced technological competencies increasingly required by modern automotive workplaces.

Industry practitioners consistently emphasized the importance of graduates being proficient in electronic vehicle systems, Electronic Fuel Injection (EFI), and computer-assisted diagnostics. Additionally, they highlighted the growing emphasis on soft skills such as communication, teamwork, and professional discipline during the recruitment process. One informant from Daihatsu noted that many recent graduates lacked the ability to interpret OBD scanner data and produce structured diagnostic reports. From these interviews, five categories of critical competencies were identified: technical skills in electronic systems, digital tool

literacy, problem-solving and diagnostic reasoning, soft skills, and occupational safety awareness.

Observation of teaching practices in two practical courses—Automotive Electronic Control Systems and Hybrid Vehicle Technology, revealed a gap between curriculum content and technological application. Instruction was still largely traditional, dominated by instructor demonstrations and outdated workshop activities. Access to contemporary tools such as hybrid vehicle systems and electric platforms was either minimal or non-existent. Students were found to be enthusiastic but underexposed to problem-based learning and real-world diagnostic challenges. Practical sessions were still conducted using obsolete vehicle models, further limiting the students' ability to engage with current industrial practices.

The document analysis of the curriculum and Semester Learning Plans (RPS) indicated that Industry 4.0 competencies and 21st-century learning goals had begun to be conceptually introduced. However, in practice, digital and diagnostic competencies remained underdeveloped, often confined to theoretical treatment with limited practical application. These curricular developments were also not supported by sufficient lecturer training or investment in appropriate diagnostic equipment, leading to a persistent gap between the expected graduate outcomes and the realities of industrial practice. These findings underscore the need for systematic curriculum enhancement and closer collaboration with industry stakeholders.

Comparison of Student Competencies and Industry Expectations

A comparative summary delineating the competencies requisite for the automotive industry alongside the current proficiency levels of students—derived from both observational and interview data—is encapsulated in Table 1 and further depicted in Figure 2. This analysis underscores the domains in which educational results do not meet industry standards, offering a precise diagnostic perspective on the most urgent skill deficiencies that require attention through curriculum improvement and collaboration with industry stakeholders.

Table 1. Comparison Between Industry Competency Needs and Student Proficiency

No	Competency	Industry Demand (%)	Student Proficiency (%)	Gap (%)
1	Modern Automotive Technology	90	65	25
2	PLC Programming & Sensor Integration	80	40	40
3	Electronic Fuel Injection (EFI) Systems	85	60	25
4	Troubleshooting Diagnostic Skills	88	55	33
5	Soft Skills (Communication & Work Ethic)	92	70	22
6	Occupational Safety (K3)	75	60	15

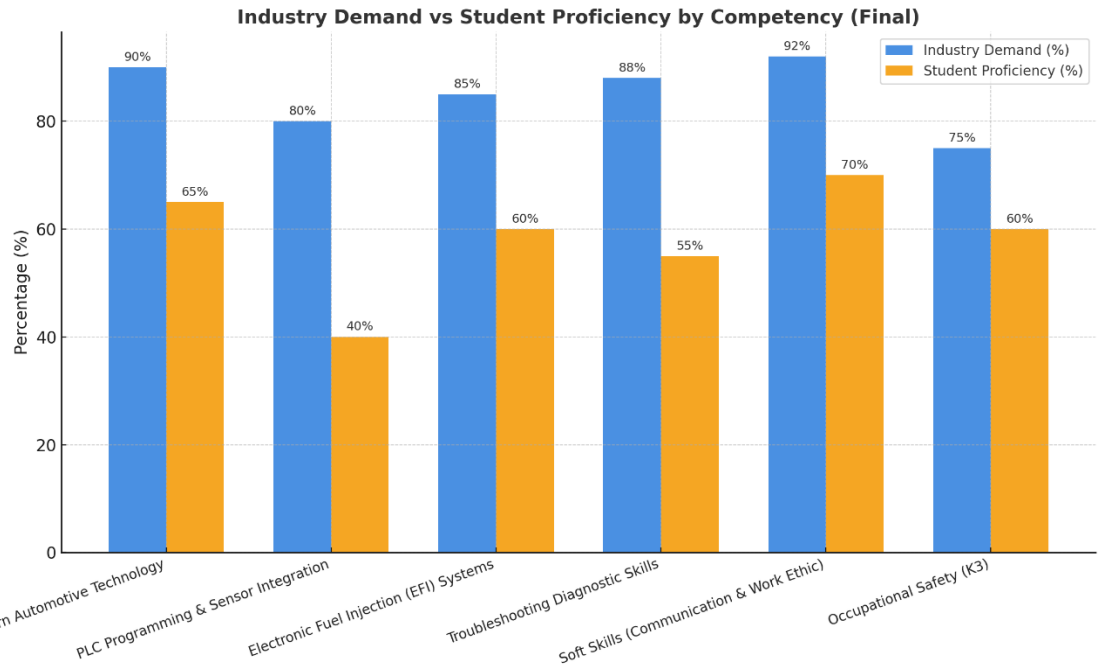

Figure 2. Graph Comparing Industry Competency Demands and Student Proficiency/Competency.

Further qualitative analysis using thematic techniques revealed three major themes that emphasize the root causes of the identified competency gaps. These themes were distilled from interviews with industry practitioners, lecturers, and observations of learning environments.

1. **The first theme** centers on the lack of mastery in automotive digital technologies, particularly in areas such as sensor programming and software-based diagnostics. While industries increasingly rely on computerized systems for maintenance and repair, most students have limited exposure to these technologies during their academic training.
2. **The second theme** highlights the inadequacy of industry-standard infrastructure in the university's practical learning environment. This includes the limited availability of diagnostic tools, outdated training vehicles, and a general lack of access to hybrid or electric vehicle systems. Such limitations hinder students from experiencing real-world industrial challenges and mastering contemporary automotive platforms.
3. **The third theme** addresses the underdevelopment of soft skills and work ethics, which are essential for adapting to modern industrial workplaces. Communication skills, teamwork, time management, and discipline are still not optimally cultivated through the current instructional methods. These non-technical competencies are considered critical by employers and are often a decisive factor during recruitment and on-the-job performance.

Together, these themes underline the urgency for a systemic overhaul in curriculum design, instructional practices, and facility upgrades to ensure that vocational education remains relevant and responsive to the evolving demands of the automotive industry in the era of Industry 4.0.

Discussion

This research is based on the theory of workforce competence alignment, highlighting that the congruence between graduate competencies and industry requirements serves as a critical measure of the effectiveness of vocational education [21]. In the realm of automotive technical education, this alignment encompasses the acquisition of contemporary technological skills, comprehension of advanced vehicle systems, alongside the development of soft skills and an awareness of industrial work culture. Furthermore, the Technological Pedagogical and Content Knowledge (TPACK) framework facilitates the assessment of technology integration within

automotive education, emphasizing the convergence of technical content, pedagogical approaches, and digital resources [22].

The findings indicate that the competencies of students in the Automotive Engineering Education Program at Universitas Negeri Medan are not yet fully aligned with the evolving demands of the automotive industry in the industry 4.0 era. This aligns with the findings of Y. Pradan, who reported that more than 60% of automotive education graduates in Indonesia lack proficiency in vehicle systems reliant on digital and electronic sensors [23]. Similarly, Sobari et al. identified a significant gap between vocational curricula and industry-required competencies, particularly in programming, digital diagnostics, and knowledge of systems such as EFI, ABS, and CAN bus [6].

Observation results from this study further reveal that teaching methods remain conventional, dominated by lectures and instructor-led demonstrations in workshops. This reinforces the claims of N. Pratama and D. Dermawan, who note that many vocational institutions in Indonesia have yet to adopt project-based or industry-based learning approaches. In fact, real-world, project-oriented instruction has been proven to enhance students' technical competencies and job readiness [24].

This study highlights the growing importance attributed by the industry to non-technical competencies, such as communication, teamwork, and work ethics, in addition to technical skills. Research conducted by A. Telaumbanua indicates that while students exhibit certain foundational soft skills, their incorporation into the learning and assessment processes is characterized by inconsistency and underdevelopment [25]. The results indicate a necessity for enhanced integration of character education and workplace behavior simulation in vocational education curricula. A key contribution of this study lies in its regional specificity. Unlike prior research that adopts a national or document-based perspective, this study is grounded in empirical data collected directly from automotive industries in North Sumatra. Through in-depth interviews with industry practitioners and direct observations of hands-on learning activities, this research offers a localized competency map that can serve as a reference for contextual and responsive curriculum development.

In conclusion, this study affirms that to meet the demands of the industry 4.0 era, vocational institutions must undergo not only curricular reform but also pedagogical and institutional transformation. Strengthening the triple helix collaboration between universities, industry, and government is essential to producing graduates who are truly competent and industry-ready [26].

CONCLUSION AND RECOMENDATION

Conclusion

Based on the findings and analysis of this study, it can be concluded that a significant gap exists between the competencies possessed by students of the Automotive Engineering Education Program at Universitas Negeri Medan and the actual demands of the automotive industry in the era of the Fourth Industrial Revolution. This gap is particularly evident in the areas of modern automotive technology, including digital and electronic vehicle systems, the use of computer-based diagnostic tools, and the understanding of smart vehicle systems, which are now standard in the industry. The root causes of this competency gap include the predominance of conventional teaching methods such as instructor demonstrations and repetitive workshop exercises, limited access to up-to-date facilities and technology, and a curriculum that is not yet fully aligned with industry-based learning models.

Recommendation

The Automotive Engineering Education Program at Universitas Negeri Medan must undertake a comprehensive curriculum review and alignment to better reflect the evolving

competency demands of the automotive industry in the 4.0 era. This should involve integrating courses focused on digital vehicle technologies—such as electronic control systems, sensor and actuator technologies, and automotive diagnostic software—into the core curriculum. Strengthening partnerships with the business and industrial sectors is also essential to ensure that curricular developments remain responsive to technological advancements in the workplace. For future researchers, it is recommended to expand the scope of inquiry by involving a wider range of stakeholders from various regions and sectors within the automotive industry to obtain a more holistic understanding of vocational competency requirements. Additionally, adopting quantitative or mixed-method research approaches may help measure curriculum relevance and assess the effectiveness of pedagogical interventions, thereby supporting a more data-driven and sustainable model for vocational education development.

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