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Beyond Digital Skills: Addressing The Technical and Soft Skills Deficit in Malaysian TVET for the Manufacturing Sector

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Abstract

This qualitative study confirms that the skills mismatch among Technical and Vocational Education and Training (TVET) graduates in Malaysia has shifted from traditional technical skills to digital skills especially in the manufacturing sector in Malaysia, in order to produce a high skilled worker that can support Malaysia's policy aspirations under the New Industrial Master Plan (NIMP) 2030, to achieve the Gross Domestic Product (GDP) growth targets and creating high-value employment opportunities in the manufacturing sector. The primary aim of this study is to identify the digital skills required by TVET graduates to prepare them for the evolving demands of the workforce. Seven (7) industry experts from manufacturing sectors were selected through a snowball sampling method to address the three (3) research objectives. Data were analysed via Thematic analysis with the support of NVivo software for data management and interpretation. The findings indicate that the digital skills required of TVET graduates can be categorised into two (2) main dimensions: technical digital skills and digital soft skills. Both dimensions are pertinent in preparing graduates to adapt effectively to an increasingly digitalised industrial environment. Overall, the study supports Malaysia's national policy initiatives to develop a digitally competent workforce capable of driving sustainable economic growth, within the manufacturing industry.

1. Introduction

The presence of digital technology across all economic sectors has transformed Malaysia's industrial workforce. Rapid developments in digital technologies, including automation, artificial intelligence (AI) and the Internet of Things (IoT) have transformed the way industrial workers perform their tasks (Mohamed Ali et al., 2024). According to Hizam-Hanafiah and Soomro (2021), the digital technologies, which are most widely adopted by Malaysian companies are Mobile Technologies, Cloud Computing, and Cybersecurity, each showing a high level of implementation. In the manufacturing sector, digital transformation is a key pillar of Malaysia's goal to become a digitally advanced economy, as outlined in the NIMP 2030. This objective aligns with Mission 2: 'Tech Up' for a Digitally Vibrant Nation which focuses on integrating automation, IoT, AI and data analytics into industrial processes.

The Fifth Industrial Revolution (IR 5.0) focused on the deployment of cutting-edge digital technology which represents the next stage in Malaysia's industrial evolution to sustain the pace of this transition. According to Humayun (2021), this revolution involves human-machine cooperation using cutting-edge technologies like IoT, AI, Big Data, and robotics to improve manufacturing efficiency. A study from Javaid et al. (2021) also states that the application of AI in Industry 4.0 manufacturing gives substantial advantages by streamlining production procedures, cutting expenses through predictive maintenance, and facilitating effective supply chain management.

TVET has been established in Malaysia to produce technical workers to support the Malaysia's economic growth. To meet the government's Industry 4.0 goals, Malaysian industries need skilled workers (Malaysian Investment Development Authority, 2022). Skilled workers are defined as individuals possessing specialized knowledge and expertise in a particular field (Mohd Fateh et al., 2022). Therefore, TVET programs play a pivotal role or game changer in developing local skilled labor, reducing reliance on foreign workers (Tokeran, 2024). Evidence from previous studies shows that TVET initiatives can expand employment opportunities and help address the skills mismatch among youth (Salleh & Sulaiman, 2020). Consequently, integrating digital transformation into the education sector, particularly in TVET programs, has the potential to produce highly skilled graduates with the digital competencies required for industrial roles.

1.1 Problem Statement

Malaysia has introduced various initiatives and strategies to address the skills mismatch issues among TVET graduates and align their competencies with industry needs. However, this issue continues to persist in the digital era. The issue of skills mismatch was highlighted by the Department of Polytechnic and Community College Education (2018), which noted that the industry expects TVET graduates to possess a comprehensive set of competencies, including knowledge, technical skills, good social skills and attitudes. According to Salim (2024), the Malaysian government needs to redesign the entire TVET program ecosystem due to the most TVET institutions are unable to satisfy industry demands. This finding is consistent with previous research showing that TVET programs are not regularly updated to keep up with the pace at which technology is developing, leaving graduates with abilities that are no longer applicable to the demands of modern employment (Ibrahim & Nashir, 2022).

Additionally, there is expanding proof that TVET graduates' digital competencies were below the expectations of industry standards. According to Halik Bassah and Mohd Noor (2023), TVET students have basic computer literacy but the usage of digital devices is limited while having theoretical understanding and technical competence. Besides that, study from Ismail and Hassan's (2019) discovered that instructors and students have moderate levels of digital competency in Industry 4.0 technologies. Also, a survey study from Tee et al. (2024) found that the demand for digital competencies among workers is increasing as new technologies emerge.

The gap between TVET graduates' digital competencies and industry demands will continue to affect their employability if these gaps are not filled. Low competency levels could indirectly lower industrial production and leave Malaysia at a disadvantage in the global digital economy. As a result, it is crucial to look at this problem from a variety of angles, such as the industry's perspective, the nature of digital skills gaps, and methods for producing TVET graduates whose capabilities match goals of Industry 4.0. To close the current gap between TVET institutions and industry demands, the digital competency criteria for Industry 4.0 especially in the manufacturing industry must be determined.

1.2 Objectives

This study is to examine the readiness of TVET graduates in Malaysia to fulfil the government’s vision and objectives of producing a high-skilled worker. The digital competency requirements in Industry 4.0 need to be identified in order to bridge the existing gap between TVET institutions and industry needs.

The objectives of the study are as follows:

- To explore the usage of digital technology in Malaysia's manufacturing industry.
- To determine the digital skills that needed for TVET graduates to aligned with the industry demands.
- To identify the significant digital skills gaps among the TVET graduates based on the industry perspectives.

2. Literature Review

2.1 Digital Transformation and Industry 4.0 in the Malaysian Context

Industry 4.0 has revolutionized workplace practices across industries nationwide. Leading sectors, especially the manufacturing sector, have benefited greatly from the adoption of cutting-edge technology like automation, AI, robots, the IoT, and cloud computing. AI-driven automation ensures high precision, consistency, and quality in critical tasks like laser cutting by enabling intelligent equipment and control systems to optimize production processes (Sajja & Addula, 2024). Through strategic plans like Industry4WRD and the NIMP 2030, Malaysian has taken aggressive steps to speed up the digitization of important industries, including manufacturing.

The Industry4WRD policy introduced by the Malaysian government aims to create a conducive ecosystem and transform the manufacturing sector to be prepared for Industry 4.0. Upskilling and reskilling industrial workers can develop a workforce with skills aligned to the requirements of Industry 4.0 (Ministry of International Trade and Industry, 2018). Indirectly, this policy enables the government to establish a strong and resilient ecosystem while promoting the gradual transition of the manufacturing sector toward digitalization and automation. However, the implementation of this policy faces certain constraints including shortage of skilled workers. A shortage of skilled workers may limit the country's ability to sustain economic growth (Rubin et al., 2024). Skilled workers in the manufacturing industry must possess new competencies in information technology, data analytics and AI to adapt to increasingly dynamic production processes in the era of Industry 4.0 (Kumar & Gupta, 2022).

3. Methodology

A qualitative research approach is appropriate to explore the relevant digital technologies in the manufacturing sector for developing TVET graduates' digital competencies. The details of the methodology were discussed in the following subchapter.

3.1 Sampling and Instrument

The data for this study were collected through semi-structured in-depth interviews with seven industry workers. Participants were selected using the snowball sampling method and possessed specialized knowledge of digital technology use in the manufacturing sector. The snowball sampling method was particularly useful for accessing a small population and obtaining rich, saturated data. Additionally, it can enhance data quality, as participants are more likely to provide honest and detailed insights (Ting et al., 2025). Table 1 lists the seven industry workers who participated in the study.

Table 1 *The participants' demographics*

Study Participants	Position	Work Experience (years)	Sub-sector
P01	Process Engineer	6	Electrical and electronic products
P02	Engineer	2	Electrical and electronic products
P03	Senior Process Engineer	20	Electrical and electronic products
P04	Design Engineer	3	Transport equipment and other manufacturers
P05	Engineer	2	Electrical and electronic products
P06	Electrical Engineer	2	Transport equipment and other manufacturers
P07	Engineer	2	Electrical and electronic products

This study aims to explore a vital issue in today's constantly evolving workforce, such as the possible mismatch between TVET graduates' digital skills required by today's modern employers which is the industry. There is an increasing concern indicating that TVET curriculum may not be keeping up with industry's adoption of advanced digital tools, automation, and new technology developments. Semi-structured interviews with

industry employers were utilized to gather data for this study in order to explore this matter. This methodology enables the researchers to explore further into participant impressions and opinions, which are not possible by quantitative approaches (Belina, 2022).

3.2 Procedure and Data Analysis

Each participant's semi-structured interview lasted 40 to 45 minutes. The selected industry players were first contacted by the researchers to get their permission to participate. Interviews were scheduled at the specified time and location when consent was received. In order to enable the supply of essential input on the research topic and aims, participants were given a guide that outlined the study's objectives and a brief background. Upon the interviews, the researcher transcribed the sessions and sent the transcripts to the participants for confirmation that their opinions and answers were adequately reflected. Within three months, the entire interview procedure was completed. To ensure the smooth implementation of this thematic process, the researcher adapted the thematic analysis framework proposed by Braun and Clarke (2006), as illustrated in Figure 1.

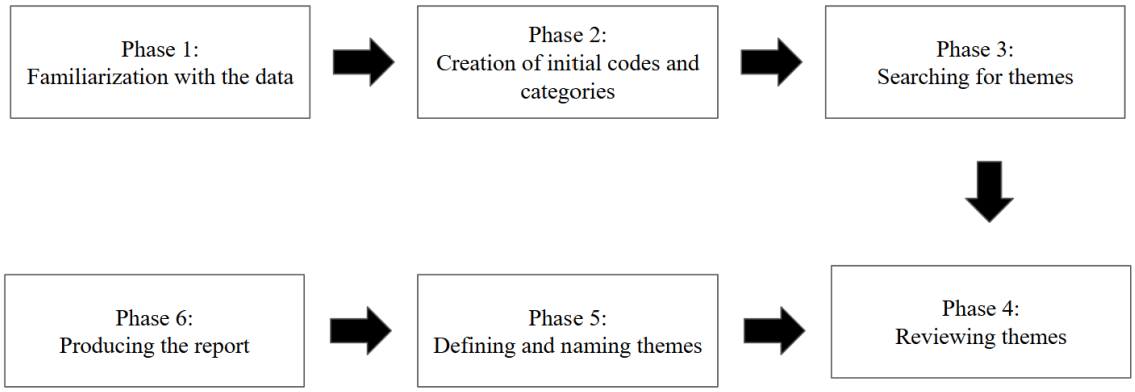

Fig. 1 *Thematic analysis phases (adapted from Braun and Clarke, 2006)*

The analysis began with the preparation and repeated reading of the interview transcripts. The main purpose is to help the researchers understand the data clearly. All participants' interview transcripts were used as the main source of data. The focus is on participants' views regarding the use of digital technology in the manufacturing sector. In the 2nd phase, all the important statements and quotations were identified and coded systematically. Similar codes were grouped together and labelled accordingly. Axial coding was then used to identify relationships between the codes.

The 3rd phase involved searching for themes. This is done by grouping related codes into broader categories (Rohanai et al., 2024). Data that were not relevant to the objectives of the study were excluded. In the 4th phase, the themes were reviewed. This is to ensure that they accurately represented the data and addressed the study objectives (Ngatiman et al., 2023). The researcher also checked whether any important data had been overlooked during coding. The 5th phase involved defining and naming the themes based on their main meanings, as suggested by Braun and Clarke (2006). Only relevant themes were retained for the study. Finally, the researcher prepared the report in a systematic narrative form. Participants' quotations were included to support the findings of the study.

3.3 Validity and Reliability

The triangulation method was used in this study to increase the credibility of the research findings. Gathering and comparison of the opinions from seven (7) industry players representing various manufacturing subsectors in the manufacturing sector to achieve the triangulation method. Participants vary work experience levels an others professional positions, such as process and design engineers, were taken into consideration when analysing the data. By combining data from other sources, this method allowed the researcher to validate the digital skill shortages that were found. As a result, the likelihood of any researcher bias would be decreased.

In addition, the member checking method was implemented to ensure accuracy of the data obtained (McKim, 2023). The researcher emailed each of the participant the whole transcripts for review when the interview transcriptions were finished. Participants were asked to confirm the transcripts' contents, fix any technical words that were incorrectly captured, and make sure that the transcripts represented their opinions regarding the identification of gaps in digital skills. This procedure improved the reliability of the study results while also validating the data.

J. of Technical Education and Training Vol. 18 No. 1 (2026) p. 360-374

4. Results and Discussion

A thematic analysis of the semi-structured interview data revealed insightful technological disparities within the current TVET landscape. A thematic analysis of the semi-structured interview data revealed insightful technological disparities within the current TVET landscape. The identified findings were mismatch between TVET curriculum and industry demands, the lack of access to cutting-edge technologies and limited availability of instructional resources. Further, the data highlighted the challenges on the part of TVET graduates in keeping pace with rapid technological advancements in specific within the manufacturing sector. Table 2 illustrates the relationship between the research questions and the emerging themes.

Table 2 *Theme and sub-theme based on research questions*

Research Question	Theme	Sub-theme
To explore the usage of digital technology in Malaysia's manufacturing industry.	The Use and Need for Digital Technology in the Industry	Types of Digital Technologies Used Benefits of Technology Adaptation in Industry Challenges of Technology Adaptation in Industry
To determine the digital skills that needed for TVET graduates to aligned with the industry demands.	TVET Curriculum Alignment with Industry Needs	Industry Expectations from TVET Graduates Collaboration Between Industry and TVET Institutions
To identify the significant digital skills gaps among the TVET graduates based on the industry perspectives.	Digital Skills Gap Among Graduates	Technical Skills Gap Soft Skills Gap

4.1 Theme 1: The Use and Need for Digital Technology in the Industry

This theme examines the specific digital technologies currently employed in the manufacturing sector, as well as the benefits and challenges. The findings indicate that, although digital transformation is actively pursued, it is primarily driven by operational efficiency and cost reduction. This observation is corroborated by Tangwaragorn et al. (2024), whose systematic analysis of digital transformation readiness indexes identifies operation and management as a pivotal dimension propelling the integration of the technology.

4.1.1 Sub-Theme 1: Types of Digital Technologies Used

This sub-theme examines the specific technological skills expected of TVET graduates. The analysis shows a strong consensus among participants regarding the necessity of foundational digital skills, with a focus on the Microsoft Excel for data processing and reporting tasks. This expectation is corroborated by Mbambo and Du Plessis (2025), who assert that developing proficiency across the Microsoft Office suite which include Word, Excel, OneNote, Teams, and PowerPoint to establishes a vital framework for more comprehensive digital literacy. Reinforcing this perspective, participants 5 and 7 identifies Microsoft Office as the foundational software requisite for engineering professionals, as detailed in Table 3.

Participants 5 and 7 emphasized that Microsoft Office is the first tool an engineer needs to master, as illustrated below:

Table 3 *Respondent evidence for types of digital technologies used*

Digital Technologies Used	Participant	Quote
Microsoft Office	P05	*The technologies or software that we, engineers, commonly use especially in any engineering sector, is Microsoft Excel. We need to master it because Microsoft Excel is frequently used to perform data analytics or data analysis in the current industry.*
	P07	*For my part, I mostly use Microsoft Excel and from what I have observed, most technicians require reports, and these reports are now entirely in Microsoft Excel.*
AutoCAD & SolidWorks	P02	*… the specialized software that my company frequently uses is AutoCAD. It serves as a basic tool and as far as I know, all companies use AutoCAD.*
	P06	*… for example, engineers use AutoCAD and SolidWorks to carry out their tasks.*

The findings clearly indicated that in today's environment, digital technologies are prerequisite. The TVET graduates must equip themselves with these necessary skill sets and become proficient with them, as highlighted above, AutoCAD and SolidWorks are fundamental tools for standard 3D modelling tasks. This aligns with existing study, which notes the widespread adoption of this computer-aided design (CAD) programs for structural modelling (Shikh Anuar et al., 2023).

The study revealed that the technology in the industry experienced a tremendous growth and the job market surpassing expectations for sophisticated technologies capabilities including 3D rendering, parametric modelling, and structural simulation. This expectation of advanced technical proficiency extends beyond AutoCAD software, as participant 5 noted. Conventional platforms like Microsoft Excel are frequently leveraged for robust data analysis. The TVET graduates are expected to equip with advanced data literacy and knowledge simply to execute complex data simulations and interpretations.

These results are supported by recent study highlighting 3D rendering for virtual reality and computational fluid dynamics (CFD) simulations as pivotal drivers of industrial digital transformation (Lopez & Biancolini, 2025). To sum up, while foundational knowledge suffices for routine operational tasks, advanced proficiency in simulation and parametric analysis is requisite for navigating the complex demands of contemporary manufacturing. A deficit in these high-level competencies among TVET graduates threatens not only to compromise operational productivity but also to stifle broader innovation within the manufacturing sector.

4.1.2 Sub-Theme 2: Benefits and Challenges in Technology Adaptation

This sub-theme also describes both the benefits and challenges associated with integrating digital technologies within the manufacturing sector. The findings indicate that digital adoption transcends mere technical upgrades, rather it represents a strategic imperative that enhances operational efficiency. As detailed in Table 4, labour efficiency emerges as a primary benefit. Participants 6 and 7 emphasized that digital automation substantially curtails manual tasks and broader human resource dependencies. While participant 6 focused on the elimination of redundant manual processes, participant 7 offered a quantitative perspective, noting a direct reduction in the required workforce volume. This paradigm shift supports the study from Wang et al. (2022), who state that digital transformation acts as a catalyst for overall firm performance through optimized resource allocation.

Table 4 *Respondent evidence for benefits of digital technology*

Identified Benefit	Participant	Quote
Labor Efficiency	P06	*... we no longer have to climb up and down ships or stairs to perform tasks manually*
	P07	*... we rely heavily on this digital technology because without such automation, we would need at least four personnel to carry out a process, whereas with one automated machine, only a single technician is required to operate it.*
Remote Monitoring	P02	*With IoT, we can monitor operations remotely. If there is a fault, we can detect it immediately as it sends a notification, so we don't have to physically go to the site to identify the problem.*
	P07	*With this digital technology, specifically the Internet of Things, it makes my work easier. We can monitor operations remotely and there are certain aspects that we can adjust from a distance.*
Digital Operational Support	P01	*We manage projects by integrating digital data management with on-site labor. I as engineer will monitor from data management level, while technicians execute tasks on-site.*
	P05	*... I think all companies are open to adopt the latest digital technologies and these technologies are indeed very helpful in terms of operations and technical aspects.*

This study also reveals that remote monitoring via the IoT will give benefits to the substantial operational advantages. Participants 2 and 7 emphasized the transition to digitalization specifically, engineers receiving automated notifications rather than conducting manual inspections has significantly conserved time. This finding is supported by Daraba et al. (2024) who assert that real-time monitoring enhances both production efficiency and reliability. Additionally, Cakir et al. (2022) state that real-time monitoring systems possess the precision to detect even minor operational faults. Furthermore, the ability to control the system from anywhere as mentioned by participant 7 shows that the manufacturing sector in Malaysia is moving toward autonomous systems.

Additionally, this studies also found that operational frameworks are essentially strengthened by the digital technologies. Participant 1 mention that the digitalization in the workplace has redefined traditional supervisory method. While the technician can carry out specific physical activities on-site, engineers can monitor the data by remotely. Participant 5 also pointed out that the benefits of digitalization can optimize the operation in the industry. Additionally, integrating these technologies reduces material waste, protects occupational health, and maximizes operational efficiency (Resman et al., 2025).

Nevertheless, the process of digitalization will result some notable challenges. As illustrated in Table 5, participants 4 and 7 emphasized that the main challenges are the high initial cost. This finding aligns with Meor Gheda et al. (2022), stated that financial investments significantly hinder the successful implementation of digital transformation.

Table 5 *Respondent evidence for the challenges in digital adaptation*

Identified Challenge	Participant	Quote
High Investment	P04	*... yes, the cost is very high*
	P07	*The main concern is the cost, because ideally, we want to avoid incurring very high expenses.*
Lack of Digital Skills	P03	*... when it comes to use Microsoft Excel to extract data, they are struggling because they have never been taught.*
	P04	*... surprisingly, there are some people in our department who are also not proficient in Microsoft Excel and need to be taught.*

Identified Challenge	Participant	Quote
	P06	*… they mostly only know hands-on work and are generally not familiar with computer-based tasks.*

Another major challenge is the technicians possess low levels of digital skills. The use of advanced technologies such as automated machinery considered as the foundation of using the technologies in the manufacturing sector. Digitalization in manufacturing is essential for optimizing production and enhancing product quality by developing a multi-skilled workforce through continuous training, upskilling, and reskilling of skilled workers (Akyazi et al., 2020). Lack of digital skills among technicians is a major challenge in the manufacturing industry as illustrated in Table 5.

This gap is concerning given that the manufacturing sector increasingly demands future-oriented competencies, such as programming and advanced data analytics (Li et al., 2021). For Small and Medium Enterprises (SMEs) in particular, this gap can be diminished with the foundational data management tools among the workers. According to past researchers, proficiency software such as Microsoft Excel serves as a critical catalyst for SMEs to drive productivity, operational efficiency, and informed, data-driven decision-making in an increasingly competitive landscape (Nath, 2021; Yuningsih et al., 2024).

4.2 Theme 2: TVET Curriculum Alignment with Industry Needs

As job requirements continue to evolve, the manufacturing sector in Malaysia must acquire new technical skills to meet the demands in this digital era. Therefore, developing an industry-aligned curriculum is crucial to enhance the quality of TVET programs and to produce graduates who contribute effectively to the economic growth (Mohd Affandi et al., 2024).

4.2.1 Sub-Theme 1: Industry Expectations form TVET Graduates

Industries increasingly expect TVET graduates to demonstrate advanced technical skills. According to Halik Bassah and Mohd Noor (2023), effective collaboration between industry and educational institutions is vital to cultivating a highly skilled and competent workforce.

Table 6 *Respondent evidence for industry expectation*

Industry Expectation	Participant	Quote
Industry 4.0 Skills	P03	*These Industry 4.0 skills are important because they can be applied across various fields. Technicians can benefit regardless of the specific sector they enter.*
Technological Exposure	P05	*... students nowadays should be given greater exposure to the latest technologies that can be effectively implemented within the current manufacturing sector.*
Advanced Software Proficiency	P06	*… graduates who have learned AutoCAD are generally competent in it. It is included in their syllabus. However, there are no advanced-level courses offered.*

As detailed in Table 6, industry expectations increasingly centre on the transferability of Industry 4.0 competencies and the necessity for advanced technical skills. These findings align with previous research by Ismail and Hassan (2019), who emphasize that the modern workforce must be adept at understanding, maintaining, and troubleshooting complex digital technologies. Furthermore, participant 6 identified a critical deficit in advanced-level training, noting that TVET graduates must have a basic proficiency in the AutoCAD software and mastering the advanced technical skills such as 3D rendering. Consequently, to close this gap, industry and TVET institution need to have an effective collaboration. As Rodzalan et al. (2022) suggest, this can be effectively achieved by facilitating industrial placements and practical training programs that directly align with the technical demands.

4.2.2 Sub-Theme 2: Collaboration Between Industry and TVET Institutions

Effective collaboration is essential to developing a workforce that is both highly qualified and culturally competent in the digital economy (Halik Bassah & Mohd Noor, 2023). In fact, a strategic partnership between TVET institutions and manufacturing industry are well-known practice for highly effective mechanism in the workforce development Mohamad et al., 2023). As stated in Table 7, participants 3 and 4 specifically emphasized whether the student's projects might be used by the industry. Such integration and the collaboration between the industry will ensures that student research aligns directly with real-world IoT applications, thereby effectively mitigating the existing competency gap (Rodzalan et al., 2022).

Table 7 *Mechanism of industry and TVET collaboration*

Mechanism	Participant	Quote
Talent Development	P01	*... the industry engages in many collaborations, such as offering scholarships and managing student exchange programs. They select students who demonstrate strong potential and send them to universities or specialized training courses.*
Recruitment	P03	*Currently, the MoU is effective for internship placements. Interns were informed that the placement serves as a de facto interview and high performance may result in an employment offer. So far, I have not seen a better approach than this*
Project-Based Learning	P04	*For instance, our interns undertake their Final Year Projects (FYPs) using industrial datasets provided by the company. These projects are directly aligned with real industry applications. Consequently, their FYPs often incorporate the latest Internet of Things (IoT) technologies that are already implemented within the industry.*
Workplace Exposure	P05	*I believe this collaboration has been established for several years. TVET students are often attached to companies during their semester breaks to gain exposure to real working environments*

To create a well-designed curriculum, TVET institutions and industry must actively collaborate. Participant 5 pointed out that one of the biggest challenges at the moment is the absence of formal curriculum feedback. Institutions must move towards to open platforms for curriculum validation in order to keep TVET graduates competitive (Mustapha et al., 2023). By integrating expert industry input and establishing direct academic to industry pathways, as mentioned by participant 3 in Table 8, the TVET ecosystem can strategically pivot an international standard in the curriculum TVET.

Table 8 *Industry involvement in curriculum innovation*

Curriculum Goal Innovation	Participant	Quote
Digital Innovation	P01	*In terms of curriculum development between industry and digital technology, I believe the organization is increasingly willing to participate in initiatives that enhance digitalization.*
Workforce Pathway	P03	*... the industry is open for collaboration, and they are generally willing to be involved, as long as it facilitates a direct pathway for graduates to enter the workforce within the company ...*

Curriculum Goal Innovation	Participant	Quote
High Quality Benchmarking	P04	*… do we have any meeting for the demands or requirements of the industry? How can the industry provide feedback to TVET institutions so that TVET can design or revise curriculum and learning modules? This is because we want our TVET graduates to be on par with TVET graduates abroad.*

4.3 Theme 3: Digital Skills Gap Among Graduates

This theme is crucial in addressing the third research objective. It specifically delineates the competency deficiencies, particularly regarding digital skill sets and identified by industry experts among recent TVET graduates entering the manufacturing sector.

4.3.1 Sub-Theme 1: Technical Skills Gap

The proficiencies obtained through education, training, or research that enable efficient task execution in the workplace are referred to as technical skills (Nurdin, 2023). Considering how crucial digital competencies are to daily task in the industry, this sub-theme focuses mainly on the particular technical aspects of digital skills that the manufacturing industry requires. TVET graduates frequently lack of basic computer literacy skill and common skill using the Microsoft software, as shown in Table 9. Ononye and Agbot (2023) state that writing documents, letters, and reports require the usage of basic computational tools in daily operational task.

The researchers also indicates that the industry expects TVET graduates to demonstrate advanced digital skills. In particular, these advanced skills are defined by the ability to go beyond simple software functions in the AutoCAD software such as parametric modelling, and 3D rendering. This advanced skill is supported by Lopez and Biancolini (2025) who stated that parametric CAD, computational fluid dynamics (CFD) simulation management, and 3D rendering for virtual reality is a cutting-edge element of the current industrial digital revolution.

Participant 4 also mention that programming languages is an essential skill for the robotics and the application of data analytics to interpret industrial outputs. This finding supported from past researcher Li et al. (2021) state that asserting that programming and data analysis are paramount within the contemporary manufacturing workforce. Crucially, these empirical findings align with Malaysia's national policy objectives under the NIMP 2030, which underscores the necessity of a highly skilled workforce to catalyse robust economic growth.

Table 9 *Participant evidence for technical skill gaps*

Identified Gap	Participant	Quote
Advanced Programming	P04	*In terms of coding, we are able to gain the necessary skills because coding involves different languages that they need to understand. Similarly, for robotics, we also need to have a proper understanding.*
Digital Documentation	P05	*As I mentioned earlier, sometimes engineers or technicians are required to prepare a brief report for the engineer themselves. To produce a good report, they need to have a certain approach and possess strong skills.*
Digital vs Physical	P06	*… when it comes to hands-on tasks, they do not have any issues. However, when it comes to digital skills, they are somewhat slow, I would say.*
Analytical Data	P07	*An additional significant skill (data analysis) is required for technicians so that they can understand what they are doing.*

4.3.2 Sub-Theme 2: Soft Skills Gap

The soft skills gap emerged as a significant sub-theme and was identified as a major barrier to workplace adaptability and effective communication. Based on the interviews, majority of TVET graduates are not proficient in Technical English, which has a direct impact on their capability to operate modern technology and digital software. According to Mohamad et al. (2024), in order for TVET graduates to stay competitive, they must be fluent in English. The results show that TVET graduates find it difficult to understand digital manuals and use English-language software interfaces like Microsoft Excel if they are not fluent in the English language.

Table 10 *Participant evidence for soft skill gaps*

Identified Gap	Participant	Quote
Technical English Proficiency	P03	*… what concerns me now is that the technicians do not understand English. This is because most of our technologies and machines come from Japan. When the manuals are translated into English, if they cannot understand the language, they cannot grasp the meaning.*
	P04	*They find it difficult to speak in English, which affects both communication and their use of Microsoft Excel.*
Critical Thinking	P01	*TVET institutions, Politeknik, and universities should implement ways to develop critical thinking in students. Many of the new graduates, which I have encountered during interviews, become flustered when presented with a slightly challenging or unconventional question.*
	P05	*… perhaps in terms of critical thinking and problem-solving skills, these are the aspects that we need to continually strengthen and integrate into students' learning, so they can solve the problems independently*
Self-Directed Learning	P03	*For example, if they want to operate a machine but do not understand its functions, they need to consult the manual, even though the machine itself has a help button.*
	P04	*If teaching is involved, I agree, but it should focus more on self-learning or require only core supervision.*

Furthermore, participant 1 and 5 highlighted that TVET graduate need to have critical thinking as shown in Table 10. These findings are consistent with Kasim et al. (2024), who founded that TVET graduates lack the critical thinking skills required for problem-solving task. López et al. (2023) suggested that incorporating real-world applications within TVET programs can enhance these abilities. Finally, researchers also found that self-directed learning is essential. According to Wahyudi et al. (2024), self-learning can enhance both cognitive and non-cognitive skills which are critical for industry readiness. In addition, these skills are aligned with the National TVET Policy 2030 (Wahab et al., 2024).

5. Conclusion

This qualitative study confirms that the critical skills gap among TVET graduates in Malaysia, particularly in the manufacturing sector, has shifted from basic technical abilities to digital competencies. The primary contribution of this study lies in identifying the specific digital technologies currently utilized within Malaysia's manufacturing industry. In addition, the study highlights the existing digital skills gap, emphasizing the importance of addressing the mismatch between digital competencies possessed by TVET graduates and the expectation of industry.

Fundamental digital competencies, such as basic computer literacy and software proficiency, are considered essential skills that graduates must master. The industry also emphasises the importance of strengthening soft skills that complement digital competencies, as both are closely interconnected. Deficiencies in critical thinking, limited English proficiency and lack of self-directed learning attitudes were identified as among the major soft

skill weaknesses among TVET graduates. Without these competencies, graduates may face difficulties in effectively adapting to and utilising emerging digital and advanced technologies.

Despite these findings the study has several limitations. First, this qualitative study was exploratory in nature and the involvement of only seven (7) industry experts represents small sample size for the manufacturing sector. Furthermore, the majority of the participants were drawn from the electrical and electronic products sub-sector. As a result, the perspectives obtained largely reflect the views of this particular sub-sector rather than the broader manufacturing industry in Malaysia. In addition, most participants possessed fewer than five (5) years of industry experience, which may influence the depth and breadth of the perspectives shared compared to those with more extensive professional experience.

Therefore, future studies are recommended to adopt quantitative approaches such as large-scale survey research, to validate the use and relevance of digital technologies within the manufacturing setup. Future research should also expand interview participation to include manufacturing sub-sectors such as oil and gas, petrochemical, rubber and plastics particularly by involving industry experts with more than five (5) years of professional experience. To address the identified gap, this study proposes several improvements. First, the development of a "Technical English for Industry" module is essential to enable TVET graduates to better interpret technical documentation and industry-specific terminology commonly used in the workplace. Second, TVET institutions should implement the Digital Sandbox strategy proposed by the Department of Polytechnic and Community College Education (2023). This strategy involves student projects and activities that integrate IR 4.0 technologies into learning.

Such initiatives may help students to develop advanced skills, including 3D rendering and parametric modelling through stronger collaboration with industry partners. Overall, all stakeholders within the TVET sector, including policymakers and educational institutions, must undertake substantial reforms to bridge the identified skills gap. These efforts also aligned with Malaysia's national initiatives, particularly the NIMP 2030, which seeks to accelerate digitalisation within the manufacturing sector and strengthen the nation's economic competitiveness.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors are responsible for the study conception, research design, data collection, data analysis, result interpretation and manuscript drafting.

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