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Job Readiness Level to Address 4.0 Skills: An Empirical Study on TVET Students in Electrical and Electronics Field

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Abstract

Malaysia has developed TVET programs to nurture a skilled workforce for its industrial sector. Many graduates face challenges in job readiness, impacting their employability in today's evolving technological environment. Outdated skills pose obstacles, potentially leading to unemployment or reduced workplace performance. This study determined the job readiness level of final-year TVET students in the Electrical and Electronics fields across the Malaysia Technical University Network (MTUN), focusing on Industry 4.0 skills. Using a quantitative, descriptive research design and surveys, the study identified essential Industry 4.0 skills using an IR 4.0 skills checklist, evaluated the current job readiness level of final-year TVET students in the Electrical and Electronics fields at MTUN using a job readiness questionnaire, and identified the differences in job readiness levels across MTUN universities. Stratified sampling and simple random sampling techniques were applied in this research. There were 11 IR 4.0 skills considered essential for job readiness in the Electrical and Electronics field from the industry perspective. The ranking of the 11 skills, from top to bottom, is as follows: technical knowledge, reasoning and problem-solving, analytical thinking and technological literacy, big data analytics, communication skills, artificial intelligence, leadership and social influence, curiosity and lifelong learning, quality control, and critical thinking, under the dimensions of People, Process, and Technology. The job readiness level of final-year TVET undergraduate students in the Electrical and Electronics (E&E) field at the MTUN was 3.61, which fell under the category of approaching readiness. The significance value of the Kruskal-Wallis test was 0.012, which was less than 0.05. A statistically significant difference was found in the job readiness levels of final-year TVET undergraduate students in the Electrical and Electronics (E&E) field across the MTUN. UTHM's overall mean was higher than those of the other three universities.

1. Introduction

The Fourth Industrial Revolution (IR 4.0) signifies an era of advanced technological innovations and digital transformation across global industries (Islam, 2022). Industry 4.0 represents the integration of digital technologies, automation, and data-centric systems, leading to a significant transformation in business operations. This shift enhances manufacturing precision and efficiency through intelligent automation and data-driven insights (Fanoro et al., 2021). With interconnected systems, businesses have become more agile and responsive,

improving production capabilities. Products are now manufactured more efficiently, and services are delivered more innovatively through technology-driven methods, collectively shaping a new era in industry and commerce (Fanoro et al., 2021).

Originating in Germany in 2011 to boost the competitiveness of its manufacturing sector, Industry 4.0 has since been adopted by several developed nations like the United States, the Russian Federation, and China (Soomro et al., 2021). Malaysia, as a developing country, recently introduced "The National Policy on Industry 4.0" to incorporate Industry 4.0 principles and strengthen its manufacturing sector through innovation (Ministry of International Trade and Industry, 2018). In the Electrical and Electronics (E&E) industry, IR 4.0 has significantly influenced processes, skill requirements, and job readiness (Ejsmont, 2021). The Electrical and Electronics industry in Malaysia now requires expertise in data analytics, artificial intelligence, IoT, and automation, transforming traditional job roles and revolutionizing production processes, supply chain management, and customer engagement strategies (Rodzalan et al., 2022).

However, challenges persist, including the significant skills gap created by rapid technological advancement (Ismail et al., 2020; Ping & Ling, 2023; Supian et al., 2020). Many job seekers in the Electrical and Electronics industry lack the digital literacy, technical expertise, and adaptability required for emerging technologies like artificial intelligence, automation, and data analytics (Halik & Asri, 2022; Nugraha et al., 2020). This skills mismatch hinders employability and overall job readiness (Nurjanah & Ana, 2022). Moreover, the dynamic nature of the Electrical and Electronics industry necessitates continuous learning and upskilling. However, the limited availability of relevant training programs and resources exacerbates the problem (Fazillah & Abdullah, 2020). Consequently, job seekers face difficulties securing employment, and the industry struggles with productivity, innovation, and competitiveness (International Labour Office, 2011; Rodzalan et al., 2022).

This research aimed to analyze the Industry 4.0 skills required from industry perspectives in the Electrical and Electronics sector and assess the job readiness of Malaysia Technical University Network (MTUN) TVET students in the Electrical and Electronics field. By examining skills requirements, training initiatives, and industry practices, this study sought to provide valuable insights into how the industry prepared its workforce for the demands of IR 4.0. Understanding the IR 4.0 skills needed in the current Electrical and Electronics industry and the job readiness of MTUN TVET students would enable stakeholders to develop effective strategies for talent development and workforce planning.

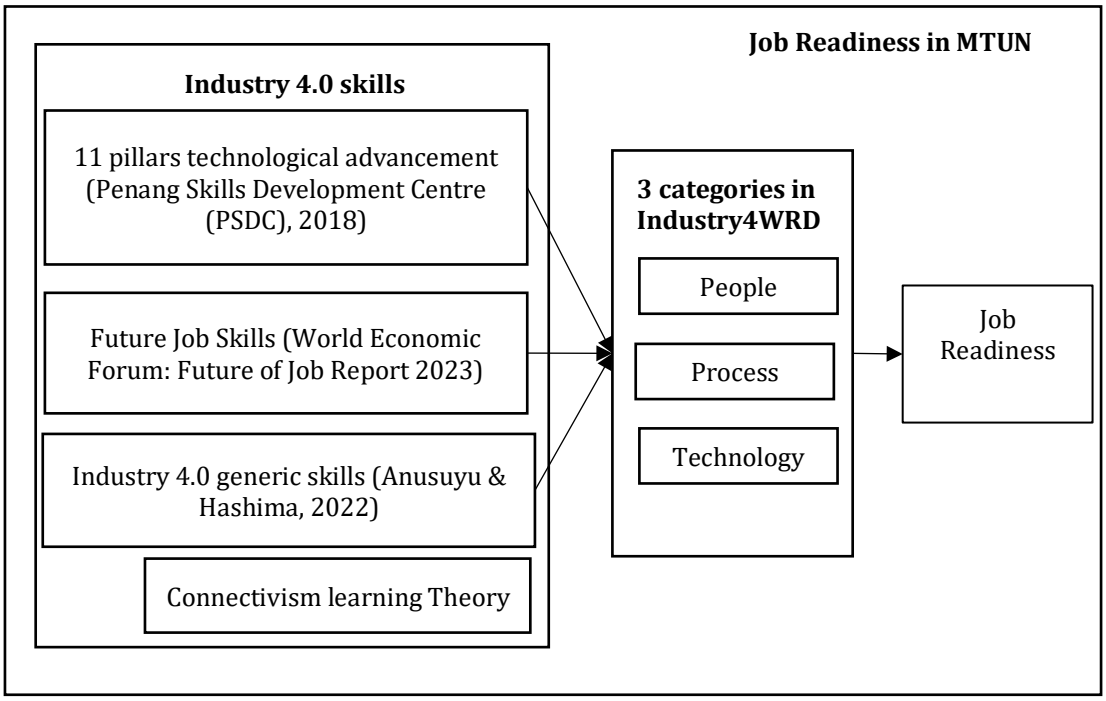

Fig. 1 *Conceptual framework of this research*

The conceptual framework presented here aimed to outline the essential IR 4.0 skills required in the Electrical and Electronics (E&E) industry and assess the job readiness of final-year TVET Electrical and Electronics undergraduate students within the Malaysia Technical University Network (MTUN). Central to this framework was the variable of job readiness in IR 4.0, crucial for understanding students' preparedness to meet industry demands. When comparing job readiness levels across universities, the main variables examined were the

universities themselves, serving as the independent variable, and the IR 4.0 job readiness levels, acting as the dependent variable, as shown in Fig. 1.

This framework categorized IR 4.0 skills into three distinct dimensions: People, Process, and Technology. These dimensions provided a theoretical structure to explore factors influencing job readiness amidst the Fourth Industrial Revolution's technological advancements. Emphasizing skills like critical thinking, problem-solving, and communication, the People dimension underscores the importance of soft skills alongside technical competencies. The Process dimension highlights the necessity for adeptness in lean methodologies, agile practices, and data-driven decision-making processes. Meanwhile, the Technology dimension focuses on mastering emerging technologies such as AI and technical skills, essential for navigating modern industrial landscapes. Together, these dimensions delineated the comprehensive set of competencies required for job readiness in the dynamic realm of Industry 4.0.

Aligned with Connectivism learning theory, this framework emphasizes continuous learning and adaptation to new information (Kop & Hill, 2008). It acknowledges the rapid evolution of skills in the Industry 4.0 era, urging professionals to continually update their competencies. Connectivism supports collaborative learning through networks, essential for enhancing skills like problem-solving and effective communication in the context of IR 4.0. Moreover, it recognizes technology's pivotal role in facilitating learning and skill acquisition, particularly crucial amidst advanced technologies characterizing Industry 4.0. By fostering adaptability and critical thinking, Connectivism promotes a mindset conducive to maintaining job readiness in an environment marked by constant change and technological advancement.

2. Literature Review

The United Nations Educational Scientific and Cultural Organization (UNESCO) (2002) defined technical and vocational education and training (TVET) as part of the educational process that includes the study of technologies and sciences alongside general education. TVET involved acquiring practical skills, attitudes, understanding, and knowledge related to various occupational sectors in economic and social life. Different regions referred to TVET by various names, such as Vocational Education, Technical Education, Career and Technical Education (CTE), and Workforce Education. Despite the different names, TVET fundamentally represented the same concept. International organizations like UNESCO and the World Bank emphasized TVET's critical role in national development. In Malaysia, the Government Transformation Programme (GTP) aimed to create 3.3 million new jobs by 2020, with a significant portion requiring vocational certificates and diplomas. TVET was crucial for supplying skilled workers to the labor market, addressing the shortage of high-skilled workers compared to neighboring countries. The Malaysian government prioritized skills training under the 10th Malaysian Plan and aimed to double TVET program enrollment in schools from 10% to 20%.

Recognizing the importance of TVET in fostering economic growth, the Malaysian government allocated RM6.7 billion in 2023 and RM6.8 billion in 2024 to support TVET initiatives. This funding included RM100 million for industry-recognized certifications and RM1.6 billion through Human Resource Development Berhad (HRD Corp) for various training programs. The initial MADANI budget focused on transforming TVET education through collaborations with government-linked companies (GLCs) and private enterprises. As of October 5, 2023, 61 memoranda of understanding had been signed to establish an Academy in Industry for on-the-job training and provide incentives for local workforce training. To address skill shortages, the government offered loans for skills training, upgraded facilities, and acquired training equipment. The Malaysian Technical University Network (MTUN) was established from technical university colleges rebranded as full-fledged universities: Universiti Malaysia Pahang Al-Sultan Abdullah (UMPSA), Universiti Tun Hussein Onn Malaysia (UTHM), Universiti Teknikal Malaysia Melaka (UTeM), and Universiti Malaysia Perlis (UniMAP). MTUN specialized in offering higher education programs in engineering and technology with a focus on practical and hands-on learning to ensure that graduates were well-prepared to meet the demands of modern industries (Malaysian Ministry of Higher Education, 2018).

2.1 Job Readiness of TVET Students

Job readiness involves a mix of skills, attitudes, and qualities that make students employable, including cognitive, psychomotor, affective, and commercial awareness skills (Prikshat et al., 2018). This readiness is reflected in graduates' ability to apply their college-acquired skills to their careers. Studies showed that students exhibited enthusiasm and a positive attitude towards the challenges of IR 4.0, despite having limited technical knowledge (Ismail et al., 2020; Yunos & Din, 2019). Malaysian universities are seen as effective in preparing students for the job market, though issues with soft skills such as self-esteem, time management, communication, and leadership persist (Nazron et al., 2017; Ping & Ling, 2023). Employers have noted the lack of work experience and soft skills as significant obstacles to employment, suggesting a need for better integration of industrial training in academic programs (Azmi et al., 2018; Belwal et al., 2017).

Graduate unemployment in Malaysia has been further influenced by mismatches between educational achievements and job requirements, especially in the context of Industry 4.0 (Chavan & Carter, 2018; Green &

Henseke, 2016). Employers often find a gap between their expectations and the abilities of university graduates (Norman et al., 2018; Azmi et al., 2018). Career readiness, defined by Adnan et al. (2021) as the acquisition and demonstration of fundamental skills, is essential for transitioning into the workplace. This includes competencies like problem-solving, critical thinking, teamwork, and digital literacy. However, many graduates feel their education has not adequately prepared them for the job market, particularly in terms of digital and technology skills, and they highlight the importance of collaboration and communication (Makki et al., 2023; Supian et al., 2020). Therefore, improving employability skills and bridging the gap between educational outcomes and job market expectations is crucial for addressing graduate unemployment.

2.2 Malaysia Industry4WRD

The landscape of industrialization has been undergoing a profound shift driven by significant technological innovation. The most recent phase, the Fourth Industrial Revolution (IR 4.0) or Industry 4.0, began in 2011 (Schwab, 2018). This revolution represents a transformation in the manufacturing sector, marked by digitalization and the integration of connected technologies (Ministry of International Trade and Industry, 2018). Industry 4.0 remains one of the most discussed and researched subjects today, with countries and corporations focusing on understanding, fostering, and implementing this new industrial approach (Jones & Pimdee, 2017). In response, the Malaysian government launched the Industry4WRD policy to prepare its manufacturing sector for digital transformation. The policy highlighted four key drivers: technology, human capital, global trade and network, and institutional framework, essential for facilitating this shift. At the core of IR 4.0 are advanced digitalization and automation, leading to new production methods, personalized products, and innovative business strategies. This transformation is expected to reduce labor and production costs, relying on knowledge, innovation, and creativity (McKinsey, 2020; Schwab, 2018). The government allocated RM 210 million from 2019 to 2021 to support this transition (Ministry of International Trade and Industry, 2018).

The Malaysia Productivity Corporation's Industry4WRD Readiness Assessment (Industry4WRD-RA) has helped up to 500 SMEs embrace Industry 4.0 technologies by evaluating their readiness and identifying areas for improvement (Malaysia Productivity Corporation, 2021). The assessment covers three main factors: People, Process, and Technology. Technology, which accounts for 50% of the assessment, focuses on intelligent, connected, and automated systems. It includes dimensions like enterprise intelligence and shop floor automation. Process, making up 30%, involves supply chain, product, and operations management with dimensions such as technology management and cybersecurity. People, accounting for 20%, emphasizes human capital development and transformation initiatives, including leadership and Industry 4.0 strategy (Rohaizat, 2021). This comprehensive approach aims to enhance productivity and growth by aligning with the evolving demands of Industry 4.0.

2.3 IR 4.0 Skills Required in Electrical and Electronics Industry

Historians have identified three industrial revolutions in human history: IR 1.0 focused on mechanization, IR 2.0 on electricity and mass production, and IR 3.0 on automation (Darwish, 2018; Schwab, 2018). These revolutions not only transformed production and business models but also reshaped the skill sets expected of future workers across various industries (Benešová & Tupa, 2017). Industry 4.0, driven by advanced technologies, continues this trend with a focus on digitalization, robotics, and global competition, fundamentally altering employment landscapes and demanding specialized skills for the digital and collaborative economies (Green & Henseke, 2016; Kergroach, 2017; Motyl et al., 2017). The shift to Industry 4.0 necessitates a workforce adept in digital and technical competencies, crucial for enhancing organizational competitiveness and innovation (Benešová & Tupa, 2017). Moreover, organizations aiming to adopt Industry 4.0 successfully must cultivate a workforce equipped with both technical expertise and adaptive capabilities, emphasizing information transparency, automation, decision-making skills, and employee flexibility (Hirmer et al., 2016; Schallock et al., 2018).

The arrival of Industry 4.0, the fourth industrial revolution, marks a profound departure from its predecessors driven by steam or gas, showcasing a more sophisticated evolution. Industry 4.0 fundamentally revolves around integrating artificial intelligence (AI) into manufacturing processes, with smart factories at its forefront. This transformation is supported by 11 key pillars, which collectively reshape manufacturing into a highly efficient, interconnected ecosystem. AI plays a central role, analyzing vast production data accessible via the Industrial Internet of Things (IIoT), while big data analytics and cloud computing enhance decision-making and facilitate seamless data management. Autonomous robots collaborate with human workers to perform complex tasks in real-time, augmenting efficiency. Technological advancements in simulated and augmented reality enhance product design and prototyping, while horizontal and vertical system integration foster organizational synergy. Additive manufacturing and digitalized supply chains optimize production and distribution processes, supported by robust cybersecurity measures ensuring system integrity. Together, these pillars enable Industry 4.0 to deliver unprecedented levels of efficiency, productivity, and adaptability across the manufacturing landscape (Akyazi et al., 2022; Penang Skills Development Centre (PSDC), 2018).

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Analytical Thinking remains the most widely recognized core skill across companies, comprising approximately 9% of reported essential skills. Creative Thinking closely follows as another cognitive skill, surpassing three self-efficacy skills: Resilience, Flexibility, and Agility; Motivation and Self-awareness; and Curiosity and Lifelong Learning. This acknowledgment underscores the importance of workers' ability to adapt in disrupted work environments. Dependability and Attention to Detail, the fourth self-efficacy skill in the Global Skills Taxonomy, holds the seventh position, just behind Technological Literacy. Also among the top 10 core skills are two attitudes related to collaboration—Empathy and Active Listening, and Leadership and Social Influence—along with Quality Control, making up 5% of worker skill sets despite its tenth ranking, highlighting its importance to specific businesses (World Economic Forum, 2023)

Generic skills are fundamental competencies applicable across various professions, forming the bedrock for developing employability skills crucial for both young individuals and adults (Caleb & Udofia, 2013). Technical and Vocational Education and Training (TVET) students are expected not only to acquire refined technical skills but also to cultivate generic skills like flexibility, adaptability, and the ability to engage in diverse job roles (Nurjanah & Ana, 2022). Over the past two decades, employers have heightened their expectations regarding the skills of new graduates, recognizing that academic qualifications alone may not suffice for securing employment (Smith & Krüger, 2008). This shift emphasizes competence and the demonstration of high-quality generic skills in the workplace, driven by technological advancements, globalization, international competition, productivity goals, sector reforms, and changing market demands (Cavanagh et al., 2015).

However, employers globally have expressed consistent dissatisfaction with university graduates, particularly in Nigeria, where confidence in their readiness for the job market is lacking (Pitan, 2017). This poses challenges for universities and potential employers alike. Developing relevant skills and competencies is crucial for enhancing graduate employability, which in turn enhances a university's reputation and attractiveness compared to other institutions (Dumford & Miller, 2017). A significant source of graduate dissatisfaction lies in perceived deficiencies in generic skills such as problem-solving, communication, and leadership (Kamaruddin et al., 2019). These skills, defined as essential non-technical abilities for navigating jobs and interpersonal dynamics, include cognitive elements like communication, teamwork, problem-solving, and critical thinking (Kaliappan & Hamid, 2022). Thus, this highlights the importance of TVET institutions, particularly vocational colleges, in equipping students with these vital skills for competitiveness post-graduation (Zhang, 2012).

3. Methodology

The research design in this study outlined the framework for organizing and executing the research, which aimed to determine the essential Industry 4.0 skills from the industry's perspective, assess the job readiness level of TVET students, and specifically evaluate final-year TVET undergraduate students in Electrical and Electronics (E&E) at Malaysia Technical University Network (MTUN). A quantitative approach, involving data collection through questionnaires, was chosen as the most suitable method (Albers, 2017). The study employed a descriptive research design using surveys to gather data on job readiness and IR 4.0 skills. Surveys, as noted by Cohen et al. (2017), are effective for exploring issues from multiple perspectives and quickly collecting information from large samples. Objective one utilized a checklist to gather quantitative insights from industry experts in Electrical and Electronics to identify the essential Industry 4.0 skills for TVET students. Descriptive statistics were employed for data analysis. Objective two was to evaluate the job readiness level of final-year MTUN TVET Electrical and Electronics students using a 5-point Likert scale questionnaire. Mean frequency analysis was applied to interpret the data. Objective three compared the job readiness levels across MTUN universities using the Kruskal-Wallis statistical method due to the non-normal distribution of the data. The study combined Industry 4.0 checklist and job readiness questionnaire to provide a comprehensive understanding of job readiness and necessary Industry 4.0 skills, ultimately aiming to inform recommendations for adequately preparing TVET students for the future workforce.

A target population refers to the group of individuals targeted to obtain data (Bell, 2021). For this study, the target groups comprised industry experts in the Electrical and Electronics (E&E) industry and final-year MTUN TVET undergraduate students in the Electrical and Electronics (E&E) field, both males and females. These industry experts were at the management level for their companies and had at least five years of working experience in this field. This student group was chosen because they were pursuing TVET courses in Electrical and Electronics and may have had varying perceptions of their job readiness for Industry 4.0 skills. Moreover, these courses are registered under the Malaysia Board of Technologists (MBOT). To understand the skills they needed to master, students completed an IR 4.0 job readiness questionnaire. Probability sampling, specifically stratified sampling followed by simple random sampling, was used to ensure each student had an equal chance of being selected (Rahim et al., 2022). This method enhanced the study's generalizability and validity while preventing biases such as undercoverage bias. Stratified sampling with proportional allocation ensured the sample size for each stratum was proportionate to the population size of each university involved. The total population for this study was 922, with a sample size of 270 determined using the Krejcie and Morgan Table.

The study employed two primary instruments for data collection: a checklist and a questionnaire. The checklist method involved a quantitative assessment of Industry 4.0 skills, prepared via Google Forms and distributed to three experts in the Electrical and Electronics industry to identify essential skills. Descriptive analysis was used to analyze the checklist data. The questionnaire, based on previous studies (Ismail et al., 2020; Massetor et al., 2021; Ramisetty, 2017; Teng et al., 2019; Yunos & Din, 2019), consisted of four parts: Part A for demographic information, Part B for job readiness in terms of the People dimension, Part C for the Process dimension, and Part D for the Technology dimension. Data were analyzed using IBM SPSS Statistics, with descriptive statistical analysis (average mean) used for Parts A, B, C, and D. A five-point Likert scale was used to assess respondents' agreement levels, ranging from "1" for Strongly Disagree to "5" for Strongly Agree (Mcleod, 2023). The Information Literacy Education Implementation Readiness Scale was used to gauge students' readiness for Industrial Revolution 4.0, with scores indicating levels of readiness from "developing" to "ready" (Ahmad et al., 2019). Table 1 shows the list of research objectives and hypotheses. The study addressed three research questions, each analyzed using different methods. Research question one was analyzed using frequencies and percentages. This question utilized an IR 4.0 skills checklist, with 26 industry experts in Electrical and Electronics selected to identify the essential Industry 4.0 skills for the field. Skills selected by more than 40% of industry experts were considered essential. Research question two was analyzed through descriptive analysis. The mean scores of all questionnaire items were calculated using SPSS. The total score's mean was compared to the benchmark, categorizing readiness as ready, approaching readiness, or developing readiness. Research question three was analyzed using the Kruskal-Wallis test due to non-normal data distribution, comparing three or more groups to determine which MTUN final-year TVET Electrical and Electronics undergraduate students had the best job readiness for Industry 4.0 skills. Research questions two and three were addressed using a job readiness questionnaire.

Table 1 *List of research objectives and hypotheses*

	Objectives	Hypotheses	Analysis
1	To identify the Industry 4.0 skills required for final year TVET undergraduate students in Electrical and Electronics (E&E) field at Malaysia Technical University Network (MTUN) from the industry perspective.	-	Frequencies
2	To examine the level of job readiness possessed by final year TVET undergraduate students in Electrical and Electronics (E&E) field at Malaysia Technical University Network (MTUN)	-	Mean scores
3	To investigate the differences of the job readiness level among final year TVET undergraduate students in Electrical and Electronics (E&E) field in different universities of Malaysia Technical University Network (MTUN)	H_{01}: There is no significant difference in the Malaysia Technical University Network (MTUN) and job readiness level of final year TVET undergraduate students in Electrical and Electronics (E&E) field at Malaysia Technical University Network (MTUN)	Kruskal-Waliis Test

4. Findings and Discussions

Based on the objectives of this study, there were two instruments: the IR 4.0 skills checklist from industry perspectives and the IR 4.0 skills questionnaire based on the results of the checklist. This section discusses the findings from data analyses, which include the job readiness level of final year TVET undergraduate students in electrical and electronics and the comparison of job readiness levels among the MTUN.

4.1 Essential Industry 4.0 Skills in the Electrical and Electronics Industry

A checklist analysis was conducted to gather insights from industry experts on the essential Industry 4.0 skills needed in the Electrical and Electronics industry. This analysis was done through an online questionnaire aiming to assess both the job readiness of recent graduates and ways to enhance their preparedness. The questionnaire comprised 10 questions, seven of which gathered respondents' background information such as name, gender, age, company name, position, sector, and work experience. The remaining questions focused on the experts' views on essential Industry 4.0 skills for graduates, current job readiness, and strategies to improve it. Industry experts accessed the checklist through a Google Form link shared via email and LinkedIn. Table 2 shows that a total of 26 respondents, with work experience ranging from 6 to 35 years, participated in the survey. These respondents held

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various positions, including top management, senior management and junior management. The companies they represented spanned sectors such as electrical and electronics.

Table 2 *Profile of industry experts*

Pseudonyms	Company	Sector	Years of Experience	Position
Mr. Kalidass	A	Mechatronics	26-30	Senior Engineer
Mr. Oon	B	Electrical	26-30	Assistant Manager, Dept. of Technical / Service
Mr. Gan	C	Electrical	16-20	Associate
Mr. Douglas	D	Electrical	16-20	Senior Electrical Engineer
Mr. Adha	E	Electrical	26-30	Director
Mr. Chin	F	Mechatronics	11-15	Sales executive
Mr. Goh	G	Electrical	16-20	Director
Mr. Sam	H	Electronics	11-15	Principal Engineer
Mr. Freeman	I	Electronics	21-25	Director
Mr. YC	J	Electrical	6-10	Sales Manager
Mr. Yew	K	Electrical	31-35	CEO
Mr. YCF	L	Electrical	21-25	Managing Director
Mr. Saifuzzaman	M	Electrical	16-20	Senior Engineer
Mr. Oh	N	Electrical	6-10	Team Lead
Mr. Shahrir	O	Electrical	11-15	Electrical Engineer
Mr. Raman	P	Electronics	31-35	Assistant Manager
Mr. Eng	Q	Electrical	21-25	Director
Mr. Anuar	R	Electrical	21-25	Executive Commissioning & Start-Up (Electrical)
Mr. Faisal	S	Electrical	11-15	Assistant Director
Mr. Jamil	T	Electronics	11-15	Electronic Engineer
Ms. Ying	U	Electronics	6-10	Sales Manager
Mr. Tan	V	Electrical	21-25	Director
Ms. Yau	W	Electrical	11-15	Technical Director
Ms. Racheal	X	Electrical	16-20	General Manager, Transmission
Mr. Ng	Y	Electrical	16-20	Associate
Mr. Ahmad	Z	Electrical	11-15	Engineer

The analysis, as illustrated in Fig. 2, highlights the skills deemed critical for the Electrical and Electronics sector in the context of Industry 4.0. Technical knowledge emerged as the most essential skill, with 21 respondents (80.8%) emphasizing its importance. This skill is fundamental for equipping individuals with the expertise required to navigate the technological advancements brought about by Industry 4.0. Technical skills, as described by Spinks et al. (2006), encompass foundational and specialized knowledge in science, technology, and mathematics. In Malaysia, the National Occupational Skills Standards (NOSS) underscore the importance of practical application and industry-specific training. With Industry 4.0 technologies such as cloud computing, the Internet of Things (IoT), and cyber-physical systems (CPS) reshaping the industrial landscape, there is an urgent need for professionals proficient in these areas (Tortorella et al., 2023). Therefore, robust technical education is pivotal for fostering job readiness in a technology-driven economy. Reasoning and problem-solving were identified as crucial skills by 69.2% of respondents. These cognitive abilities enable individuals to address complex challenges and adapt to the evolving demands of the modern job market (Kamaruddin & Rasdi, 2021). Incorporating these skills into education equips students with the capacity to meet industry expectations and enhances their employability.

Analytical thinking and innovation, along with technological literacy, were each highlighted by 57.7% of respondents as vital for the sector. Analytical thinking is essential for synthesizing information, recognizing patterns, and developing innovative solutions, especially in data-intensive environments (Rodzalan et al., 2022). Despite its significance, this skill is often undervalued in educational settings. Similarly, technological literacy is critical for mastering specialized software and advanced equipment integral to the industry (Kaliappan & Hamid, 2022). These competencies ensure professionals can meet both national and global industry demands.

Big data analytics and communication skills were each identified as important by 53.8% of respondents. The ability to analyze large datasets is indispensable in modern industries, while effective communication fosters collaboration and efficient information exchange (Azmi et al., 2018). Furthermore, 50% of respondents highlighted the significance of artificial intelligence (AI) expertise, leadership and social influence, and curiosity and lifelong learning. AI technologies are instrumental in optimizing manufacturing processes, while leadership drives innovation and competitiveness (Fiandra et al., 2021). Lifelong learning ensures professionals remain adaptable and responsive to industry advancements.

Additional skills deemed important included quality control (46.2%), critical thinking (42.3%), and creative thinking (38.5%). These skills are essential for maintaining high standards, fostering innovation, and addressing unique challenges in the workplace. Other identified competencies included industrial IoT, complex problem-solving, time management, self-confidence, emotional intelligence, autonomous robots, simulation and augmented reality, new business models, and cloud computing, each of which was recognized by 26.9%–34.6% of respondents. Skills like programming, cybersecurity, and additive manufacturing were noted by fewer respondents but remain relevant for niche applications in Industry 4.0. In conclusion, the findings emphasize the need for educational institutions and industry stakeholders to prioritize the development of these critical skills.

Fig. 2 *Graph of IR 4.0 skills selection by industry experts*

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4.2 Job Readiness Level

Table 3 illustrates the mean and standard deviation distribution for the overall job readiness level of MTUN TVET electrical and electronics final year undergraduate students. These figures reflect the respondents' general readiness across various dimensions. The People dimension readiness scored a mean of 3.62 with a standard deviation of 0.401. The Process dimension readiness had a mean of 3.48 and a standard deviation of 0.455. The Technology dimension readiness achieved a mean of 3.65 with a standard deviation of 0.389. Overall, the job readiness level of these students was rated with a mean of 3.61 and a standard deviation of 0.364, indicating they were approaching readiness. This positioning indicated that they were between developing readiness and being fully ready, as their mean score surpasses the midpoint between approaching readiness (3.00) and readiness (4.00). This finding shows that final-year TVET students in Electrical and Electronics were not yet fully prepared for the current skill demands. Although they possessed IR 4.0 skills from the industry's perspective, they had not yet fully mastered them.

The job readiness level for the People dimension categorized the students as approaching readiness. Within this dimension, only three items—A13, A15, and A16—were classified as "ready." These items reflected students' openness to learning from various sources and their readiness to acquire new skills, aligning closely with the critical Industry 4.0 skill of curiosity and lifelong learning. The classification of approaching readiness indicated that students were at a moderate level, not yet achieving full readiness. TVET students demonstrated above-average personal attributes such as creativity, leadership, and innovative thinking, particularly within the context of Industry 4.0 (Ahmad et al., 2023). These findings were consistent with the job readiness results of TVET students in the People dimension reported by Ahmad et al. (2023).

The People dimension encompassed various generic skills sought by employers, including critical thinking, complex problem-solving, and innovation. These findings suggested that TVET students could meet many of the requirements for the Electrical and Electronics industry. In the Process dimension, all items were categorized as approaching readiness, indicating that students possessed relevant skills but were not yet fully prepared. The item B1 ("I can ensure that products meet the required standards") had the highest mean score for readiness, while B6 ("I know how to apply basic knowledge of quality control on products") received a median mean score. Both items related to the Industry 4.0 skill of quality control, reflecting that students could identify defects in products and perform repairs. However, students lacked the ability to provide solutions to more complex issues (Rodzalan et al., 2022). This finding highlighted that while they had foundational quality control knowledge, they had not yet achieved mastery. The item B11 ("I have practical experience with big data technologies") had the lowest mean score in the Process dimension. Fattahi & Ullah (2022) found that vocational students had limited opportunities to engage with big data technologies, which explained their lower readiness in this area. These findings aligned with the approaching readiness result for big data analytics in this study.

In the Technology dimension, all items were similarly categorized as approaching readiness. The item C15 ("I can use AI to increase my efficiency") received the highest mean score, while C12 ("I understand the concept of artificial intelligence (AI)") had a median mean score. These two items related to the Industry 4.0 skill of Artificial Intelligence, indicating that students were familiar with AI applications. However, their readiness in AI remained at an approaching level. Manocha & Sharma (2020) reported that while TVET students were proficient in applying AI, they lacked a deeper understanding of algorithms, suggesting a gap in their theoretical knowledge. The item C3 ("I possess the capability to repair electronics systems") had the lowest mean score in the Technology dimension, though it remained in the approaching readiness category. This finding indicated that students could repair electrical or electronic systems, create wiring diagrams using software, and understand safety regulations and standards, as supported by Sharberi et al. (2019).

Overall, the job readiness level of final-year TVET undergraduate students in the Electrical and Electronics (E&E) field at the Malaysia Technical University Network (MTUN) was categorized as approaching readiness. This positioning indicated that students were between developing readiness and being fully ready, with their mean score exceeding the midpoint between approaching readiness (3.00) and readiness (4.00). Although students possessed Industry 4.0 skills from the industry's perspective, they had not yet fully mastered them. Research by Sharberi et al. (2019) corroborated these findings, showing above-average job readiness in knowledge, skills, and attitudes. Similarly, Supian et al. (2020) found moderate job readiness among students due to infrequent use of technology, while Nurjanah & Ana (2022) reported moderate readiness across ability, academic, behavioral, and self-potential factors. This study revealed that respondents demonstrated an approaching readiness level across all dimensions. While capable of entering the workforce, they would benefit from additional training to enhance their job readiness. The current job readiness level of final-year TVET undergraduate students in the E&E field at MTUN showed a gap of 0.4 to reach a readiness score of 4.0. This gap could be bridged through targeted short-term training programs and courses. With a mean job readiness score of 3.61, categorized as approaching readiness, TVET graduates in the E&E field are positioned between developing and fully ready for the job market (Nurjanah & Ana, 2022). This underscores the importance of aligning curricula with industry demands to bridge skills gaps and improve graduates' employability (Ismail et al., 2020; Supian et al., 2020).

Table 3 *Distribution of the mean and standard deviation of the overall job readiness level of MTUN TVET electrical and electronics final year undergraduate students*

	Mean	Standard Deviation	Readiness
People Dimension Readiness	3.62	0.401	Approaching Readiness
Process Dimension Readiness	3.48	0.455	Approaching Readiness
Technology Dimension Readiness	3.65	0.389	Approaching Readiness
Overall Job Readiness Level	3.61	0.364	Approaching Readiness

4.3 Comparison of Job Readiness Level among Universities of MTUN

Table 4 presents the results of the normality tests, specifically the Kolmogorov-Smirnov and Shapiro-Wilk tests. The Kolmogorov-Smirnov test produced a test statistic of 0.101 with 312 degrees of freedom (df), and the significance level (Sig.) was reported as less than 0.001. Since the significance value is less than the commonly used alpha level of 0.05, the null hypothesis, which states that the data follows a normal distribution, is rejected. Similarly, the Shapiro-Wilk test generated a test statistic of 0.975 with 312 degrees of freedom, and the significance level (Sig.) was also less than 0.001. As with the Kolmogorov-Smirnov test, the significance value was below the alpha level of 0.05, indicating that the data was a non-normal distribution.

Table 4 *Test of normality*

Tests of Normality					
Kolmogorov-Smirnov[a]			Shapiro-Wilk		
Statistic	df	Sig.	Statistic	df	Sig.
.101	312	< .001	.975	312	< .001

Note. a. Lilliefors Significance Correction

The analysis of normality test results, as detailed in Table 4, unequivocally demonstrated that the data did not conform to a normal distribution. These outcomes necessitate the adoption of non-parametric tests for subsequent analysis, as parametric tests rely on the assumption of normality. Due to the identified violation of normality assumptions, the analytical approach shifted from parametric to non-parametric tests. Consequently, the one-way ANOVA was supplanted by the Kruskal-Wallis Test. Tables 5 displays the results of an Independent-Samples Kruskal-Wallis Test conducted to determine if job readiness levels differ across various university categories. The research hypothesis (H_{01}) posited no significant difference in job readiness levels among final-year TVET undergraduate students in Electrical and Electronics (E&E) at Malaysia Technical University Network (MTUN) institutions. The null hypothesis asserted that job readiness levels were uniform across all university categories. The asymptotic significance (2-sided test) was 0.012, supporting the hypothesis test summary table's significance value. Consequently, the null hypothesis was rejected, indicating a statistically significant difference in job readiness levels among MTUN universities.

Table 5 *Independent-samples Kruskal-Wallis test summary*

No.	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Job Readiness Level is the same across categories of UNIVERSITY.	Independent-Samples Kruskal-Wallis Test	.012	Reject the null hypothesis.

Note. a. The significance level is .050.
b. Asymptotic significance is displayed.

Referring to Table 6 for pairwise comparisons among universities, significant differences were detected only between UMPSA-UTHM, UniMAP-UTHM, and UTeM-UTHM, each exhibiting significance values below 0.05. This meant that a significance level below 0.05 signifies rejection of the null hypothesis, indicating substantive

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distinctions between these university pairs. UMPSA-UTeM, UMPSA-UniMAP and UniMAP-UTeM had no statistically significant difference, each exhibiting significance values above 0.05. This meant that no significance level above 0.05 signifies acceptance of the null hypothesis, indicating approximately same between these university pairs. Thus, with respect to research question three, significant value in job readiness level was observed among different university categories hosting final-year TVET undergraduate students in the Electrical and Electronics (E&E) field at Malaysia Technical University Network (MTUN). Job readiness level of TVET Electrical and Electronics final year undergraduate students among UTeM, UniMAP and UMPSA were no statistically significant differences, meaning that their job readiness level was approximately the same. UTHM and other three MTUN universities had a statistically significant differences, meaning that job readiness level of students was not at the same level of others. Table 7 shows that UTHM's overall mean is higher than those of the other three universities.

Table 6 *Pairwise comparisons of universities*

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.
UMPSA-UniMAP	13.327	18.322	.727	.467
UMPSA-UTeM	13.819	17.858	.774	.439
UMPSA-UTHM	71.731	23.986	2.991	.003
UniMAP-UTeM	.492	11.392	.043	.966
UniMAP-UTHM	58.405	19.651	2.972	.003
UTeM-UTHM	57.912	19.219	3.013	.003

Table 7 *Job readiness level of each MTUN university*

Universities	Mean	Readiness
UTHM	3.8148	Approaching Readiness
UTeM	3.5798	Approaching Readiness
UniMAP	3.6114	Approaching Readiness
UMPSA	3.5275	Approaching Readiness
Total	3.6054	Approaching Readiness

These findings were critical for understanding the differences in job readiness among final-year TVET undergraduate students in the Electrical and Electronics (E&E) field at the Malaysia Technical University Network (MTUN). The significant differences in job readiness levels suggested that some universities were better equipped to prepare their students for the demands of Industry 4.0. This could have been due to various factors, including the quality of industry partnerships, the relevance and rigor of the curriculum, the availability of modern equipment and technology, and the effectiveness of soft skills training (Ahmad et al., 2019; Rodzalan et al., 2022).

5. Conclusion

Malaysia's Technical and Vocational Education and Training (TVET) programs aim to produce a skilled workforce for the industrial sector, but concerns remain about the readiness of graduates for Industry 4.0 (IR 4.0) workplaces, particularly in the critical Electrical and Electronics (E&E) industry. This study assessed the job readiness of final-year TVET undergraduate students in the E&E field at the Malaysia Technical University Network (MTUN) and identified 11 essential IR 4.0 skills. These skills included technical knowledge, reasoning and problem-solving, analytical thinking, technological literacy, big data analytics, communication skills, artificial intelligence, leadership and social influence, curiosity and lifelong learning, quality control, and critical thinking. Findings revealed that students were generally in the "approaching readiness" category across People, Process, and Technology dimensions, with notable gaps in skills like quality control and big data technologies. The overall mean job readiness levels for UniMAP, UTeM, and UMPSA did not exhibit statistically significant differences, whereas UTHM's overall mean was notably higher than those of the other three universities, signifying a statistically significant difference for UTHM in comparison. In summary, there was a statistically significant difference in the job readiness levels of final-year TVET undergraduate students in the Electrical and Electronics (E&E) field across the MTUN universities. Overall, while TVET students demonstrated the potential to meet industry demands, further training is needed to enhance their preparedness for the rapidly evolving IR 4.0 landscape.

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Conflict of Interest

The authors declare that there is no conflict of interest 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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