

4IR Characteristics toward Malaysia TVET

Syuhada Yunos, Ahmad Rizal Madar

Faculty of Technical and Vocational Education, University Tun Hussein Onn, Batu Pahat, 86400, Malaysia

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ABSTRACT

Malaysia's TVET institutions, particularly under the MTUN framework, integrate 4IR technology in line with worldwide industry trends. It shows Malaysia's proactive attitude to digital literacy, innovation, and lifelong learning for students and professionals. Universities and companies collaborate to give graduates digital economy-relevant technical and soft skills. This study contextualizes the practice issue and its context by reviewing prior studies. An exhaustive literature study on the significance of improving TVET quality to prepare graduates for the changing labor market reveals various counterarguments that question the approaches' efficacy and suitability. This study reviews 4IR components uncovered by previous academics and defines new workforce competencies for the Fourth Industrial Revolution. To set the stage, this study begins with the fourth industrial revolution. The next segment will cover 4IR transformation, while the third will examine The Malaysian Technical University Network (MTUN)'s Technical and Vocational Education and Training (TVET) and its alignment with Industry 4.0. This study examines the Fourth Industrial Revolution and Malaysian Technical and Vocational Education and Training. TVET universities must improve business relationships to update curricula for the Fourth Industrial Revolution. Investment in digital infrastructure, faculty development, and AI, IoT, and robotics in education is crucial. Integrating lifelong learning platforms like mobile learning and micro-credential programs can boost graduates' adaptability and employability in the changing workforce.

Keywords: TVET, Future Workforce, 4IR, 4IR Skill and Fourth Industrial Revolution

INTRODUCTION

Technologies and worldviews could differentiate industrial revolutions, according to Klaus S. (2017). Economy and society undergo major changes. After agriculture was replaced by machinery, the first industrial revolution began. Steam power and iron and steel production aided this transition. This revolution affected transportation, communication, and industry across Europe and the global Industrial Revolution. Manufacturing hydropower marked the first revolution. Later in the 19th century, the second industrial revolution began where the first had ended. When telecommunications and transportation networks became widespread, manufacturing and industry made technological advances. Electricity became more widespread, allowing industries to modernize production lines and increase productivity. After these telecommunications and transportation networks were built, more people and ideas could travel, which boosted urbanization hence the 2nd revolution are known as electrical.

Further technological advances sparked the Third Industrial Revolution, or Digital Revolution, also known as the Information Age. The transition from mechanical and analog to digital electronics began in the late 20th century. Many technologies highlighted this change. Personal computers, sophisticated communication technologies, and internet use proliferated during this time. This is digitalization. According to Klaus S. (2017), cyber-physical systems arrived in the fourth industrial revolution to integrate technology into human life and society. The Fourth Industrial Revolution integrates the digital, physical, and biological environments. Technologically, this revolution affected century-old manufacturing and industrial processes. In manufacturing facilities, machine-to-machine communication and the Internet of Things increase automation, improve communication, and enable intelligent machines that can self-diagnose.

Technology has also enabled the seamless integration of virtual and physical manufacturing components during the Fourth Industrial Revolution, according to Klaus S. (2017). The 4IR began at the start of the 21st century and follow the digital revolution. An internet that is more ubiquitous and cloud-based, artificial intelligence, machine learning, compact, powerful, and affordable sensors distinguish it. An accelerated pattern of far-reaching change that leaves little time for preparedness is similar to the Fourth Industrial Revolution. Others are ready to adapt to the changing technological landscape and take advantage of its benefits, while others are unaware. 4IR was first proposed by Klaus Klaus S. (2017), founder and executive chairman of the World Economic Forum, and refers to a fusion of technologies that is blurring the physical, digital, and biological domains with unprecedented velocity, scope, and systemic impact. 4IR will likely change society, how people use technology, and where they work. Results vary by country and culture, requiring unique automation and digitalization solutions. Advances in computational efficiency for real-time data collection, analysis, judgment, and trend analysis are ushering in a fully linked digital age in the 4IR years Fig. 1 History of Industrial Revolution.

The incorporation of Fourth Industrial Revolution technology in Malaysia's Technical and Vocational Education and Training (TVET) institutions, especially within the MTUN framework, reveals significant conformity with worldwide industrial trends. It underscores Malaysia's proactive strategy in promoting digital literacy, innovation, and continuous education among students and employees. The partnership between universities and companies guarantees that graduates possess the requisite technical and interpersonal skills essential for the digital economy. Despite progress, TVET institutions continue to have difficulties in completely aligning curricula with the swift evolution of 4IR technology breakthroughs. Numerous training programs are deficient in access to advanced infrastructure, competent instructors, and digital resources necessary for thorough skill enhancement. Moreover, an inequality persists between academic preparation and industry requirements, limiting graduates' preparedness for rapid employment in high-tech professions.

This study examines toward the components of the Fourth Industrial Revolution that earlier researchers have identified and outlines the new skills that the workforce will need during this time. This first part of the study gives an overview of the fourth industrial revolution to set the stage for the research. The next part will focus on topics related to 4IR transformation, and then we'll dive into various aspects of Technical and Vocational Education and Training (TVET) within the Malaysian Technical University Network (MTUN) and how it aligns with the needs of Industry 4.0. This study looks at the features of the Fourth Industrial Revolution and how they connect to the Technical and Vocational Education and Training sectors in Malaysia.

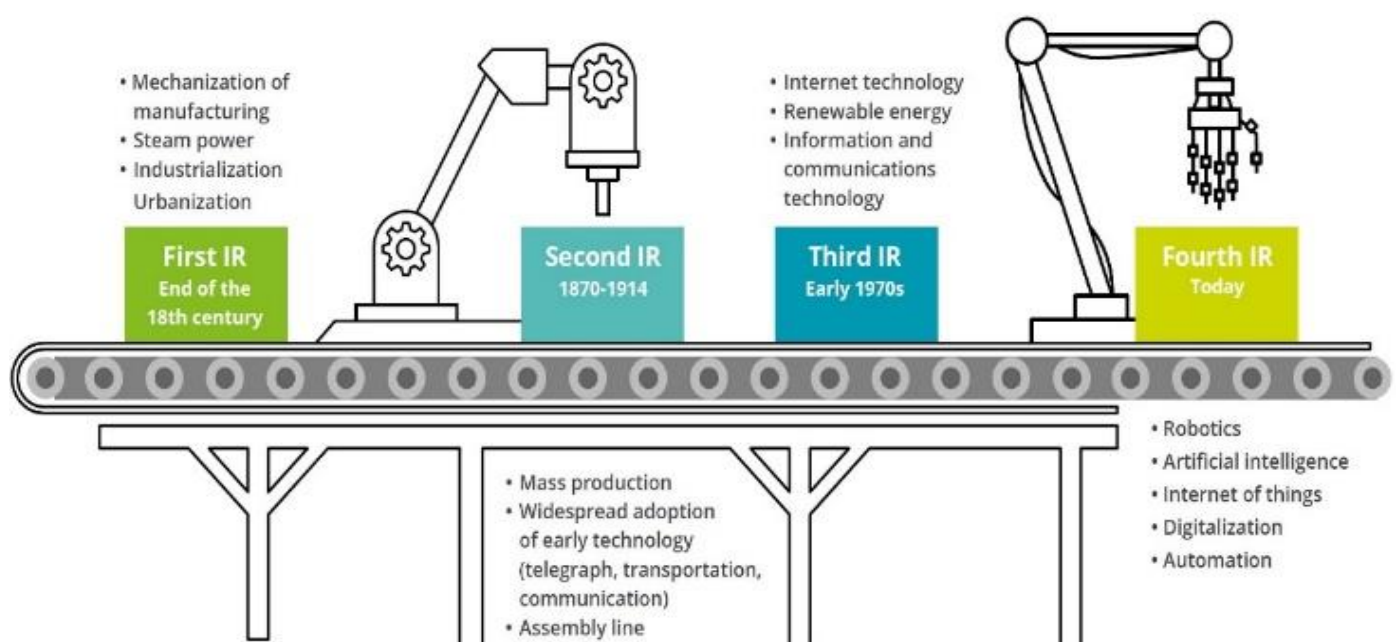


Fig. 1 History of Industrial Revolution

4IR Characteristics

The Fourth Industrial Revolution (4IR), often referred to as Industry 4.0, is fundamentally reshaping the landscape of industrial operations through advancements in automation technologies, connectivity technologies, and data exchange platforms. Central to this transformation are innovations in artificial intelligence (AI), robotics, and additive manufacturing, which collectively enhance the efficiency and flexibility of production processes (Müller et al., 2018; Zhou et al., 2023). These technologies facilitate a shift from traditional mass production, characterized by economies of scale, to mass customization, where products and services are tailored to individual consumer needs (Zhou et al., 2023). This paradigm shift is not merely technological; it represents a comprehensive rethinking of business models and operational strategies across various sectors.

The convergence of these technologies enables a new era of smart and connected digital automation, which is pivotal for enhancing productivity, output, and operational efficiency (Müller et al., 2018; Zhou et al., 2023). The integration of the Internet of Things (IoT) allows for real-time data exchange and connectivity among machines, products, and human operators, fostering a dynamic management environment that can adapt to changing market demands (Müller et al., 2018; Ziegler et al., 2019). This interconnectedness is crucial for developing new business models that prioritize flexibility, agility, and speed, thereby enabling organizations to respond swiftly to consumer preferences and market fluctuations (Grabowska & Saniuk, 2022; Müller & Däschle, 2018). As a result, businesses are increasingly adopting innovative management techniques that leverage these technological advancements to optimize their operations and enhance their competitive edge (Grabowska & Saniuk, 2022; Müller & Däschle, 2018).

Moreover, the implications of Industry 4.0 extend beyond operational efficiencies; they also encompass significant changes to the workplace and the nature of work itself. The interdependence of human resources and technological systems is leading to a redefinition of roles and responsibilities within organizations (Müller et al., 2018; Dobrowolska & Knop, 2020). As automation technologies take over routine tasks, the demand for a workforce equipped with new skills and capabilities is paramount. This necessitates a renewed focus on lifelong learning and continuous skill development to ensure that employees can thrive in an increasingly automated environment (Zhou et al., 2023; Dobrowolska & Knop, 2020; Müller & Däschle, 2018). The emphasis on upskilling and reskilling is critical, as it prepares the workforce to engage with advanced technologies and adapt to the evolving industrial landscape.

The scope and velocity of the revolution are what make the 4th Industrial Revolution (4IR) different from previous industrial revolutions. The 4th Industrial Revolution is characterized by digital technologies that fuse physical, digital, and biological worlds. What makes the current period exceptional is the rapid technological transformation comprised of artificial intelligence, robotics, machine learning, data analytics, and the Internet of Things. Data-centric technology and machine-based analytics are exceeding human capacity. Along with technological changes, there are also shifts in business models. Traditional business models are organized around operational efficiency, scale, and reach. In contrast, 4IR business models are agile and allow for continual evolution of business activities.

In conclusion, the Fourth Industrial Revolution, driven by Industry 4.0, is catalysing a profound transformation in how industries operate. The integration of automation, connectivity, and data exchange technologies is not only enhancing productivity and efficiency but also reshaping business models and the workforce. As organizations navigate this new industrial reality, the focus on developing relevant skills and fostering a culture of lifelong learning will be essential for sustaining competitive advantage and driving economic growth in 4IR era.

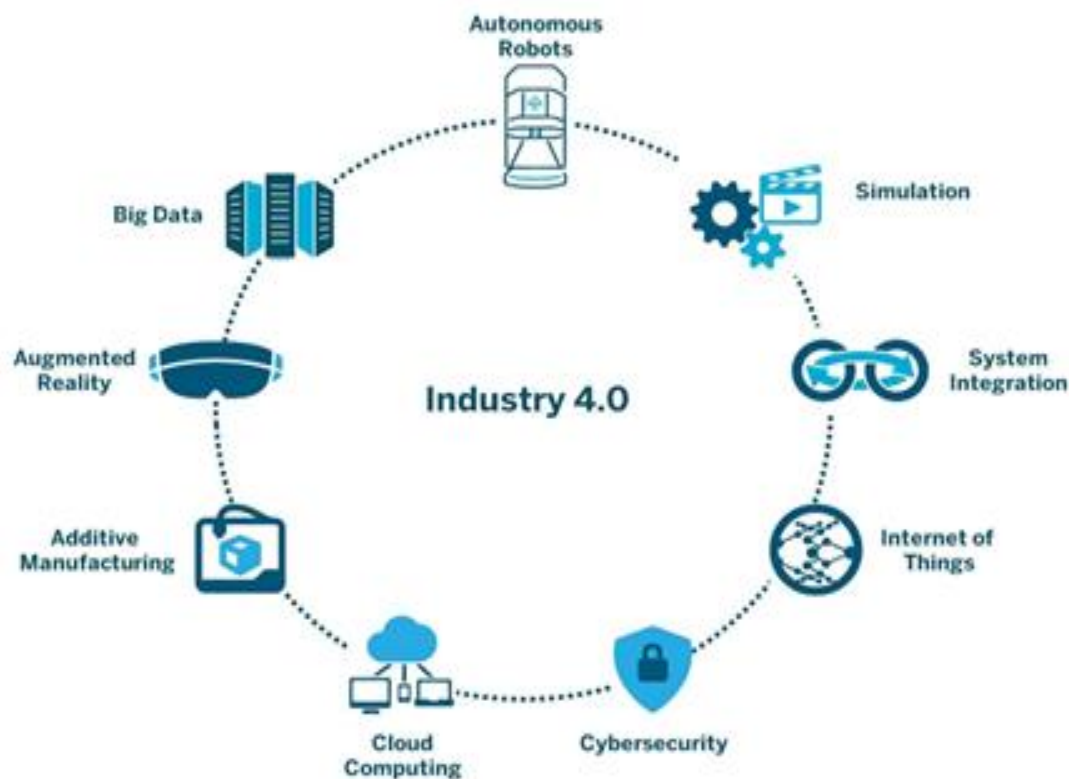


Fig. 2 Technologies of Fourth Industrial Revolution

4IR Impact on Future Workforce

Like any technological breakthrough, labor effects are unpredictable and evolve. In 4IR, the decision is ambiguous. A 2020 poll (Mohd Salleh et al., 2020) found that half of a company executives think 4IR technology will eliminate jobs and 69% think it will generate new ones. In contrast, 45% of workers worry about 4IR's impact on their jobs. Work is changing swiftly, with automation taking over some tasks and requiring new digital skills. Indeed, demand is so strong that recruitment is barely sustainable.

Many companies need 4IR-ready graduates or trainees immediately. Companies must work harder to digitally fit their staff. Given how quickly technology develops, corporations may wish to operate as a digital "tech school" for employees to update their abilities. 4IR's frontline business entities recognize lifelong learning is essential. Upskilling must be more rapid, more relevant, and more collaborative to be beneficial. It needs new worker relationships to share knowledge and collaborate. To establish a 4IR learning globally and intensively, companies must embrace user-friendly platforms like mobile apps, videos, and webcasts that employees currently use. Vocational graduates are most prepared for Industry 4.0 and the global job market (Peixoto Aguilar, 2020). The sector's fundamental developments require everyone to be work-ready (Yusop et al., 2024).

Chaka (2020) showed that 54 of 64 journal papers linked 4IR capabilities and competences to 21st-century soft skills as communication, innovation, creativity, problem-solving, teamwork, critical thinking, and decision-making. The 4IR transforms the economy, society, health, education, culture, employment, and skill development. The advancement of technology will enable the automation and robotization of labor-intensive job. More research institutes are concluding that technological advances may eliminate a lot of jobs.

Many industries will lose jobs and change their activity due to the Fourth Industrial Revolution. Thus, educational programs must teach pupils 21st-century workplace skills (Delipiter, 2019). Nurjanah et al. (2022) also believe that being ready to adopt digital technology, having strong communication skills, being able to work well with others, being adaptable, having strong analytical and problem-solving skills, and being an innovative, independent, creative, and curious learner are the top factors to face Industry 4.0. The majority of

systematic review papers address a firm's readiness to adopt new technologies in response to digitalization in Era 4.0. This shows that in the Industrial Revolution 4.0, vocational graduates' work preparedness depends largely on their technology skills.

4IR affects workforce patterns in several ways. As automation and digitalization spread across all industries, blue-collar and white-collar jobs are blurring (Liu & Xu, 2016; Mudzar & Chew, 2022). This change requires a workforce with sophisticated technology skills, critical thinking, problem-solving, and interpersonal communication (Mudzar & Chew, 2022; Islam, 2022). In developing countries, multi-skilled labor is crucial due to labor shortages in skilled positions and high unemployment rates in low-skilled sectors due to the shift to automated production methods (Islam 2022; Mudzar & Chew 2022).

Technology in production is also changing sectors and worker identities. Advancements in technology necessitate people who can see trends, reason through innovations, and manage digital marketing and HR (Mudzar & Chew, 2022; Islam, 2022). Technological advances are expected to boost production and provide new jobs, but they will require major role reorganization. 2023 (Felani; Sarabdeen & Alofaysan). Automation may eliminate some professions, but others will arise that demand technological expertise and creative problem-solving (Sun, 2023). This shift requires proactive skill development to prepare the workforce for rapid technological change. In conclusion, the Fourth Industrial Revolution is changing work and requiring a complete reassessment of labour market skills. As corporations and academic adapt to these changes, they must train a worker with both technical and soft skills to succeed in a digital age.

Malaysia Technical University Networking (MTUN) related studies involving toward Fourth Industrial Revolution

TVET in the Malaysian Technical University Network (MTUN) and its alignment with Industry 4.0 are examined in the studies. These findings emphasize the significance of improving TVET quality to prepare graduates for the changing job market, but a critical study shows various counterarguments that question the techniques' efficacy and sufficiency.

Self-efficacy, soft skills, and personality qualities affect graduate employability, and career adaptability mediates these factors, according to Wong (2024). However, this perspective may ignore systemic difficulties in the TVET framework that cause employability issues. The concentration on self-efficacy risks placing the role of employability completely on students, rather than addressing institutional and industrial obstacles that may limit their success. Even the most self-confident students may struggle to find work if the curriculum does not meet industry needs or if educational institutions and employers do not collaborate.

Md Hani et al. (2024) suggest a digital competency paradigm for TVET educators, emphasizing the need for digital skills. This is crucial, but the study may not address educators' professional growth barriers. The idea that teaching using digital skills will increase outcomes ignores educators' scarce resources, institutional support, and time restrictions. Due to the rapid pace of technological advancement, even well-trained educators may find their skills outdated, requiring ongoing support and training that may not be possible in current educational structures. Rosly et al. (2019) mention MTUN universities and the Department of Skills Development collaborate on TVET instructors' National Occupational Standard Skills (NOSS). Although collaboration is vital, structural hurdles and a lack of stakeholder communication may hinder these endeavors. The planned Master of Technology program may also be difficult to implement if it fails to meet the varying needs of TVET instructors across disciplines and institutions.

Industry and education must work together to close the skills gap in the fourth industrial revolution. Educational institutions have launched many collaborations to bring industry and education closer together. Omar (2024) emphasizes the importance of TVET-industry relationships for curriculum relevance and quality. However, corporate involvement raises concerns about educational goals and industry needs misaligning. Short-term skills training may be prioritized over complete education, resulting in a technically capable workforce without critical thinking and problem-solving skills. This could hurt graduates' long-term employability and adaptability in a fast-changing employment environment. Students need adequate

technological access and digital competence to use e-portfolios effectively in education. Students without these core features may not completely benefit from e-portfolios. Idrus (2024) proposes an e-portfolio to help TVET graduates develop careers, arguing that TVET must include information technology. Students' technology access and digital literacy determine e-portfolio success. E-portfolios may worsen socioeconomic disparities rather than narrow the skills gap in low-income areas.

Technology may also overshadow other talents graduates require, such as interpersonal and emotional intelligence. In the quickly changing economy 4.0, graduates must have the skills and knowledge to succeed in the industry environment, making this symbiotic interaction between education and industry important. Educational institutions have launched many collaborations to bring industry and education closer together. These include developing comprehensive curriculum based on industry needs, implementing structured and effective internship programs, fostering integrated project collaborations, introducing problem-based curricula, establishing social enterprise forms that work with industry, and setting up incubation centers across various industries that provide essential training and guidance. These initiatives were initiated by educational institutions to turn vocational education students become job creators rather than job seekers. Thus, Jam & Puteh (2022) stress the necessity of curriculum creation and educator professional development for TVET quality. However, calling for more research into these characteristics may indicate a lack of relevant findings from previous studies. Without industry-responsive curriculum development methodologies and frameworks, TVET quality improvements are unlikely. Yasin (2024) suggests that skill education can improve health outcomes in low-income communities through TVET. This connection is useful, but it may simplify the complex relationship between education, economic progress, and social difficulties. The premise that improving TVET will solve poverty and sustainability ignores the diverse character of these issues, which require comprehensive policy solutions.

Finally, Jusoh et al. (2024) examined how TVET prepares workers for Industry 4.0 and recommended an integrative approach to educational preparedness. However, literature evaluations and theoretical frameworks may not capture educational institutions' practical realities. TVET success depends on applying these theories in real life. These studies show that Malaysia's TVET sustainability needs a multifaceted approach. Focusing on graduate employability, integrating digital competences, encouraging industrial relationships, and regularly updating curriculum can help MTUN institutions prepare students for the challenges of the 4IR workforce. Table 1: Summary of MTUN Previous Studies in 4IR

TABLE I : Summary of MTUN Previous Studies in 4IR

No.	Author	Findings
1.	Wong (2024)	In this study, final-year Malaysian Technical University Networks students' self-efficacy, soft skills, and personality traits affect their perceived graduate employability. It highlights career adaptability as a mediating element for improving TVET quality to meet Industry 4.0 requirements. This study supports MTUN's goal of increasing TVET quality to better prepare students for the changing labor market by concentrating on graduate employability. Quantitative data from a structured questionnaire can inform MTUN educational improvement methods.
2.	Md Hani et al, (2024)	A Malaysian Technical University Network (MTUN) TVET instructor digital competence model is developed in this study. It examines the issues educators have in integrating digital technology into their instruction, especially in Industry 4.0. The report underlines the need for TVET educators to master digital skills to improve teaching and learning. The research uses a mixed-methods approach to identify significant elements influencing these competences and suggest a structured framework for TVET educators. MTUN aims to enhance TVET quality to meet modern industrial demands and equip educators to prepare students for the workforce.
3.	Rosly et al., (2019)	Develop the National Occupational Standard Skills (NOSS) for Malaysian TVET lecturers, which supports the Malaysian Technical University Network's goals. The study focuses MTUN universities and the Department of Skills Development (DSD) working together to

		develop TVET instructor core competencies. The research uses content analysis and focus group interviews to identify TVET instructors' minimum requirements and propose a Master of Technology program for their professional growth. MTUN's goal is to improve TVET education in Malaysia by equipping educators with the skills and standards needed to fulfill industry demands.
4.	Omar, (2024)	This study the significance of collaboration between technical and vocational education and training (TVET) and industry, which is directly relevant to MTUN's objective of enhancing the quality of TVET to meet the demands of Industry 4.0. The bibliometric review highlights how such collaborations can improve the relevance and quality of TVET programs, ensuring that students acquire the practical skills and knowledge required by employers. This aligns with MTUN's mission to modernize TVET practices and strengthen industry partnerships to better prepare graduates for the evolving job market.
5.	Idrus, (2024)	This study discusses the creation of an e-portfolio to help TVET graduates pursue careers, which is related to MTUN's goal of strengthening TVET to meet Industry 4.0 demands. The report stresses the need of incorporating IT into TVET to guarantee graduates have industry-relevant skills and are more employable and competitive. This supports MTUN's goal of upgrading TVET to better educate students for the changing workforce. E-portfolios help MTUN's objective to improve TVET quality by bridging the skills gap between education and industry.
6.	Jam & Puteh (2022)	Jam & Puteh (2022) discusses the teaching and learning indicators relevant to Education 4.0 within the context of Malaysia Technical University Network (MTUN). It emphasizes the importance of curriculum development and educator professional development as critical components for enhancing the quality of technical and vocational education and training (TVET) in alignment with Industry 4.0 demands. The study suggests that further research is necessary to explore these variables comprehensively, thereby supporting MTUN's objective of improving TVET quality to meet contemporary industrial requirements.
7.	Yasin (2024)	The quality of life of low-income Malaysians is affected by technical and vocational education and training (TVET). It shows that improving skill education knowledge and attitudes can improve health-related quality of life. The study underlines the relevance of skilled education in economic development and social challenges, supporting MTUN's goal of boosting TVET quality to satisfy Industry 4.0 demands. It also suggests that effective TVET programs can promote sustainability and poverty reduction, which are vital for Industry 4.0.
8.	Jusoh, R. et al, (2024)	In Malaysia, Technical and Vocational Education (TVET) prepares workers for the fourth industrial revolution 4.0. The study investigates how TVET develops knowledge and skills to prepare the workforce for this revolution using a literature analysis and previous studies. The researchers searched Google Scholar and online publications for relevant articles and studies. Researchers examined how workforce provision theories intersected with Educational Readiness Model for Industrial Revolution 4.0 theories and models. This integrative approach yielded insights, views, and recommendations for TVET adoption and advancement in educational institutions globally. The study found that an organization's success depends on its products, services, and workforce.

TVET toward Fourth Industrial Revolution

TVET universities make up the Malaysia Technical University Network (MTUN). According to MBOT (2018), they were created to produce highly competent technical graduates to enable the country become highly industrialized by 2020. The 11th Malaysia Plan (2016–2020) emphasizes "focusing development on people" to improve TVET. Malaysia's six strategic aims will enable it adapt to today's fast-changing global and political landscapes. The Prime Minister said the administration would keep improving students and mainstreaming TVET. MTUN, a network of four technical universities (UTeM, UniMAP, UMP, and UTHM),

has been tasked with producing a highly-skilled workforce the future captains of industry who are up-to-date on the latest technologies and have a keen business sense, making them fully functioning world citizens. Malaysia's higher education system must keep pace with 4IR technology to be globally recognized and helpful. It makes sense that the market influences job relevance of college degrees. How, where, and how people are used has changed rapidly due to employment market developments. MTUN expects mobile apps and online learning to change rapidly in the next years.

Now, MTUN institutions must develop a strategy to compete in the ever-changing global higher education landscape. In the new decade of machine growth, UTeM, one of MTUN's institutions, has created an Apps University to stay relevant worldwide (Ithnin, et al., 2017) which led to the formation of the Centre for Instructional Resources and Technology (CIRT), which will adapt to the technology boom. The University's Official Learning Management System (uLearn), which links to UTeM OERS and MOOCs, is managed and improved by CIRT. Through structured programs like CEO@faculty, which recruits CEOs from top firms, MTUN universities will expand their commercial partnerships. These CEOs advise universities as industry specialists. They enhance student learning by sharing best practices and firsthand expertise.

UTeM's Samsung IoT Centre and Malaysia Centre for e-Learning (MyCeL) help students acquire "digital thinking." Student intriguing new process management methods. While involve the global standards and Industry 4.0 requires curricular changes to satisfy high-growth, high-value (HGHV) enterprises and customer needs. Advanced manufacturing, EVs, electronics, renewable energy, and the digital economy are hot themes. Additions include Occupational/Industry Standard Practice(OISP) compliant courses using virtual reality, AI, and the Internet of Things. Malaysia intends to be a TVET center. Sending students to China for Belia Mahir training and collaborating with UK schools to raise key licensing have strengthened its worldwide ties (Rizan Hassan, 2025). Malaysia was successful in spearheading the ASEAN TVET Council's regional policy discussion on how trade skills may assist Southeast Asia flourish sustainably. In conclusion, TVET toward 4IR is complex, dynamic, and fascinating that could improve society. The workplace will focus less on tasks and more on people with 4IR and AI. Human-machine integration will make it easier to compare humanities, social sciences, and science and technology themes. More research, and unique ideas from diverse sectors are needed. MTUN universities must lead the way in developing Malaysian higher education, notably TVET. TVET institutions should strengthen industry-academia partnerships to ensure continuous curriculum updates aligned with emerging 4IR demands. Investment in digital infrastructure, faculty upskilling, and integration of AI, IoT, and robotics into learning systems is essential. Furthermore, embedding lifelong learning platforms, such as mobile-based learning and micro-credential programs, can enhance graduate adaptability and employability in the evolving 4IR workforce.

CONCLUSIONS

In summary, this investigation demonstrated that Malaysia's Technical and Vocational Education and Training (TVET) institutions, particularly those operating under the MTUN system, are significantly aligned with global industrial trends as a result of the integration of 4IR technologies. It emphasizes Malaysia's proactive approach to promoting digital literacy, innovation, and continuous learning among learners and employees. Universities and industries collaborate to guarantee that graduates possess the necessary technical and interpersonal skills for the digital economy. TVET institutions continue to encounter obstacles in thoroughly adapting curricula to the rapid tempo of 4IR technological changes, despite advancements in their development. A significant number of training programs are unable to provide the necessary digital tools, expert trainers, and advanced infrastructure to facilitate the comprehensive development of these skills. In addition, the suitability of graduates for immediate employment in high-tech sectors is restricted by the inconsistency between academic training and industry requirements. It is imperative that TVET institutions fortify their industry-academia partnerships to guarantee that their curricula are consistently updated in accordance with the forthcoming 4IR requirements. Integrating AI, IoT, and robotics into learning systems, upskilling faculty, and investing in digital infrastructure are all critical. Additionally, the inclusion of continuous learning platforms, including micro-credential programs and mobile-based learning, can improve the adaptability and employability of graduates in the changing workforce.

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