



The Challenges of Implementing Industrial Revolution 4.0 Elements in TVET

Suriani Ngatiman¹, Tajularipin Sulaiman^{2*}, Kai Yan Wong²

¹Faculty of Educational Studies,
 Universiti Putra Malaysia, Serdang, Selangor Darul Ehsan, 43000, MALAYSIA

²Faculty of Educational Studies / Sports Academy,
 Universiti Putra Malaysia, Serdang, Selangor Darul Ehsan, 43000, MALAYSIA

*Corresponding Author

DOI: <https://doi.org/10.30880/jtet.2023.15.03.015>

Received 5th August 2023; Accepted 15th September 2023; Available online 29th September 2023

Abstract: The advent of the industrial revolution 4.0 (IR4.0) impacted the national industry and the need to provide a highly skilled and competitive workforce. However, the previous study on the implementation of IR4.0 in vocational colleges in Malaysia is still unsatisfactory. Previous studies have also focused on Technical Education and Vocational Training (TVET) at the higher education. Therefore, this study conducted to explore the challenges towards the implementation of the IR4.0 element in the Vocational College (VC) curriculum. VC offers education skills certificate and diploma level to secondary school students. VC needs to be prepared to face this phenomenon in providing national human resources. The study employs qualitative design using in depth semi structured interview method guided by the interview protocol. Seven participants who met the sampling criteria were involved in this study. The Interview recording systematically managed and translated verbatim as interview transcripts. Then a thematic analysis performed using ATLAS.ti software (version 8) to construct appropriate codes, categories and themes to answer the research questions. The results of the interviews found five main challenges identified on the implementation of the IR4.0 element in the VC curriculum; curriculum review, providing teaching workforce, providing infrastructure, industry relations and engaging in education. Overall findings indicate the need for a revisit of the VC curriculum to implement the IR4.0 element and has implications to implement in providing a national workforce that meets the needs of the industrial demand. This study expected useful to *Bahagian Pendidikan dan Latihan Teknikal Vokasional (BPLTV)* in strengthening the Vocational Education Transformation agenda through the implementation of VC curriculum revisit by considering the challenges of IR4.0 implementation from various angles discussed to ensure students' knowledge and skills meet IR4.0 requirements to contribute to national development.

Keywords: Industrial Revolution 4.0, vocational college, curriculum, TVET

1. Introduction

The development of the Industrial Revolution (IR4.0) in the current 21st century has found new technologies that are more efficient and artificially intelligent than the last era. Rapid technological change affects the operation of the country's industrial sector, especially the need for a competent and competitive workforce-oriented IR4.0 (Spöttl & Windelband, 2021). Currently, the presence of IR4.0 introduces the input of technologies such as the Internet of Things (IoT), big data analytics, cloud computing, cybersecurity, additive manufacturing, augmented reality, automated robots or artificial intelligence, integrated systems, and simulations, demands that manpower resource providers provide students with the right skills. Through vocational education, students are trained with the skills to prepare for the world of work (MOE, 2019) which is generally referred to as Technical and Vocational Training Education (TVET) (UNESCO-UNEVOC,

2017). TVET introduces students to vital knowledge and skills as it motivates them to take responsibility for their learning and outcomes, and it plays a pivotal role in ensuring that modern IR4.0 technologies are introduced to skilled workers that the industry needs (Motevalli, Roslan, Sulaiman, Hamzah, Hassan & Garmjani, 2013).

TVET institutions in Malaysia are categorized as public and private education sectors, including universities, polytechnics, community colleges, industrial training institutes and schools. This diversity of these institutions provides a better opportunity for the country to overcome the challenges of IR4.0 with the technological revolution before the industrial sector suffers from a shortage of skilled workers in the future (Mohd Ishar et al., 2020). Therefore, TVET institutions should emphasize the preparation and adaptation of IR4.0 requirements in the training and education programs offered. According to Gennrich (2019), during this IR4.0 era, the TVET system must be modernised to collaborate with new technologies and industries, this is because the experience based TVET is the most consistent model in supporting and improving the ability of an efficient and effective workforce for the industry. As a result, education should change especially TVET to keep pace with technological developments and the IR4.0 industry work environment (Nor Aida et al., 2017).

Nevertheless, IR4.0 has created many new challenges and unexplored needs, especially in implementing TVET. TVET institutions are encouraged to be prepared with the latest skills standards and curriculum to ensure that the 4.0 industry revolution can be understood and learned (Regina et al., 2021). Meanwhile, Spöttl & Windelband (2021) also suggested the need to redesign the competency based TVET curriculum, offering relevant training and assessment of learning in parallel with the development of instructor and student competencies in the context of IR4.0.

Besides, another pivotal issue of IR 4.0 is the lack of readiness of Malaysian businesses to take advantage of IR 4.0, as most businesses continue to adopt the low-cost skill model to maintain minimum wages and are unwilling to upgrade their technology due to a lack of publicity on the benefits of IR 4.0. Eventually, with the rapid changes of IR 4.0, the lack of opportunity for hands-on experiences with IR 4.0 leads to a generation without practical experience with IR 4.0 technologies, leading to a gap in TVET (Amiron, Latib, & Subari, 2019). Moreover, previous studies have found various challenges in the implementation of IR4.0 elements in TVET at the tertiary level (Cheok & Ran 2022). Among them, previous studies have shown the level of knowledge and skills based on IR4.0 in lecturers is at a moderate level, insufficient finances, or funds as well as experts specializing in IR4.0 implementation (Hamzah et al., 2021; Sham et al., 2019), inadequate administrative support for providing technical support and the low level of using the latest technology in teaching and learning (Yahya, 2020). However, there is still a lack of research about studies in Vocational Colleges (VC) that offer skills training to secondary students in implementing the IR4.0 in vocational colleges curriculum. In this regard, the researchers in the current study feel a need for an exploratory study of the challenges faced in implementing elements of IR4.0 in the VC curriculum needs to be done. This study was implemented to detect these challenges and an action can be proposed to the Technical and Vocational Education Division, TVED also known as *Bahagian Pendidikan Latihan Teknikal dan Vokasional*, the Malaysia Technical and Vocational Education Division to implement the IR4.0 element in the VC curriculum which in turn improves the quality of manpower with skills in line with industry demand (Ling et al., 2020). With the foregoing, this study investigated and explored the challenges of implementing elements of IR4.0 in Vocational colleges in Malaysia.

2. Industrial Revolution 4.0

The term Industrial Revolution 4.0 also commonly known as IR4.0 emerged in the industrial and manufacturing sectors mainly in German and Europe. The beginning of the first industrial revolution with the use of water and steam energy to drive production, was followed by the emergence of the second industrial revolution when there was the use of electricity in mass production. Thereafter, the third industrial revolution came with the use of information and communication technology and electronic hardware to automate mega-production, and multimedia, finally, the emergence of the fourth industrial revolution is now an innovation from the third industrial revolution with the inclusion of digital revolution that combines physical, digital, and biological fields (Schwab, 2016; Razali, Ismail, Yazid, Ahmad, Hashim, Rohanai, & Shafieek, 2023).

Nowadays, Industrial Revolution 4.0 is also referred to as Industry 4.0 or Industrial Internet of Things (IIoT) (Batchkova et al., 2018; Adebayo, Chaubey & Numbu, 2019). In the concept of IR4.0, as mentioned by Batchkova et al. (2018); Cordes & Stacey (2017), have listed nine elements that support the growth of IR4.0. These elements focus on operations using the latest information as well as the latest information technologies such as the Internet of Things (IoT), big data analytics, cloud computing, cybersecurity, additive manufacturing, augmented reality, automated robots or artificial intelligence, integrated systems and simulations.

Furthermore, the above elements are adopted to set up the future industrial revolution, which is commonly discussed among researchers, entrepreneurs and commercial organizations (government and private sector) (Abdelmajjed, 2022). At the same time, the IR4.0 element is also known as an efficient new technology in the manufacturing industry and is capable of dominating today's economic growth. Besides, as IR4.0 is introduced, automation will be widely used with the support of digital technology and software transformation to optimize work production processes (Harties, 2019). All these elements of IR4.0 are core to the production and implementation sectors of Smart Factory (Lee et al., 2017). On the other hand, as we know, the synonymous of the production sector requires the operational labour that is generated from the vocational streams, this is because the source of manpower produced from this vocational stream is ultimately

the main contributor to the country's economic productivity in this IR4.0 era. However, to implement IR4.0 technology at the national human resource level, TVET faces challenges that need to be addressed. One of the main challenges in implementing IR4.0 is the provision of technologies such as internet access, internet infrastructure and appropriate up-to-date equipment (Oesterreich & Teuteberg, 2016; Ling, Hamid & Te Chuan, 2020). These major challenges are the high cost of funding equipment costs, teacher skills training and material resources in the education and training process (Hamzah et al., 2021). Ministries and industries should also be involved in channelling funding as an investment in the provision of relevant human resources to ensure that the goals of IR4.0 can be achieved.

2.1 Technical Education and Vocational Training (TVET)

In Malaysia, Technical Education and Vocational Training (TVET) also known as *Pendidikan dan Latihan Teknikal dan Vokasional* in the Malay language, both share the same meaning as a combination of processes of education, training and skills upgrading related to the fields of employment, production, service and life (UNESCO-UNEVOC, 2017). IR 4.0 in the Malaysian education system was introduced by the former leader of the Ministry of Higher Education (MOHE) at that time, Datuk Seri Idris Jusoh, with the theme "Higher Education 4.0: Knowledge, Industry and Humanities" in 2018. In the context of education 4.0, technological variables that are synonymous with IR 4.0 are also listed, such as digital technology, as well as information and communication technology (Büchi *et al.*, 2020; Maksimchuk and Pershina, 2017; Shahroom and Hussin, 2018). TVET can also be seen as a place to train young people to become human resources, which in turn contributes to economic growth through the emergence of employment opportunities. Through this understanding, TVET has developed into an institution that promotes lifelong learning through providing work-based learning, continuous learning and professional development (Asirvatham, 2019). Besides, the strategic plan for the Transformation of Vocational Education in Malaysia is to develop talents with skills according to current industry demands, therefore, a successful milestone in the implementation of the strategic plan was to upgrade Technical Secondary Schools to VC under the Ministry of Education Malaysia (MOE, 2011). In addition, to achieve the employment quality and standards set by the industry, the Ministry of Skills Development is responsible for developing the National Occupational Skills Standard (NOSS) as a guideline for the implementation of education and training in VC. The guarantee of success of TVET products relies on the marketability of energy resources according to industry supply needs (Okumu & Bbaale, 2019). Thus, human resources training at VC is relevant to meet the needs of the industry market for future employment.

2.2 Vocational College Curriculum

Vocational Colleges (VC) were formerly known as Technical Secondary Schools. Since the Ministry of Education Malaysia started implementing the Vocational Education Transformation agenda in 2013, a total of 84 Technical Secondary Schools have been upgraded to VCs. The target students for entering the VC are PT3 graduate secondary school students, after admission, the selected PT3 graduate secondary school students would receive education and training at the certificate and diploma level recognized by professional bodies provided by the VCs. Moreover, VCs provide formal experience and education by introducing a real workplace environment (Azmanirah et al., 2014, Roos, Trasberg, Kõiv & Säre, 2021). Therefore, to match the actual work environment, the curriculum of the Vocational Stream Subject learning syllabus has been changed to use the Vocational College Standard Curriculum. This standard curriculum addresses the key elements that students need to understand, implement, and realise vocational knowledge, skills and values throughout their study at the college (MOE, 2011). The curriculum documents are used by VC's faculty as a guide to the content and teaching methods that will be used either theoretically or practically.

However, Malaysia expects the number of TVET graduates to increase to 7.98 million by 2030. In contrast, based on the current statistics, there is still a shortfall of nearly 8 million graduates by the deadline. This shows the imbalance between supply and demand in Malaysia, resulting in not enough TVET graduates in Malaysia (Dzeto, 2014; Abdullah, Salleh, Sulaiman & Kamarrudin, 2022). Nonetheless, Ismail, Chik, and Hemdi (2021) suggested that strengthening the TVET curriculum in Malaysia is one of the solutions to address the TVET labour supply-demand imbalance, and the researchers also suggested that TVET courses could focus on 70% of practice training and 30% to ensure that the TVET program produces a skilled, capable and competitive workforce in the labour market whose employable skills play a relevant role in job readiness and career development.

Furthermore, the curriculum is a crucial component in education and is designed to prepare students physically, emotionally, spiritually, and intellectually, as stated in the National Philosophy of Education. In the context of a TVET, curriculum plays a vital role in preparing students for the employment opportunities and challenges they face in the future. At the same time, the development of IR4.0 has had a significant impact on educational reform. According to Samad et al. (2017) as well as Roos et al. (2021), they recognize the importance of new curriculum content for TVET to prepare the workforce of VC graduates by incorporating content that addresses relevant technical and vocational competencies based on the latest developments. As added by Mardziah et al. (2019), successful implementation of TVET is needed to consider the changing needs of teachers, students, education, and industry to balance the implementation of complex IR4.0 elements. However, these needs are not easily achieved as numerous challenges require to be addressed, as pointed out by Hamzah et al., 2021, these challenges include the knowledge and skill levels of lecturers in teaching and learning using IR4.0 curriculum, as well as the provision of infrastructure appropriate to the curriculum at the polytechnic is at a

moderate level. The desire to improve the TVET curriculum and enhance the development of IR4.0 reflects the sensitivity of education in meeting the demands of the industry to move into developed countries.

3. Research Methodology

The current study uses a qualitative method of semi-structured in-depth interviews to obtain information on the challenges faced in implementing elements of IR4.0 in the TVET curriculum. As mentioned by Creswell and Poth (2018); Merriam and Tisdell (2015); and Othman (2009), qualitative research is an opportunity for researchers to construct a holistic, as well as dynamic picture based on the experiences of the study participants by performing analysis and understanding verbatim reports in detail.

3.1 Sampling Method

The sampling techniques were intended to select participants based on characteristics such as educational qualification background, job position, and experience in the TVET curriculum. Firstly, all participants must obtain at least a bachelor’s degree in TVET. Second, in terms of job positions, participants with more than 5 years of teaching or work experience in the TVET field must have at least a Vocational Teacher Certificate (VTO). Finally, participants must be experienced and involved as a panel of TVET curriculum drafters. According to Tuckett (2004), there is no measure in determining the sample size of a qualitative study, but more emphasis is placed on the richness and essence of the information collected rather than the number of study participants. Therefore, a total of seven (7) participants who met the sampling criteria participated in this study, as shown in Table 1. Their participation also considers their ability and willingness to provide the required information.

Table 1 - Participants background information

Code	Institution	Experience	Education Background	Position /Expertise
P01	Technical and Vocational Training Education Division, Ministry of Education Malaysia	25 years	Bachelor Degree in Vocational Training Manager (VTM)	Chief Assistant Director, Vocational Curriculum Development Cluster
P02	Technical and Vocational Training Education Division, Ministry of Education Malaysia	21 years	Master of Education; Technologist (Ts); Vocational Training Executive (VTE)	Chief Assistant Director Vocational Curriculum Assessment Cluster
P03	Mara Higher Vocational Colleges	17 years	Bachelor's Degree in (Ts); Vocational Training Officer (VTO)	Lecturer; NOSS drafting panel
P04	Technical Education Campus Teacher Education Institute	27 years	Doctor of Philosophy (PhD); Technologist (Ts); Vocational Training Executive (VTE)	Senior Lecturer; Curriculum Developer TVET Institute of Teacher Education
P05	Ministry of Skills Development Department, Putrajaya	20 years	Bachelor Degree; Technologist (Ts); Vocational Training Executive (VTE)	National Industry Expert
P06	Vocational College	26 years	Doctor of Philosophy (PhD); Vocational Training Manager (VTM)	Vocational College Director
P07	Vocational College	15 years	Master of Education; Vocational Training Officer (VTO)	Vocational College Lecturer; Vocational College Curriculum Drafting Panel

3.2 Research Instrument

The interview protocol was used as an instrument in the current research. The interview protocol was developed through the reading and analysis of literature studies in the implementation of IR4.0 elements in TVET. The process of validation of the interview protocol was done by obtaining confirmation from four experts in the field related to the research topic.

According to Fraenkel et al. (2012), instrument validity aims to ensure that the indicators used contain characteristics that can be measured and are relevant to the purpose of the study.

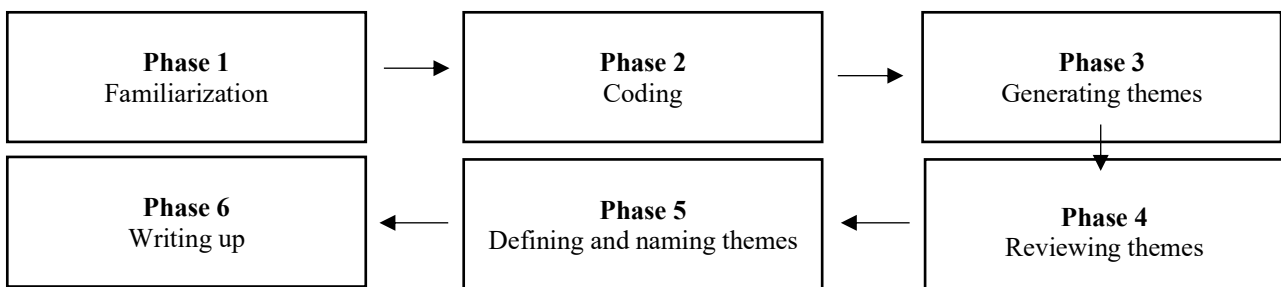
3.3 Data Collection

In-depth semi-structured interview sessions were conducted to explore unknown information to answer the research questions. The data collection process begins by building an initial relationship by making an appointment through a phone call. After the participants agreed to be part of the study, the interview session was conducted face-to-face. Interviews were recorded using a voice recorder for data management of the study.

3.4 Data Analysis

The process of data analysis begins by converting audio voice recordings to verbatim interview transcripts to ensure that there is no information and data are lost during the data analysis period, this is important to ensure that no information is lost because the production of interview transcripts is the main database in qualitative research (Merriam & Tisdell, 2015; Othman, 2018). In addition, the interview data is managed systematically to maintain the confidentiality of the participants and comply with the ethics of conducting the study. Next, the data was analysed using thematic analysis to find out the challenges of implementing IR4.0 elements in the TVET curriculum. The analysis began by listening to the audio recordings and reading the interview transcripts repeatedly to obtain a coding pattern until the researcher mastered all the information based on the six phases of thematic analysis organized by Braun & Clarke (2006) as shown in Table 1. The interview transcripts were then analysed using Computer Aided Qualitative Data Analysis (CAQDAS) software namely ATLAS.ti (version 8) to help researchers construct codes, categories and themes as well as construct appropriate concept maps that are suitable to answer research questions (Creswell, 2013).

Table 2 - Phases of thematic analysis (adaptation of Braun & Clarke, 2006)



Phase 1: Researchers familiarize themselves with the data. The researchers became familiar themselves with the depth and breadth of the content of interview transcripts containing raw data through repeated readings. Researchers have initiated active steps to understand and deepen the meaning and pattern of data related to the IR4.0 elements in VC.

Phase 2: Establish codes and categories. During this phase, the researcher has begun to give meaning and identify patterns to the data by focusing on the special features of the data. Meaningful and important interview text excerpts related to the study were first identified and given attention. The initial coding phase identified citations using ATLAS.ti. An initial code outline of the findings was created to display an initial overview of data patterns and their relationships to each other.

Phase 3: Generate a theme. The researcher evaluates and organizes data related to special features to form several codes that are set based on quotes that carry the same meaning or can stand alone to form an appropriate theme. However, data that does not give any meaning is left alone for this study.

Phase 4: Reviewing theme formation. In the fourth phase, the researcher reviews the themes formed by looking at the theme framework developed from the data that can function according to the needs of the study. At this time a review is also made to see if there is a need to convert or encode any additional data that was dropped during the previous encoding process. After several revisions of the theme development framework, the researchers have identified five potential themes for this study.

Phase 5: Defining and naming the theme. At this point, the researcher has determined the aspects needed to name the theme by performing a detailed analysis. The theme was chosen to illustrate the overall continuity of the theme to answer the objective of the study, the challenges of implementing IR4.0 elements in the VC curriculum. Naming the themes will use simple, precise phrases and give the reader an immediate understanding of the theme.

Phase 6: Writing up. After analysis and determination of themes from the raw data and cross-checking are done and agreement is reached, writing is carried out in this phase. The report is written to dissect the data in a narrative form along with arguments and interview excerpts that answer the research questions.

A summary of the thematic analysis phases adapted from Braun & Clarke (2006) is to show the analysis process carried out during coding, theme formation and report writing as well as establishing reliance in each phase used while carrying out this study.

4. Finding and Discussion

Based on the analysis of the interview transcripts, the codes were constructed and grouped according to appropriate categories until they were coded with appropriate themes. In the end, the number of codes has been reduced from the initial level. This study has found five main themes relevant to the challenges of implementing the IR4.0 element in the VC curriculum to be discussed. The findings of this study are to answer the research questions relevant to this study based on the thematic analysis process suggested by Braun and Clarke (2006).

Research Question: What do you think about the challenges of implementing the IR4.0 elements in the Vocational College curriculum?

The following Table 3 summaries the findings from the interview based on the research question above for this current study:

Table 3 - Summary of the findings from the interview based on the research question

CODES	Respond to the interview
Curriculum Review	[... curriculum developers need to be sensitive to the latest industry changes... curriculum cycle becomes a platform to implement curriculum improvements that contain IR4.0 technology elements...] P02 [... other training providers have started to change... until when VCs want to be in the old notch and use the old syllabus... need to keep up with the latest industry developments and needs...] P05 [... program content that does not correspond to job opportunities should (need) to be reviewed and improved...] P07
Prepare TVET teaching workforce	[...teaching workforce among our lecturers from the point of view of the extent to which they have (possess) knowledge and skills (about elements) of IR4.0... such as the use of 3D printers, the use of CNC... not all lecturers can handle...] P06 [...curriculum changes, the teacher's competence also has to (also needs to) change according to the change in the curriculum...] P04 [...VC instructor must have an educational background equal to or more than the level to be taught to the student (VC student) ...] P01
Provide Infrastructure	[...VC curriculum was developed to meet industry standards, but the existing infrastructure and workshop conditions are still old and not as used in industry...] P01 [...facilities available at VC do not support IR4.0 practice speed... limited internet access, devices and software that cannot accommodate the use of college residents...] P07 [...as a curriculum drafter... preparation of strategic plan planning to review the need for curriculum implementation with industry standards in terms of equipment, workshop facilities and learning needs to be given more careful attention...] P03 [...facilities and non-specific facilities that do not have specifications can affect the recognition of the program by JPK and MQA which can affect the reputation and quality of VC...] P05
Industry Collaboration	[...we need industry collaboration through sharing expertise and technology to develop programs such as virtual, simulations for use by instructors and students during practical training...] P03 [...collaboration and connection with industry, such as bringing technology into the college, taking students on industrial internships and study tours can overcome the challenges of college faced with IR4.0...] P04 [...air conditioning and refrigeration program at VC... proactively collaborates with industry to provide training to students through collaboration with ACSON has brought in (to VC) the latest and high-tech air units in the current market to train students and do practice...] P06
Involvement in Education	[...BPLTV has started mentioning the need for IR4.0 element to be implemented in VC... a series of meetings and discussions has been done ... including planning and

proposal to review VC with more relevant content and meet the requirements of IR4.0 with stakeholders...] P02

[...any changes are directive... not changed arbitrarily... from BPLTV management to college, the determination of the implementation of TVET requires a policy as the source of implementation authority ...] P06

[...BPLTV needs to look at what the IR4.0 requirements are in Vocational Colleges nationwide, then financially plan... -examine the needs of each VC ... This financial allocation application must be applied up to the stage of obtaining a special allocation ... planning the next Twelfth Malaysia Plan (RMK-12) financial strategic plan ...] P07

4.1 Curriculum Review

Providing a curriculum that implements IR4.0 elements needs to be developed by the Technical and Vocational Education Division as the party responsible for formulating the content of the VC curriculum. The results of the analysis found that all study participants agreed that the main challenge that needs to be faced is to implement the revision of the VC curriculum accordingly. Some of the things that are a priority to see are the integration of IR4.0 technology in the curriculum through the programs offered. McKinsey Global Institute (2017) has suggested that the development of technology brought together by IR4.0 becomes the main long-term strategy in the formation of knowledge and skills disciplines in the formation of a skilled workforce that is trained in TVET training institutions. So far, the Vocational College Standard Curriculum (VCSC) developed at VC still refers to NOSS as an industry standard guide. As stated by Ishak & Sukardi (2020) the existing TVET curriculum is still too general thus causing problems during its implementation. The phenomenon of digital literacy is very helpful in improving the quality of the curriculum through learning innovation (Krishan et al., 2020). Preparedness for digitization and the advancement of Information and Communications Technology (ICT) and Information Technology (IT) in the TVET curriculum is to provide a professional and competent workforce supported by the skills to operate advanced digital technology and equipment such as multimedia (Gentili, 2017; Razali, et al., 2023). Thus, the challenge of revising the VC curriculum needs to consider the need to implement IR4.0 elements, especially new technologies, digital literacy elements and competencies to improve the quality of the curriculum and the professionalism of VC graduates in the future.

[... curriculum developers need to be sensitive to the latest industry changes... curriculum cycle becomes a platform to implement curriculum improvements that contain IR4.0 technology elements...] P02

[... other training providers have started to change... until when VCs want to be in the old notch and use the old syllabus... need to keep up with the latest industry developments and needs...] P05

[... program content that does not correspond to job opportunities should (need) to be reviewed and improved...] P07

4.2 Prepare TVET Teaching Workforce

In facing the challenges of TVET in the era of IR4.0, the competence of the teaching workforce also appears to be discussed. The findings of this study show that many VC teaching workforce are from Generation X who have high skills in the field, but it is difficult to accept the change of the existing education system to the VC education system, especially in the implementation of the curriculum. However, the teaching workforce from the youth group who are new in the service line in teaching, have exposure to technology but lack expertise in the field they are engaged in. Competent instructors are individuals who master the skills and knowledge in the field and have an efficient, trained and competent manner. According to Mohd Jalil et al. (2015), instructors need to be responsive to any changes that occur in the industry and the curriculum to train a skilled workforce in line with the needs of the national industry, because it will lead to problems toward VC in employing instructors who do not have sufficient qualifications to teach a program (Jamaludin, 2014). Moreover, as stated by Spöttl & Windelband (2021), the qualifications of TVET instructors in the IR4.0 era changed between two situations, the first being the change of new competence enhancement driven through the readjustment of qualifications or the second the emergence or loss of qualifications. Nevertheless, there are still VC teaching workforce who choose conventional methods instead of changing with time and technology as a curriculum delivery approach regardless of new competencies (Thangaiah et al., 2020). These changes in qualifications and the appearance of these competencies are the result of structures and job processes that appear or disappear because of the presence of IR4.0 which has changed TVET as a whole. The quality of VC educators needs to continue to be strengthened so that the National Transformation 2050 (TN50) agenda meets the trend of the technological revolution to enhance knowledge, skills and the value of education can be achieved (Omar et al., 2020). Providing training and retraining VC teaching workforces to meet the new competencies is a challenge that needs to be considered when developing a curriculum on the implementation of IR4.0 in VC.

[...teaching workforce among our lecturers from the point of view of the extent to which they have (possess) knowledge and skills (about elements) of IR4.0... such as the use of 3D printers, the use of CNC... not all lecturers can handle...]
P06

[...curriculum changes, the teacher's competence also has to (also needs to) change according to the change in the curriculum...]
P04

[...VC instructor must have an educational background equal to or more than the level to be taught to the student (VC student) ...]
P01

4.3 Provide Infrastructure

The next challenge that needs to be addressed is in providing infrastructure due to the lack of relevant technology in current learning. Kamarulzaman (2014) also agreed that TVET requires the provision of complete infrastructure and the latest technology to meet the challenges of the real world of work. The findings of the current study show that the preparation of equipment and workshops for learning purposes in VC is still incomplete and not the latest technology. The findings of the current study are supported by Oviawe (2018) who also found that the infrastructure in TVET institutions is backward and insufficient, ultimately disrupting learning. Meanwhile Hamzah et al. (2021) stated that the availability of infrastructure in TVET institutions such as internet access, ICT facilities, equipment, software and simulation is at a moderate level, and it enables the application of limited IR4.0 elements. As a result of the lack of complete infrastructure facilities according to industry requirements, the production of the workforce from TVET still does not reach the optimum level because their competency level does not reach industry requirements to work in the era IR4.0 (Wolf et al., 2018). The provision of relevant infrastructure is to improve the quality of the VC curriculum and stand with other TVET institutions in providing manpower according to the IR4.0 job market which is a challenge that needs to be addressed.

[...VC curriculum was developed to meet industry standards, but the existing infrastructure and workshop conditions are still old and not as used in industry...]
P01

[...facilities available at VC do not support IR4.0 practice speed... limited internet access, devices and software that cannot accommodate the use of college residents...]
P07

[...as a curriculum drafter... preparation of strategic plan planning to review the need for curriculum implementation with industry standards in terms of equipment, workshop facilities and learning needs to be given more careful attention...]
P03

[...facilities and non-specific facilities that do not have specifications can affect the recognition of the program by JPK and MQA which can affect the reputation and quality of VC...]
P05.

4.4 Industry Collaboration

The findings of the study found that industry relations are very much needed for VC to ensure that the implementation of the VC curriculum can be implemented conceptually based on the needs of the industry. The concept of TVET is to provide experience and formal education by bringing the work environment in the industry and providing students the opportunity to expose their skills to the real work environment (Azmanirah et al., 2014). Having these skills can provide opportunities for a wider range of work. However, any connections and requirements according to industry requirements will affect the marketability of graduates of TVET institutions (Rus et al., 2015). As we all know, the practical workspace at VC is the place to perform training, but the lack of expertise in operating the equipment and the incomplete training space can affect the IR4.0 era TVET training as well as the lack of industry expertise among the teaching workforce to implement the elements of IR4.0, it becomes a challenge for TVET to provide manpower according to the needs of the IR4.0 job market (Okumu & Bbaale, 2019). Supported by Sham et al. (2019) found that the level of expertise possessed by local technical university lecturers toward the IR4.0 element is very low, for instance, based on the findings, all study participants agreed that industry collaborations can help VC improve the quality of training and solve the challenges of IR4.0 implementation. Based on an interview shared by the IR4.0 expert, the issues of the IR4.0 element can be resolved if the relationship and collaboration between industry 4.0 participants and the Vocational Colleges are sealed for a purpose that is meaningful to educators and students. This study found that through the sharing of expertise, equipment and training in the industry it is hoped to solve the challenges of implementing IR4.0 element in Vocational Colleges.

[... the appointment of curriculum drafting advisors among industry collaborations participants exposed to IR4.0 can provide input on the needs and implementation of colleges to prepare the job market according to industry needs... can even provide input to develop curriculum... including providing training to instructors and students related to technology skills new in IR4.0...]
P02

[...we need industry collaboration through sharing expertise and technology to develop programs such as virtual, simulations for use by instructors and students during practical training...]
P03

[...collaboration and connection with industry, such as bringing technology into the college, taking students on industrial internships and study tours can overcome the challenges of college faced with IR4.0...]
P04

[...air conditioning and refrigeration program at VC... proactively collaborates with industry to provide training to students through collaboration with ACSON has brought in (to VC) the latest and high-tech aircond units in the current market to train students and do practice...] P06

4.5 Involvement in Education

TVET emphasizes engagement with a systematic administrative approach. In particular, the current education scenario is the post-Movement Control Order (MCO) era due to COVID-19, therefore, there is a new norm change in teaching and learning, thus, a lot of wisdom, approaches, policies, support and participation in stakeholders in the TVET system are needed (Sulaiman, Ibrahim, Motevalli, Wong, & Hakim, 2021). Ishak & Sukardi, (2020), stated that the administration, education experts, curriculum experts, educators, parents, community and industry leaders as stakeholders who need to be involved in the administrative organization of TVET institutions. This indicates the existence of a close relationship between social relations in education administration to obtain various inputs to develop the quality of TVET. While according to Sham et al., (2019), the failure of the administration's top management to manage finances for hardware and software requirements based on the specifications and requirements of the TVET program is an obstacle to the implementation of the IR4.0 element in local higher learning institutions, such as VC. This is because the provision of equipment relevant to training and industry needs involves high financial implications and requires efficient and systematic management involvement. The findings of the study show that the study participants agree that the parent administration authority of VC, namely *Bahagian Pendidikan dan Latihan Teknikal Vokasional* (BPLTV) also known as the Technical and Vocational Education Division, should involve stakeholders in obtaining views and input related to the implementation of VC in the IR4.0 era. The advantages of the administrative lineup until the implementation of the VC curriculum implementer. Mardziah et al. (2019) also suggested that the involvement of education experts and industry collaboration must be increased in curriculum development and evaluation. Involved in the implementation of VC, the importance of mainstreaming VC in providing quality, dynamic and relevant training areas to enable the various economic needs of the country is also a challenge. Obtaining an agreement on governance in translating the emergence of VC graduates to increased labour productivity and quality of life in the community, presents a challenge to the implementation of the IR4.0 element to be implemented.

[...BPLTV has started mentioning the need for IR4.0 element to be implemented in VC... a series of meetings and discussions has been done ... including planning and proposal to review VC with more relevant content and meet the requirements of IR4.0 with stakeholders...] P02

[...any changes are directive... not changed arbitrarily... from BPLTV management to college, the determination of the implementation of TVET requires a policy as the source of implementation authority ...] P06

[...BPLTV needs to look at what the IR4.0 requirements are in Vocational Colleges nationwide, then financially plan... re-examine to the needs of each VC ... This financial allocation application must be applied up to the stage of obtaining a special allocation ... planning the next Twelfth Malaysia Plan (RMK-12) financial strategic plan ...] P07

5. Conclusion and Implication

The researcher has analysed all the data obtained from the study participants. The interview data was translated into verbatim and then the researcher performed a thematic analysis to obtain detailed information from the study participants related to IR4.0. The researcher finally found five main themes, curriculum review, providing a teaching workforce, providing infrastructure, industry collaborations and involvement in education are challenges in the implementation of IR4.0 elements in the TVET curriculum, especially in VC. The first challenge is that the revision of the VC curriculum is highly demanded to be dynamic in nature with the changes and needs of the work environment affected by the presence of IR4.0. In this study, the development of the VC curriculum is focused on the implementation of IR4.0 elements as new competencies and literacy relevant to the work world in the IR4.0 era. The elements discussed focus on new IR4.0 technologies related to TVET needs. The second challenge is to prepare the VC teaching workforce to be highly skilled and have extensive experience in the field in accordance with the requirements of IR4.0 as well as have a higher level of teaching qualifications level than the student training programs through the VC workforce training and retraining program. Similarly, the third challenge found in this study is the provision of infrastructure which finds the need to provide infrastructure equipment for theoretical and practical learning related to IR4.0 elements, especially new technologies that involve very large financial implications. The next challenge is in terms of the industry collaborations with VCs towards the use of expertise, technology and training implementation models in the industry that can lead to a win-win situation between the two parties. The final challenge is the involvement of education management in the implementation of the IR4.0 element in VC. A systematic engagement agreement among stakeholders to ensure the implementation of education in VC towards IR4.0 can be realized to achieve the goal of VC implementation in increasing the productivity of the national workforce from planning to curriculum implementation. Next to be able to meet the recognition and put VC on par with other local TVET training institutions.

The findings of the study and a cross-review of the literature highlight various occupations in the manufacturing and services industry sectors have now begun to adapt and implement the IR4.0 orientation (Harties, 2019; Lee et al., 2017;

Spöttl & Windelband, 2021). This proves the adaptation to the implementation of IR4.0 elements as a component that needs to be implemented in the VC curriculum to provide manpower resources that are in line with the job needs in the industry (Asnawi & Djatmiko, 2015). According to Hang et al. (2018), the VC curriculum should be equipped with learning and training related to theory, competencies, syllabus, learning modules, worksheets, assessment and certification with the latest developments of IR4.0.

In conclusion, the implementation of IR4.0 elements in TVET, especially in VC, is to ensure the parallel production of national manpower resources and meet the needs of the industry. In addition, a workforce that does not match the needs of the industry can be addressed. In the present 21st century, this rapidly developing economy and technology are influencing the way people work and live. Therefore, through the perspective of experts involved in this study, it is suggested that BPLTV to review the training curriculum in VC by considering the challenges of the implementation of IR4.0 from various angles that have been discussed.

Acknowledgement

We would like to express our sincere gratitude to all the individuals and organizations who have contributed to the publication of this research paper.

References

- Abdelmajied, F. Y. (2022). Industry 4.0 and its implications: Concept, opportunities, and future directions. In *Supply Chain-Recent Advances and New Perspectives in the Industry 4.0 Era*. IntechOpen.
- Abdullah, W. F. W., Salleh, K. M., Sulaiman, N. L., & Kamarrudin, M. (2022). Employability Skills in the TVET Trainer Training Program: The Perception Between Experienced Trainers and Novices Trainers. *Journal of Technical Education and Training*, 14(1), 150-157. <https://doi.org/10.30880/jtet.2022.14.01.013>
- Adebayo, A. O., Chaubey, M. S., & Numbu, L. P. (2019). Industry 4.0: The fourth industrial revolution and how it relates to the application of the Internet of Things (IoT). *Journal of Multidisciplinary Engineering Science Studies (JMESS)*, 5(2), 2477-2482.
- Amiron, E., Latib, A. A., & Subari, K. (2019). Industry revolution 4.0 skills and enablers in technical and vocational education and training curriculum. *International Journal of Recent Technology and Engineering (IJRTE)*, 8(1), 485-492.
- Asirvatham, D. (2019). "Unlocking the economy through technical and vocational education & training." *The Malaysian TVET Forum 2019*, 1-19.
- Asnawi, R., & Djatmiko, I. W. (2015, February). A challenge of vocational education for preparing green employment. In *3rd UPI International Conference on Technical and Vocational Education and Training* (pp. 175-178). Atlantis Press.
- Azmanirah, A. R., Jamil, A., & Ruhizan, M. Y. (2014). Rubric in vocational education. *International Journal of Social, Management, Economics and Business Engineering*, 8(1), 121-125.
- Batchkova, I. ., Popov, G. ., Ivanova Ts, A., & Belev, Y. . (2018). Assessment of readiness for "Industry 4 . 0." *International Scientific Journal "Industry 4.0,"* 291(6), 288-291.
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101. <https://doi.org/10.1191/1478088706qp063oa>
- Büchi, G., Cugno, M., & Castagnoli, R. (2020). Smart factory performance and Industry 4.0. *Technological Forecasting and Social Change*, 150, 1-10. <https://doi.org/10.1016/j.techfore.2019.119790>
- Cheok, C. K., & Ran, L. (2022). The Role of Malaysian Higher Education in IR 4.0. *Journal of International and Comparative Education (JICE)*, 107-117.
- Cordes, F., & Stacey, N. (2017). Is the UK industry ready for the fourth industrial revolution? *BCG: The Boston Consulting Group: Boston, MA, USA*. <https://doi.org/10.1209/0295-5075/3/1/012>
- Creswell, J. W. (2013). *Qualitative inquiry and research Design: Choosing among five approaches* (Third). SAGE Publications Inc.
- Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five approaches* (Fourth). SAGE Publications Inc.
- Dzeto, G. K. (2014). Projecting Ghana into the real middle-income economy: The role of technical, vocational education training. *Parliamentary Briefing Paper, Friedrich Ebert Stiftung, Ghana*.
- Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). *How to design and evaluate education research* (8th ed.). New York McGraw Hill.

- Gennrich, R. (2019). TVET towards industrial revolution 4.0. *Proceedings of the Technical and Vocational Education And Training International Conference (TVETIC)*, 1–7. <https://doi.org/10.1201/9780429281501>
- Gentili, C. (2017). “Time out” for classical studies? The future of Italian Liceo Classico in the 4.0 world. *Estudios Sobre Educacion*, 33, 127–143. <https://doi.org/10.15581/004.33.127-143>
- Hamzah, R. A., Kamarul, M., & Faizul, M. (2021). Kajian terhadap cabaran implementasi elemen IR4.0 dalam proses pengajaran dan pembelajaran pensyarah Kejuruteraan Elektrik politeknik Malaysia. [*A study on the challenges of implementing IR4.0 elements in the teaching and learning process of Malaysian polytechnic Electrical Engineering lecturers*]. *Journal of Social Science and Humanities*, 2(2020), 17–25.
- Hang, N. P. T., Thuy, L. T., & Tam, P. T. (2018). Impacting the industry 4 . 0 on the training quality and student satisfaction at Lac Hong University. *Management Information and Decision Sciences*, 21(1), 1–18.
- Harties, C. (2019). Supporting learning at work in an era of digitalisation of work. In A. Bahl & A. Dietzen (Eds.), *Work-based Learning as a Pathway to Competence-based Education. A UNEVOC Network Contribution* (1st ed., Vol. 8, Issue April, pp. 85–97). Federal Institute for Vocational Education and Training.
- Ishak, S. A., & Sukardi, S. (2020). Curriculum development of vocational electrical engineering to accommodate industry revolution 4.0. *IOP Conference Series: Materials Science and Engineering*, 830(4), 0–5. <https://doi.org/10.1088/1757-899X/830/4/042073>
- Ismail, J., Chik, C. T., & Hemdi, M. A. (2021). TVET graduate employability: Mismatching traits between supply and demand. *International Journal of Academic Research in Business and Social Sciences*, 11(13), 223-243. <https://doi.org/10.6007/IJARBS/v11-i13/8522>
- Jamaludin, J. (2014). *Kesediaan Guru Kolej Vokasional Dalam Pengajaran Amali Teknologi Elektronik Di Negeri Pahang*. [Vocational College Teachers' Readiness In Teaching Practical Electronics Technology In The State Of Pahang]. (Doctoral dissertation, Universiti Tun Hussein Onn Malaysia).
- Kamarulzaman, N. F. (2014). *Kekangan-Kekangan Pusat Latihan Kemahiran Dalam Pengendalian Program Kemahiran*. [Constraints of Skills Training Centers in the Management of Skills Programs]. (Doctoral dissertation, Universiti Tun Hussein Onn Malaysia).
- Kementerian Pelajaran Malaysia. (2011). *Pelan strategik: Transformasi pendidikan vokasional*. Bahagian Pendidikan Teknik dan Vokasional, Kementerian Pelajaran Malaysia. [Strategic Plan: Transformation of vocational education. Technical and Vocational Education Division, Ministry of Education Malaysia.
- Kementerian Pendidikan Malaysia. (2019). *KPM - Maklumat Umum TVET*. Bahagian Pendidikan Latihan Teknikal Dan Vokasional. [MoE - TVET General Information. Technical and Vocational Training Education Division] <https://www.moe.gov.my/pendidikan/tvet/maklumat-umum-tvet/maklumat-umum-tvet>
- Krishan, I. A., Ching, H. S., Ramalingam, S., Maruthai, E., Kandasamy, P., Mello, G. De, Munian, S., & Ling, W. W. (2020). Challenges of learning English in the 21st century: Online vs. traditional during Covid-19. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, 5(9), 1–15. <https://doi.org/10.47405/mjssh.v5i9.494>
- Lee, C. K. M., Zhang, S. Z., & Ng, K. K. H. (2017). Development of an industrial Internet of Things suite for smart factories towards re-industrialization. *Advances in Manufacturing*, 5(4), 335–343. <https://doi.org/10.1007/s40436-017-0197-2>
- Ling, Y. M., Abdul Hamid, N. A., & Chuan, L. Te. (2020). Is Malaysia ready for Industry 4.0? Issues and Challenges in Manufacturing Industry. *International Journal of Integrated Engineering*, 12(7), 134–150. <https://doi.org/10.30880/ijie.2020.12.07.016>
- Maksimchuk, O., & Pershina, T. (2017). A new paradigm of industrial system optimization based on the conception of “industry 4.0.” *MATEC Web of Conferences*, 129. <https://doi.org/10.1051/mateconf/201712904006>
- Mardziah, A., Hawa, S., & Safura, R. S. (2019). The impact of curriculum changes towards 4.0 revolution. *Proceedings: International Invention, Innovative & Creative (InIIC) Conference, 2003*, 162–166.
- McKinsey Global Institute. (2017). A future that works: Automation, employment, and productivity. In *McKinsey Global Institute* (Issue January).
- Merriam, S. & Tisdell, E. (2015). *Qualitative research: a guide to design and implementation*. New Jersey, USA: Jossey-Bass.
- Mohd Ishar, M. I., Wan Derahman, W. M. F., & Kamin, Y. (2020). Practices and planning of ministries and institutions of technical and vocational educational training (TVET) in facing the industrial revolution 4.0 (IR4.0). *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, 5(3), 47–50. <https://doi.org/10.47405/mjssh.v5i3.374>

- Mohd Jalil, A., Noor Hisham, J., & Annas Akhmal, H. (2015). TEVT di Malaysia : Cabaran dan harapan. *Seminar Kebangsaan Majlis Dekan-Dekan Pendidikan Awam*, [TEVT in Malaysia: Challenges and hopes. National Seminar of the Council of Deans of Public Education], *September*, 340–346.
- Motevalli, S., Roslan, S. B., Sulaiman, T., Hamzah, S. G., Hassan, N. C., & Garmjani, M. G. (2013). New study skills training intervention for students who suffer from test anxiety. *Asian Social Science*, *9*(7), 85.
- Nor Aida, A. R., Suhaila, A. K., Mohammad Fakhruizam, M., & Mohamed Idrus, A. M. (2017). Higher TVET education in aviation : Teaching quality and a master key to industry 4. 0. *International Journal of Education, Psychology and Counseling*, *2*(5), 44–53.
- Oesterreich, T. D., & Teuteberg, F. (2016). Understanding the implications of digitisation and automation in the context of Industry 4.0: A triangulation approach and elements of a research agenda for the construction industry. *Computers in Industry*, *83*(December), 121–139. <https://doi.org/10.1016/j.compind.2016.09.006>
- Okumu, I. M., & Bbaale, E. (2019). Technical and vocational education and training in Uganda: A critical analysis. *Development Policy Review*, *37*(6), 735–749. <https://doi.org/10.1111/dpr.12407>
- Omar, M. K., Zahar, F. N., & Rashid, A. M. (2020). Knowledge, skills, and attitudes as predictors in determining teachers' competency in malaysian TVET institutions. *Universal Journal of Educational Research*, *8*(33C), 95-104. doi:10.13189/ujer.2020.081612
- Othman, L. (2009). *Penyelidikan kualitatif: Pengenalan kepada teori dan metod*. [Qualitative research: An introduction to theory and methods]. Penerbit Universiti Pendidikan Sultan Idris.
- Othman, L. (2018). *Penyelidikan kualitatif: Pengenalan kepada teori dan metode*. Edisi Kedua. [Qualitative research: An introduction to theory and methods. Second Edition. Penerbit Univesiti Pendidikan sultan Idris.
- Oviawe, J. I. (2018). Enhancing the quality and relevance of teaching and learning through university community partnerships: The case of art at Makerere University. *Makerere Journal of Higher Education*, *10*(1), 3–21. <https://doi.org/10.4314/majohe.v10i1>
- Razali, S. S., Ismail, A., Yazid, F. M., Ahmad, M. F., Hashim, S., Rohanai, R., & Shafieek, M. S. M. (2023). TVET in The 21st Century: Exploring Multimedia Elements in Digital Teaching and Learning Based On Art Content. *Journal of Technical Education and Training*, *15*(1), 9-19.
- Regina, L., Ramlee, M., & Roslin, M. S. M. (2021). Identification of vocational well-being taxonomy for TVET sustainable growth: An initial review. *Journal of Contemporary Issues in Business and Government*, *27*(02). <https://doi.org/10.47750/cibg.2021.27.02.155>.
- Roos, L., Trasberg, K., Köiv, K., & Säre, E. (2021). Characteristics of powerful learning environments in VET transition program for at-risk students: qualitative insights from teachers and support specialists implementing the program. *Empirical Research in Vocational Education and Training*, *13*(1), 1-21.
- Rus, R. C., Yasin, R. M., Yunus, F. A. N., Rahim, M. B., & Ismail, I. M. (2015). Skilling for Job: A Grounded Theory of Vocational Training at Industrial Training Institutes of Malaysia. *Procedia - Social and Behavioral Sciences*, *204*(August), 198–205. <https://doi.org/10.1016/j.sbspro.2015.08.139>
- Samad, N. A., Ahmad, T. A. T., Ismail, A., Amiruddin, M. H., & Nor, S. nor F. M. (2017). Kerangka pembelajaran berasaskan proses kerja Kurikulum Standard Kolej Vokasional (KSVC) Diploma Vokasional Malaysia. [A learning framework based on the work process of the Malaysian Vocational Diploma Vocational College Standard Curriculum (KSVC)]. *Online Journal for TVET Practitioners*, *2*(2), 1–13.
- Schwab, K. (2016). *The fourth industrial revolution*. World Economic Forum.
- Shahroom, A. A., & Hussin, N. (2018). Industrial Revolution 4.0 and Education. *International Journal of Academic Research in Business and Social Sciences*. <https://doi.org/10.6007/ijarbs/v8-i9/4593>
- Sham, R. M., Senik, Z. C., & Danial, M. A. (2019). Exploring engineering-educators' perceptions and challenges on the IR4.0 at a Technical University in Malaysia. *International Journal of Advanced Trends in Computer Science and Engineering*, *8*(1.6 Special Issue), 497–503. <https://doi.org/10.30534/ijatcse/2019/7281.62019>
- Spöttl, G., & Windelband, L. (2021). The 4th industrial revolution—its impact on vocational skills. *Journal of Education and Work*, *34*(1), 29–52. <https://doi.org/10.1080/13639080.2020.1858230>
- Sulaiman, T., Ibrahim, A., Motevalli, S., Wong, K. Y., & Hakim, M. N. (2021). Effect of e-evaluation on work motivation among teachers during the movement control order in COVID-19: the mediating role of stress. *Interactive Technology and Smart Education*, *18*(3), 435-449.

Thangaiah, E. A., Jenal, R., & Yahaya, J. (2020). Penerokaan penggunaan e-pembelajaran dalam kalangan pelajar dan pengajar TVET - Satu kajian awal [Investigating the e-learning usage among TVET students and teachers - A preliminary study]. *Akademika*, 90(3), 5–18. <https://doi.org/https://doi.org/10.17576/akad-2020-90IK3-01>

Tuckett, A. G. (2004). Part I: Qualitative research sampling - the very real complexities Key words : *Nurse Researcher*, 12(1), 47–61.

UNESCO-UNEVOC. (2017). *Greening technical and vocational education and training (TVET): A practical guide for institutions*. United Nations Educational, Scientific and Cultural Organization. https://doi.org/10.1007/978-3-319-95870-5_300263

Wolf, M., Kleindienst, M., Ramsauer, C., Zierler, C., & Winter, E. (2018). Current and future industrial challenges : Demographic change and measures for elderly workers in industry 4.0. *ANNALS of Faculty Engineering Hunedoara – International Journal of Engineering Tome XVI Fascicule, 1(1)*, 67–77.

Yahya, M., & M. Z. (2020). Faktor Dan Persepsi Yang Mempegaruhi Penggunaan Teknologi Dalam Pendidikan Dikalangan Pensyarah Kolej Komuniti. [Factors and perceptions that influence the use of technology in education among community college lecturers]. *International Journal of Technology Management and Information System*, 2(1), 72–80.