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Aligning TVET Curriculum with Fourth Industrial Revolution Skills for the Food Services Industry: A Mixed Methods Approach

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Abstract

This paper studies factors influencing skills acquisition when using Fourth Industrial Revolution (4IR) technologies in a Food Services working environment. The scope of this study is at dine-in restaurants in four Malaysian states representing the Northern, Central, and Southern zones. A pragmatic paradigm and mixed methods approach were applied in the research design allowing the supplementing of data between the qualitative and quantitative phases. The sequential exploratory mixed methods approach was applied allowing input from the interview's thematic analysis to provide context to the survey instrument's development. This approach Input was gathered from different sample groups such as restaurant managers (9 interview participants), restaurant workers (93 survey respondents), and skills development collaborators (19 survey respondents). The data were analysed through thematic analysis, PLS-SEM, and the Fuzzy Delphi Method. Thematic analysis interpreted interview data, PLS-SEM identified relationships among factors, and the Fuzzy Delphi Method captured expert consensus on 4IR skills. Findings revealed that the significant factors for skills acquisition when using 4IR technologies are Compatibility, Trialability, Social Systems, and Relative Advantage, based on the Diffusion of Innovation theory. These factors were then aligned with the Technological-Organizational-Environmental theory's framework to guide the integration of 4IR skills into the current TVET curriculum.

1. Introduction

Technical and Vocational Education and Training (TVET) is one of the learning pathways in the Malaysian Qualifications system where its appeal is that the curriculum and training are designed to produce graduates who are trained for a specific vocation or occupational area. The reason for this is to have a faster turnaround time for graduates to be able to work in the actual working environment due to prior exposure to simulated settings in the training environment. Both the employer and graduate-turned-employee obtain benefits from TVET, the employer gets to recruit new staff who have been trained to work in the current working environment and the graduate-turned-employee can adapt to the new working environment at a faster pace compared to their counterparts. Another strength of TVET is its training and assessment concept of competency, where the trainee can only be deemed competent to obtain the skills certificate or diploma if they have shown a level of competency according to the occupational standards for their particular occupational area.

In Malaysia, the basis for TVET curriculum is the occupational standards which are known as the National Occupational Skills Standards (NOSS). This research is based on the context of TVET curriculum in Malaysia which is the NOSS. The NOSS' counterparts in other countries are such as the Training Packages in Australia, Red Seal Occupational Analyses in Canada, and Workforce Skills Qualifications in Singapore that are developed based on competency requirements (Asia-Pacific Economic Cooperation (APEC), 2014). Research by APEC (2014) on the different forms of TVET curriculum among several APEC economies highlighted that the main components that are common among these curriculum documents are that they are industry-specific, are according to occupational or job levels, and include the components of knowledge, skills, attitude, and tools used. Based on these elements that define the TVET curriculum for a particular occupation, this research aims to map 4IR skills to elements in the TVET curriculum or in this study's context, the NOSS, according to the NOSS elements that are suitable to embed information of 4IR skills required. However, it is important to determine how and where the 4IR skills can be embedded in the NOSS document. The training of skills according to specific contexts of the occupational area and working environment would facilitate the individuals to easier understand and acquire the skills required more rapidly (Nur Yunus, Razali, Mohd Affandi, Kamis, Rahim, Rozali, & Sulaiman, 2021). Findings from this study could be used to assist curriculum developers in embedding 4IR skills in TVET curriculum or NOSS of various occupational areas. Review of the curriculum and updating it with information on the latest development of technology is conducted within the curriculum review period which on average is done every 5 years for the NOSS (DSD, 2020).

The Fourth Industrial Revolution (4IR) which is also known as Industrial Revolution 4.0 (IR4.0) is one of the Industrial Revolutions that has been widely discussed since its inception by the German government in 2011 (Hermann, Pentek, & Otto, 2016). The Fourth Industrial Revolution has been discussed in detail by Klaus Schwab in his book on the topic (Schwab, 2016) and in the World Economic Forum reports since 2016 (World Economic Forum, 2016). Subsequent research has discussed the impacts of 4IR on the working world (Spöttl, 2016; Spöttl, & Windelband, 2021). Due to the technological advancements of cyber-physical systems brought forth by 4IR, the workforce has to be equipped with suitable skills when utilising 4IR technologies. These skills are defined in this study as 4IR skills. Previous research has highlighted that emerging skills such as skills required when using 4IR technologies should be embedded in tertiary-level education curricula (Jeganathan et al. 2019; Lensing & Friedhoff, 2018; Schallock et al., 2018; Spöttl, 2015; Wermann et al., 2019). Tūtlys and Spöttl (2021)'s research stressed that 4IR-related competencies should be embedded in TVET curriculum by updating the skills with skills required by the industry when utilizing 4IR technologies. The reason that 4IR skills should be mapped to industry requirements is to enable workers to be able to optimise 4IR technologies. Where the usage of these technologies should be geared towards meeting the goals of 4IR implementation in an organization (Amiron, Abdul Latib, & Subari, 2019).

This study will focus on the 4IR skills applied in the Food Services Industry which is operationally defined as the sector of the Food & Beverages Industry focusing on the food services sector such as at dine-in restaurants. This industry is focused on as it is one of the industries that had been affected by the pandemic but managed to be resilient by moving towards being digitized and applying 4IR technologies such as during the physical contact restriction periods imposed during the Covid-19 pandemic in the year 2020 till 2021. These technologies include Robotics (i.e. robots serving food in quarantine centres and food outlets) and the Internet of Things (i.e. contactless ordering of food and online payment) (Academy of Sciences Malaysia (ASM), 2020; Santiago, Borges-Tiago, & Tiago, 2024).

2. Fourth Industrial Revolution (4IR) and Impact on Skills Demands

In terms of 4IR technologies, there have been certain variations in the list of technologies due to the advancement of various solutions for a 4IR working environment. There are 4IR technologies that are not new but have been integrated with other technologies to enable seamless connectivity and data sharing such as internet connectivity (recently known as the Internet of Things), Artificial Intelligence, robotics, system integration, virtual reality, and cybersecurity. However, technologies such as 3D Printing, Augmented Reality, Advanced Materials, Big Data Analytics, and Cloud Computing can be considered relatively new in comparison to the aforesaid technologies. The Academy of Sciences Malaysia (ASM) (2020) has listed these 4IR technologies as Science & Technology Drivers which comprise 5G/6G, sensor technology, 4D/5D printing, Advanced Materials, Advanced intelligent systems, Cyber-security & encryption, Augmented analytics & data discovery, Blockchain, Neurotechnology, and Bioscience technology. Previous literature has listed these technologies as technology enablers (Schwab, 2016)), technology pillars (MITI, 2018), and science & technology drivers (ASM, 2020).

In the context of Malaysia, the Economic Planning Unit (EPU) (2021) has streamlined these lists into fundamental 4IR technologies which include Blockchain, Internet of Things (IoT), Cloud Computing and Data

Analytics, Artificial Intelligence (AI), and Advanced Materials and Technologies. It is from these technologies that advanced 4IR solutions are designed and implemented.

Schwab (2016) stressed in his book on the Fourth Industrial Revolution that rather than the availability of funds to invest in 4IR technologies, the lack of a skilled workforce is more crippling to innovation, competitiveness, and growth. Therefore, it is imperative to develop a skilled workforce who will be competent in a 4IR working environment. To optimise the use of these 4IR technologies, it is imperative that the workforce has to be skilled to utilise them optimally (Amiron, 2020; Saari et al., 2021).). This study operationally defines 4IR skills as skills required by workers to use 4IR technologies in the working environment.

So how do we impart the skills required to utilise these 4IR technologies? One of the approaches would be to provide access to learning how to optimize the use of 4IR technologies via TVET. This is because TVET is based on the input of industry practitioners and experts. TVET can be considered as a cost-effective method of training the future workforce or existing workers in a shorter period (Spottl & Windelbrand, 2021). This is due to the design of TVET curriculum that is based on job duty and tasks or competency units which allows for shorter training periods and faster turnaround time for assessment and certification. In a situation where time is of the essence, mapping the 4IR skills required by industries that apply them is effective, as the workers or students in the field of training are familiar with the work process. This is also effective because they are only required to learn knowledge and skills on how to utilise the 4IR technologies that will optimise the work process in their respective industries. This is considered more effective than having an individual learn about a particular technology, but not be exposed to how it can be applied in their field of work.

The skills development theory put forth by Romiszowski (2009) and the transfer of learning theory (Perkins, & Salomon, 1992) highlights that skills are easier learned if the individual has tacit or previous knowledge of the topic to be learned. In this context, when the individual has tacit knowledge of the context that the 4IR technologies are to be applied, it would be easier for them to understand how the technologies can be used to further optimise the work process as highlighted in the research by Nur Yunus et al. (2021) on Transfer of Learning. Thus, this research proposes to update the TVET curriculum for occupational areas utilising 4IR technologies, to expedite the learning process for workers to use 4IR technologies and solutions according to the context of their working environment.

3. Bridging Between Existing TVET Curriculum and the Evolving Needs of 4IR

The TVET curriculum in Malaysia which is known as the NOSS is developed by the Department of Skills Development (DSD) under the Ministry of Human Resources. The main data sources for NOSS development are industry practitioners who are job holders at the occupational level doing the job and not their superiors or subordinates. NOSS development workshops comprise at least 8 industry practitioners (DSD, 2020). Several DESCUM (Developing Standards and Curriculum) workshops are conducted to produce a Competency Profile Chart (CPC), Competency Profile (CP), and Curriculum of Competency Unit (CoCU). The CPC comprises lists of Core Competencies, the CP describes each Competency Unit (CU)'s work activities and the CoCU elaborates on each CU's requirements for training and assessment. These workshops are conducted within 8 months. DESCUM (Developing Standards and Curriculum) is a revised version of DACUM (Developing A Curriculum) reviewed by the DSD Expert Working Group in 2011 during the NOSS format transformation from duty and tasks to Competency Units. In comparison to DACUM, DESCUM allows referring to other materials than panel input during the development workshop. The NOSS goes through a rigorous process of evaluation and validation by industry stakeholders and regulatory bodies until it is finally endorsed at the Ministry of Human Resources level. Due to this rigorous process, NOSS are reviewed every 2-5 years based on industry requests or end-user (e.g. training centres, skills training accredited personnel) feedback. Requests can be made to review NOSS that are less than 5 years old but which have content that needs to be updated due to changes in industry situations such as changes in job scope, or changes in competencies due to technology advancements. However, the decision to review a NOSS in less than 5 years would have to be deliberated thoroughly due to the cost and time taken to review a NOSS.

For skills training students to be well prepared for the current working environment, the NOSS should include information regarding the skills relevant to using 4IR technologies in the context of the working environment, but there are previous NOSSs that have not yet included information regarding 4IR skills. Although the NOSS is defined to only outline the minimum competencies required by a worker in an occupational area, there are occupations where currently 4IR technologies are being more commonly applied in their daily work. According to Dieppe (2021), emerging and developing countries should ensure that tertiary education such as universities, vocational training facilities, on-the-job training, and continued learning should be able to provide the education and training to enable students and workers to adapt to skill requirements associated with new technologies. Whereas Papanai, & Poolkrajang (2023) highlighted that to successfully update curriculum is to ensure the input is based on a collaboration between curriculum developers, skills trainers, academics, government agencies, and most importantly industry experts and practitioners.

The occupations focused on in this study are non-technical occupations because currently most of the research on 4IR skills to be embedded in the curriculum is for technical occupations or courses (Jeganathan, Khan, Raju and Narayanasamy, 2019). The focus of this study is on the Food Services sector, specifically dine-in restaurants where customers are served food. This particular occupational area is selected as the focus of the study because restaurant workers are gradually having to work with 4IR technologies such as robot waiters or online menus accessed by customers via the Internet of Things and QR (Quick Response) code which is provided for each customer's table for ordering food and drinks. Usage of 4IR technologies in the working environment might pose a challenge for skills-training graduates or trainees who are not prepared to handle these technologies in daily operations. Therefore, it is imperative to align TVET curriculum with the 4IR skills required as per the working environment context.

It is in the view of this study that in the event of rapid technology advancement in less than 5 years, the NOSS review should be approached piecemeal (in stages) rather than reviewing the overall NOSS as it would consist of several stages of development and validation as described. Updating the NOSS via a piecemeal approach would save cost and time taken to review the NOSS which usually has a turnaround time of 8-12 months until publication of a reviewed NOSS and inclusion in the NOSS registry which is updated with newly published NOSS, two or three times annually (DSD, 2020). Therefore, this study aims to identify a suitable strategy to enable an effective update of the NOSS with information related to 4IR skills. To achieve this, there should be a guide on how the new information on 4IR skills should be incorporated. It must be noted that the strategy proposed by this study is only for the scope of the NOSS' content, and does not include strategies regarding the NOSS development and validation process.

The suggestion of embedding the 4IR skills piecemeal could be done either by updating the CoCU section in the NOSS which is a more detailed elaboration of the occupational standards that includes information used by the trainer to develop teaching materials, or by embedding the 4IR skills in the Core Abilities document which are topics taught across the various type of industries and occupational areas because the skills in Core Abilities are common in any occupation. To determine the suitable method would be via this study that analyses which factors influence skills acquisition related to the usage of 4IR technologies. If the factors related to technology are more significant, then the skills can be embedded in the CoCU section which includes details of technology functionalities; if the factors related to the occupational level are significant regardless of occupational area, then the 4IR skills should be embedded in Core Abilities; but if the factors related to occupational area are significant then the 4IR skills can be embedded in the CoCU but is streamlined according to different scope of work between the different occupational levels.

4. Theoretical Framework

Two theoretical models have guided this study to explore the factors of 4IR technologies adoption leading to 4IR skills acquisition which are the Diffusion of Innovation theory (Rogers, 1983) and the Technological-Organizational-Environmental (TOE) Framework developed by Tornatzky & Fleischer (1990). The DOI factors were mapped to the TOE framework to align with the TVET curriculum's Technology (Technology used), Organizational (Occupational Level/ Job Position), and Environmental (Occupational Area) elements. The variables of the DOI theory are used to deductively analyse the main themes identified from the interviews. This is done by mapping the DOI factors of Low Complexity, Relative Advantage, Result Demonstrability, Compatibility, and Social Systems to the identified themes. Rogers (2003) highlights that by having the knowledge of an innovation, will lead to the individual acquiring the skills on how to use it correctly and motivates individuals to gain more experience about the innovation and eventually adopt it. This knowledge includes:

- Awareness-Knowledge – This is the cognitive stage of learning that motivates individuals to learn more about the innovation and eventually adopt it.
- How-To- Knowledge - Contains information on how to use the innovation correctly.
- Principles-knowledge - Includes the 'how' and 'why' an innovation works. However, innovation can still be adopted without this knowledge, but if misused, some individuals may choose not to use the innovation.

The integrated framework in Figure 1 has been applied by previous research such as by Haneem, Kama, Taskin, Pauleen & Abu Bakar (2019), Hiran and Henten (2020), Zheng and Khalid (2022). Based on these previous studies, this research will map between the factors of DOI and TOE. Figure 1 presents the theoretical framework depicting how the theories and variables are mapped and relate to one another.

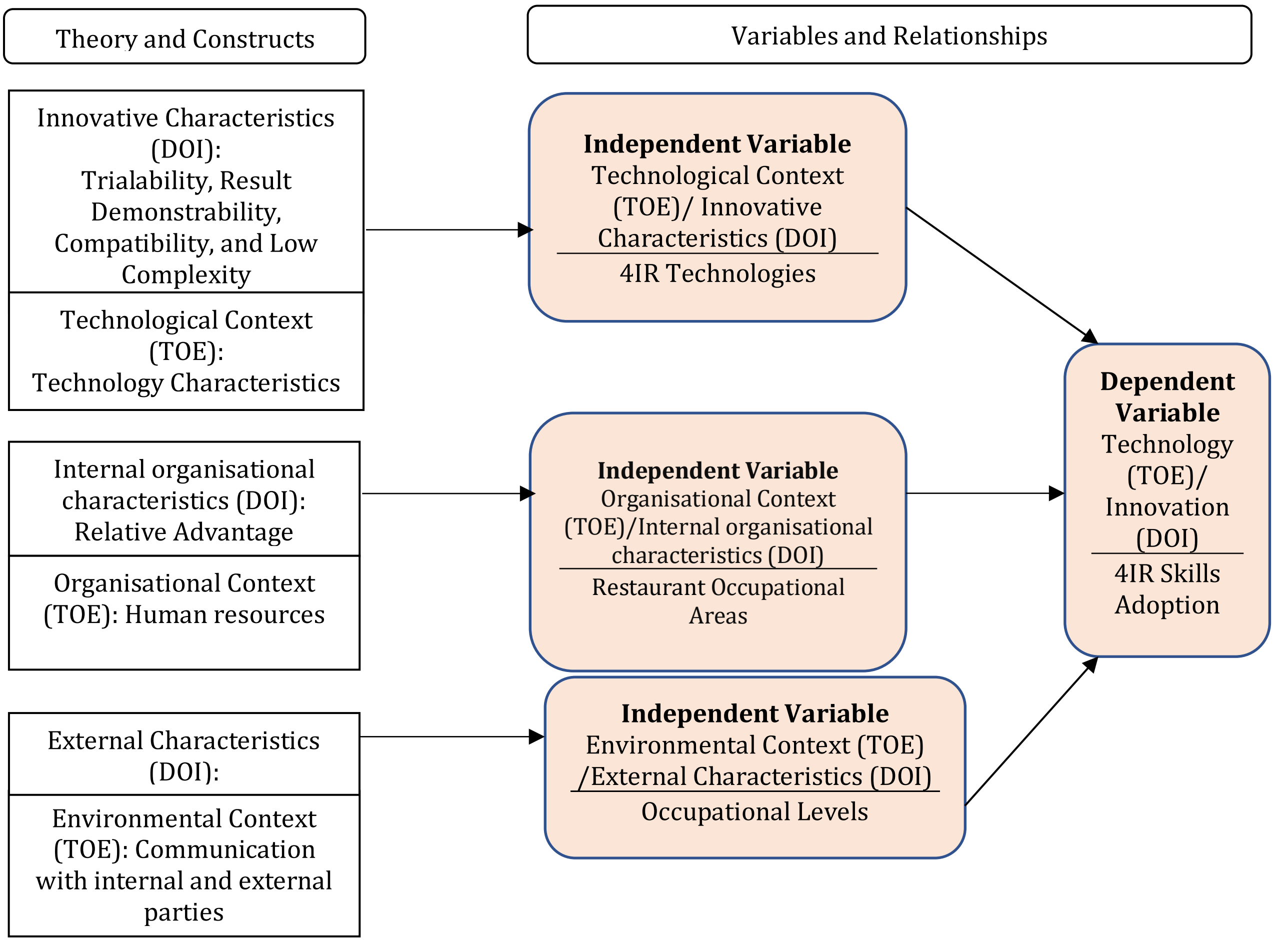

Fig. 1 *Theoretical framework of 4IR skills acquisition*

Legend:
i. DOI: Diffusion of Innovations Theory (Rogers, 1986)
ii. TOE: Technological, Organisational, and Environmental Framework (Tornatzky and Fleischer, 1990)

Figure 1 shows that DOI Innovative Characteristics of Trialability, Result Demonstrability, Compatibility and Complexity are considered to be under the Technological Context of TOE as these factors are closely related to the characteristics of the technology being used and its characteristics that may influence the skills acquisition to use the technology. However, in this study, the variable Complexity was rephrased to Low Complexity to obtain a similar positive response in the survey with restaurant workers because it was anticipated that other items would receive positive responses. DOI's Relative Advantage factor is considered to be similar to TOE's Organisational Context because the advantages of using the technology would be based on the restaurant's working environment and internal organizational structure. Lastly, DOI's Social System is similar to TOE's Environmental context, where this study analyses the influence of customers or restaurant management on the restaurant workers' 4IR skills acquisition.

5. Methods

5.1 Research Design and Paradigm

This study was guided by the pragmatism worldview paradigm which applies equal emphasis on the qualitative and quantitative approaches during data collection and data analysis. The Sequential Exploratory Mixed-methods design of the instrument development model variant was applied based on the definition of the mixed-methods design by Creswell and Plano Clark (2007).

The Sequential Exploratory Mixed Methods approach of this study begins with the qualitative phase to explore the possible factors related to 4IR skills acquisition and also the list of 4IR skills required by Food Services workers where in this study, the focus will be on the factors influencing 4IR skills acquisition of restaurant workers. The qualitative phase also provides the context for the items that are developed in the subsequent quantitative phase's survey instrument as explained in descriptions of Mixed Methods approach (Creswell, 2005; Creswell and Plano Clark, 2007; Creswell, 2014,).

The following quantitative phase aims to confirm the list of 4IR skills in the context of workers in the Food Services industry by disseminating the survey to the workers in the industry. This is followed by another survey which is analysed via the Fuzzy Delphi Method (FDM) and disseminated to trainers, curriculum developers, and academicians to gauge their views on the list of 4IR skills required by Food Service workers and also factors that influence 4IR skills acquisition. The two phases (qualitative and quantitative) are connected by the development of the survey instrument where the items adapted from previous studies are rephrased to reflect the context of Food Services workers using the 4IR technologies. This was observed by the researcher during the in-situ interviews conducted with the restaurant staff. The survey aimed to quantitatively generalise the results of the qualitative phase (Creswell, and Plano Clark, 2007). The findings of both surveys in the quantitative phase will be compared because both will measure the preference of workers and trainers/curriculum developers regarding the factors influencing 4IR skills acquisition.

5.2 Sampling

In terms of sampling, the characteristics of the sample groups between the phases were different. In the qualitative phase the interview participants were managerial-level staff at the restaurants, subsequently during the quantitative phase, the sample comprised restaurant workers, and in the final analysis of the quantitative phase, the samples were TVET curriculum developers, skills trainers, and academicians in the field of food services and 4IR technologies. It was emphasized by Cresswell and Plano Clark (2007), to involve different participants in the qualitative and quantitative phases to mitigate potential threats to the validity of data collection by having a triangulation of views on the variables of the study. Papanai & Poolkrajang (2023) also highlighted that it is important to involve not only the curriculum developers and trainers in curriculum development but most importantly industry practitioners to avoid skills mismatch. Therefore, this study analyses the input from these different groups of contributors to the updating of 4IR skills in TVET curriculum for the Food Services Industry. The criteria and background of the sample participants in the qualitative and quantitative phases are described in Table 1 below.

Table 1 *Information of qualitative and quantitative phase participants/respondents*

	Phase	Number of Samples	Main characteristic	Sampling Method used
i.	Qualitative phase – Interviews with restaurant managerial staff involved with restaurant operations or management of 4IR technologies at the restaurant.	9	Restaurant Managerial-level staff	Purposive
ii.	Quantitative phase – Survey with restaurant staff (to analyse 4IR skills required by workers in the Food Services sector)	93	Restaurant staff	Stratified random sampling
iii.	Quantitative phase – Survey with trainers, curriculum developers, and academicians related to food services and 4IR technologies	18	Curriculum developers, trainers, academicians, and restaurant management (i.e. owners, Human Resource personnel)	Purposive

Table 1 shows the information of the study's interview participants and survey respondents. In the qualitative phase, 9 interview participants were purposively sampled and the total number of interviewees was based on the method applied by Guest et al. (2020) for determining information saturation. The number of interviews needed was calculated based on the base size, run length, and the new information threshold, typically set at 5%. Guest et al. (2020) suggested two levels of new information thresholds: 5% or 0%, where this study used the 5% threshold. Saturation was anticipated after 6-7 interviews, aligning with previous studies indicating deterioration of new information after a small number of interviews. Calculations for this study indicated an 11.9% new information percentage after the initial 4 interviews and the first run of 2 interviews, surpassing the 5% threshold. Two additional interviews were conducted, with the new information percentage for the second run at 2.4%, below the 5% threshold. This led to the conclusion that information saturation was achieved with the 8 interviews. A precautionary ninth interview was conducted but revealed no new themes, reinforcing the notion that additional information diminishes over time (Guest et al., 2020).

The quantitative phase survey with restaurant staff involved a sample of 93 survey respondents from the population of 100 restaurant staff in Johor, Selangor, Wilayah Persekutuan and Penang that use 4IR technologies. The selection of these states was based on information from various Malaysian agencies reporting the states active in implementing 4IR in the industry (Academy of Sciences Malaysia (ASM), 2020; Institute of Labour Market Information and Analysis (ILMIA), 2018). The sampling method used was stratified random sampling, where the strata were according to the 4 states followed by random sampling of any staff from each of the restaurants that used 4IR technologies. The population of restaurants was based on curated searches of restaurants in the states that used 4IR technologies. The restaurants comprised franchise restaurants and privately owned restaurants and included restaurants serving Fusion Food, Thai, Malay, Chinese, Indian, and Japanese cuisine. Following the survey with restaurant staff, a quantitative survey conducted with 18 curriculum developers, trainers, academicians, and restaurant managers who were purposively sampled was conducted to obtain experts' acceptance of the 4IR skills framework elements and factors influencing 4IR skills acquisition. The different groups of samples provided various views and enabled the triangulation of findings which resulted in both confirmatory and conflicting results between the groups.

5.3 Qualitative Phase

The qualitative phase consisted of interviews with managerial-level staff at restaurants that use 4IR technologies in daily operations. The interviews were conducted in-situ where the researcher was able to directly observe how the workers used robots and IoT at the restaurants. The 8 interviews were transcribed and were analysed using thematic analysis (Guest et al., 2012; Saldana, 2013). Saldana (2013) defines themes as phrases that describe a unit of data and what it means. There were two rounds of coding cycles. The second cycle condensed codes into 12 main themes and 48 sub-themes, ensuring a comprehensive representation of important text. The initial round employed an inductive approach, aligning themes roughly with TOE and DOI theories. Subsequently, new themes were identified and compared with TOE and DOI constructs for grouping in the second round. The NVIVO software facilitated coding and classifying interview transcriptions as Cases, enhancing querying, interpretation, and sense-making.

The qualitative phase interviews were exploratory to understand the use of 4IR technologies at restaurants and the factors that influence 4IR skills acquisition, while the quantitative phase survey was aimed to obtain a wider group of sample respondents. The analysis resulted in themes and sub-themes mapped to relevant DOI constructs. The 12 main themes and 48 sub-themes were subsequently used as reference to develop the items for the survey instrument, which resulted in 32 items using a 7-point Likert scale and 5 items regarding the demography details of the survey respondents. Items for the 4IR skills that are required by restaurant workers were based on the interviews' thematic analysis. This was very crucial to the instrument development process as there were no current survey instruments (or those similar to) regarding 4IR skills or skills for Food Service workers in restaurants using 4IR technologies. The list of themes and constructs in the survey can be referred to in Table 2 below.

Table 2 *Overall view of codes and mapping to DOI/TOE constructs*

Themes	Related DOI/TOE Constructs	Sample Extracts from Interviews
1. Advantages of using of QR code	Relative advantage/Organisational, Social System/ Environmental	*"when we used the physical menu, there was a lot of cost for printing, but now, (with the online menu) when we want to update the menus, it is easier online. "*
2. Advantages of using robots	Relative advantage/Organisational, Social System/ Environmental	*"Mainly from customer's experience, the robots attract more customers. This is because the robot helps in marketing, we worry that customers will get the food late but customers like it better when robots send the food."*
3. Ease of use of 4IR technologies	Low Complexity/Technological	*"yes, it is simple to understand, after only one briefing the staff can understand how to use it"*

Themes	Related DOI/TOE Constructs	Sample Extracts from Interviews
4. Management Of Robots	Trialability/Technological	*"We can test first and the product trial will be done before clients commit"*
	Relative Advantage, Compatibility/ Organizational	*"(The) robot is more to assist the work of the staff. It can help out when there are a lot of customers."*
5. Reason to use robot	Relative Advantage, Compatibility/ Organizational	*"At first, headquarters instructed us to use the robot due to lack of workers. "*
6. Reason to use QR code	Relative Advantage, Compatibility/ Organizational	*"yes, it can also help with forecasting stock and inventory based on the customer's preference of food ordered and when the customer orders using QR code, we can know their phone number as we can put it into the database when the user has to login"*
7. Workers that can use 4IR technology	Compatibility/Organisational	*"Usually the manager will update (the online menu)"* *"The Kitchen helper or waiter will deal directly with the robots and report to F&B supervisor or manager"* *"Any of the workers can use the robot"*
8. Worker perception of 4IR Technology	Low Complexity/ Technological, Compatibility/Organizational	*"It is not difficult to use this robot, we just have to press the settings. At first everyone was excited to use it. "*
9. Most used 4IR technology	Low Complexity/ Technological	*"Both QR codes and robots are mostly used at restaurants, but robots' usage is based on restaurant's size and layout"*
10. Years using 4IR technology	Social System/ Environmental	*"Since 2022, most restaurants in Johor started using robots and IoT"'*
11. Required skills of service staff when using 4IR technology	Is the dependent variable	*"Yes, when we open the restaurant, we will charge it fully then after an hour the robot can operate until night time."* *"(usually) we clean (the robot) before closing and then we take out the tray mat and spray water/liquid , then we just wipe clean."* *"We will key in the table number for the robot to send the food"* *"the staff can set the robot settings such as speed and the*

Themes	Related DOI/TOE Constructs	Sample Extracts from Interviews
		birthday songs themselves if required
12. Future skills for using 4IR technology	Is the dependent variable	*"for more restaurants to use online contactless transactions"* *"simple programming of robot"*

Table 2 shows the items for the survey were developed based on input from the qualitative phase which was used to adapt items from several surveys in previous research that studied factors influencing technology adoption. The interviews with restaurant managerial staff provided the input to contextualise the survey items according to restaurant working environments that used 4IR technologies such as robots and online menus accessed via QR Codes which utilises the Internet of Things (IoT). The thematic analysis conducted on the interview transcriptions also resulted in identifying the main constructs of the survey based on the main variables to be analysed.

5.4 Quantitative Phase

The quantitative phase consists of the dissemination of the survey instrument to restaurant workers followed by a survey to obtain expert agreement on the elements of the 4IR skills framework for the Food Services Industry which include the factors that influence 4IR Skills acquisition and the list of 4IR skills required by restaurant workers.

Based on the qualitative phase's thematic analysis, the themes were included as items in the survey used to analyse the influence of factors contributing to the 4IR skills acquisition. Subsequently, the survey data was analysed via Partial Least Squares Structural Equation Model (PLS-SEM) using the SMART PLS Software. PLS is a Component-based approach, and employs an iterative algorithm to calculate scores for latent (hidden) variables and path coefficients (factors), quantifying the intensity and direction of relationships.

PLS-SEM was used for the subsequent analysis of the survey findings because PLS-SEM possesses the capability to manage non-normal, categorical, and ordinal data, along with small sample sizes. As identified during the data normality test in SPSS, the data in this survey was not normal. Moreover, there was also a suspicion of overlapping items measuring similar content as the Cronbach Alpha value of data in this survey was very high (>0.90). According to Mat Nawi et al. (2020), if the alpha value is too high it shows that the items are redundant as they are measuring the same indicators but in different items. Therefore to confirm this, PLS-SEM was used to analyse the possible overlapping via testing the model for multicollinearity because PLS-SEM is adept at addressing multicollinearity by employing either reflective or formative measurement. Multicollinearity happens when two or more predictor variables in a statistical model are highly correlated, meaning they provide very similar information. This makes it hard to determine the individual effect of each predictor on the outcome, leading to less reliable results and possibly misleading interpretations. Due to the proposed model's structure and the previous studies on adopting robot technology in services, the PLS-SEM method best suits the present work (Hair et al., 2011; Hair et al., 2012).

Analysis via PLS-SEM comprises both a measurement model and a structural model. The measurement model examines connections between latent and observed variables, while the structural model assesses relationships among latent variables. This model accommodates multiple dependent (endogenous) variables, enabling the investigation of relationships between them. Additionally, the model incorporates the consideration of measurement errors for observed variables (Hair et al., 2010). The process of data analysis using PLS-SEM comprises three main steps. Firstly, the measurement model is tested by running the PLS-SEM algorithm calculations in SMART PLS 4, which produces a report of the constructs' reliability, convergent, and discriminant validity. Secondly, the PLS-SEM is estimated by examining the causal relationships between the various dimensions of the measurement model and is evaluated based on indicator reliability (reflective indicator loadings >0.5), reliability of items (Cronbach's alpha >0.7), convergent reliability (assessed using Average Variance Extracted, AVE > 0.5), internal consistency (assessed using composite reliability, CR > 0.7), and discriminant validity. The measurement model is evaluated in the first step, and the structural model is assessed in the second step of the two-step approach. A measurement model relates latent variables to the corresponding observed variables (Hair et al., 2010).

Table 3 shows the values of Cronbach Alpha, Composite reliability and AVE of the Latent Variables with more than one indicator. Variables with only one indicator such as Relative Advantage and Social Systems are not included in the results because the variance between the indicators of the Latent Variable could not be measured with only 1 indicator. The two aforementioned variables had only one indicator after the process of deleting indicators to meet AVE and HTMT requirements.

Table 3 *Construct reliability and validity*

Latent Variables	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average Variance Extracted (AVE)
4IR Skills Acquisition	0.913	0.916	0.958	0.920
Compatibility	0.759	0.763	0.892	0.806
Low Complexity	0.858	0.883	0.914	0.782
Result Demonstrability	0.830	0.840	0.898	0.747
Trialability	0.792	0.896	0.902	0.822

The results in **Table 3** show that Cronbach's alpha was larger than 0.7 (>0.7) (Cronbach, 1951; Cheung et al., 2023) for all the latent variables. The Average Variance Extracted (AVE) was found to be >0.5 (Kline, 2015; Cheung et al., 2023).). A minimum composite reliability of 0.7 and minimum rho_A of 0.7 (Dijkstra & Henseler, 2015; Cheung et al., 2023) were met. Therefore, convergent validity was confirmed.

To verify validity, the AVE square roots of each latent variable are required to be larger than its correlation with the other latent variables (Fornell & Larcker, 1981). The AVE square roots (i.e., entries along the main diagonal) are larger than the correlation values (i.e., entries below the main diagonal) thus meeting the requirements.

Table 4 shows that the Heterotrait-Monotrait (HTMT) ratio (values above the main diagonal) was below 0.9 (Henseler et al., 2015). This was achieved after the deletion of indicators for the latent variables named Social Systems, Relative Advantage and 4IR Skills Acquisition that had values larger than 0.9. Thus, discriminant validity was verified for this study.

Table 4 *Discriminant validity - Heterotrait-monotrait ratio (HTMT) - Matrix*

Latent Values	4IR Skills Acquisition	Compatibility	Low Complexity	Relative Advantage
Compatibility	0.864			
Low Complexity	0.616	0.833		
Relative Advantage	0.599	0.773	0.555	
Result Demonstrability	0.722	0.864	0.858	0.602
Social Systems	0.844	0.763	0.690	0.551
Trialability	0.742	0.777	0.838	0.471

The Variance Inflation Factor (VIF) was calculated to find the degree of multicollinearity. The results in **Table 5** showed that VIF was in the range below 5.0 after eliminating the indicators to ensure multicollinearity does not exist.

Table 5 *Variance inflation factor (VIF)*

Latent Variables	Indicators /Survey Items	VIF
Relative Advantage	Enables Multi-Tasking	1.000
Low Complexity	Easy (to use) based on training and briefing	4.114
	Easy to Operate	3.565
	Easy to Set	1.625
Result Demonstrability	Attract more customers	2.901
	Overcome Worker Shortage	1.580
	Smoother Restaurant Operations	2.419
Trialability	Test Functions	1.755
	Trial period	1.755
Social System	Trend in Local Area	1.000
Compatibility	Work Aspects	1.599
	Work Culture	1.599
4IR Skills Acquisition	Train Staff on using 4IR technology	3.406
	Use Technology to Collaborate between sections	3.406

Results of testing done on the Measurement Model showed that the model meets all the requirements of constructs' reliability, convergent, and discriminant validity. Therefore the model can be used in the next step of PLS-SEM analysis where the structural model is tested. The findings are presented in the following section.

6. Analysis and Findings

This paper focuses on one of the research questions of the study which asks "What influences restaurant workers to acquire skills to use the 4IR technology?". This research question aims to identify what influences restaurant workers to acquire skills to use 4IR technology. This question was asked in both qualitative and quantitative phases to obtain a holistic view and is elaborated in the sections below.

6.1 Qualitative Phase Findings

The Qualitative phase comprised interviews with 9 interview participants who were managerial staff at the restaurants who managed restaurant outlet operations including the use of 4IR technologies. The interview participants' brief profile is included in the table below showing that they comprise restaurant managers, franchise restaurant Human Resource managers, restaurant owner and also a 4IR technology maintenance manager for restaurants. The results of the qualitative phase's interviews were analysed using thematic analysis and tabulated in Table 6 below.

Table 6 *Mapping of TOE and DOI constructs to factors influencing 4IR skills acquisition and occurrence of themes*

TOE Framework Constructs	DOI Constructs/ Interview Participants	IP1	IP2	IP3	IP4	IP5	IP6	IP 7	IP 8	IP9
Technological	Low Complexity	/	/	/	/	/	/	/	/	/
	Compatibility		/		/	/				
	Trialability	/				/				
Organisational	Relative Advantage	/	/	/	/	/	/	/	/	/
Environmental	Result Demonstrability	/					/		/	
	Social Systems		/		/		/	/		/

Note:
IP 1 : Interview Participant 1 – 4IR Technology Maintenance Manager for Restaurants
IP 2 : Interview Participant 2 – Restaurant Manager
IP 3 : Interview Participant 3 – Restaurant Manager
IP 4 : Interview Participant 4 – Restaurant Manager
IP 5 : Interview Participant 5 – Franchise Restaurant HR Manager
IP 6 : Interview Participant 6 – Restaurant Owner
IP 7 : Interview Participant 7 – Restaurant Manager
IP 8 : Interview Participant 8 – Restaurant Manager
IP 9 : Interview Participant 9 – Restaurant Owner

Table 6 presents the main reasons for using 4IR technology based on the frequency of mentions across interviews and the specific participants who raised them. These frequencies were analyzed during data reduction to identify the most prominent themes. A frequently mentioned theme suggests significance, reflecting the importance placed on it by interview participants. However, frequency alone is only an indicator; understanding why these technologies are used in restaurants is essential for answering the research question. The factors also align with the DOI and TOE theories of technology adoption, which explore the motivations behind technology use.

It can be observed from the frequency total for each factor that the low complexity of the technology and the relative advantage of the technology influences the service staff to acquire the skills to use the robots and QR codes to access the online menu. Interview participants highlighted that robots and QR Codes (Online menu) are easy to use and the settings are easy to understand therefore making it easier for service staff to use, maintain, and teach others on how to use it.

Another factor highlighted is Relative Advantage where understanding the advantages of the technology enables a more driven will to learn how to use the technology. Other factors include the Compatibility of the technology to be used in the working environment and how it is monitored remotely by the management of franchised restaurants and monitored directly by business owners who are at the restaurant daily. This monitoring is to gauge the use of the robots per day and to monitor any technical issues of the robots.

Based on the interviews, the adoption of 4IR technologies initially aimed to address the challenges posed by worker shortages during Covid-19 social distancing requirements, however, other advantages became apparent such as robots handling repetitive tasks, for instance, sending food to customers, and customers directed to online menus through QR codes, where restaurant staff were able to focus on other tasks. Consequently, the adoption of these technologies necessitated the development of skills among workers, extending beyond operational duties to include effective communication with customers, addressing technical issues, and training colleagues on how to use robots and QR codes. Notably, skills in handling robots and managing online menus, along with understanding network connectivity and electronic gadget use, became crucial for workers to address customer concerns.

6.2 Quantitative Phase Findings

6.2.1 PLS-SEM Analysis Findings

To calculate the PLS-SEM structural model, the bootstrapping technique with 5,000 subsamples for modeling was used via functions available in SMART PLS. Table 7 shows the structural model results. The t-value was not more than 1.96 (>1.96) for all the relationships between the latent variables, but not all had p-values that were less than 0.05 ($p < 0.05$).

The output in Table 7 shows that Compatibility, Social Systems and Trialability achieved convergent validity with t-statistics less than 1.96. Convergent validity is a subtype of construct validity and is an indication of how well a test measures the concept it was designed to measure. Low Complexity, Relative Advantage and Result Demonstrability are not valid to be used to measure 4IR Skills Acquisition because their P values are more than 0.05 and T Statistics are less than 1.96. The output shows that Compatibility significantly influences 4IR Skills Acquisition at $\beta=0.294$, Social Systems influence 4IR Skills Acquisition at 0.593 and Trialability influences the dependent variable with a value of 0.309, $p>0.05$. The Beta values for Low Complexity and Relative Demonstrability do not influence the dependent variable as they are less than 0.05.

Table 7 *Structural model results*

Paths /Hypotheses	Original sample (O)/Beta Value	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
Compatibility -> 4IR Skills Acquisition	0.294	0.121	2.427	0.015
Low Complexity -> 4IR Skills Acquisition	-0.189	0.105	1.791	0.073
Relative Advantage -> 4IR Skills Acquisition	0.078	0.093	0.839	0.402
Result Demonstrability -> 4IR Skills Acquisition	-0.110	0.154	0.718	0.473
Social Systems -> 4IR Skills Acquisition	0.593	0.103	5.778	0.000
Trialability -> 4IR Skills Acquisition	0.309	0.076	4.080	0.000

To examine whether the research model derived in this study can be applied to the population of the study, the predictive relevance Q2 is conducted. The output shows that Q2 >0 (Q2=0.707). It means the model is capable of predicting 4IR Skills Acquisition. The Q2 values are shown in Table 8.

Table 8 *Q2 value*

Dependent Variables	Q^2predict	RMSE	MAE
4IR Skills Adoption	0.707	0.563	0.384

Table 9 reports the R-Square value for the endogenous variables. It presents the size of influences (0 to 1) of the total of all independent latent variables on the dependent latent variable. Values of 0.25, 0.50 and 0.75 for the dependent latent variables are described as weak, moderate and large, respectively (Hair et al., 2017, p199; Hair, Ringle & Sarstedt, 2011). According to Table 4.14, the model was concluded to have large or satisfactory predictive power.

Table 9 *R-Square value*

	R-square
4IR Skills Acquisition	0.766

The coefficient (factor) f2 is the effect size of the influence of each independent latent variable on the dependent latent variable. The values of 0.05, 0.20, and 0.35 represent small, moderate, and large effect size respectively. An effect size value of less than 0.05 indicates that there is no effect. Based on the results in Table 10, the variables, Low Complexity and Result Demonstrability have a negative effect on the dependent variable, 4IR Skills Acquisition because they are smaller than 0.05. The variables Social Systems and Trialability have a large effect size on 4IR Skills Acquisition with values of 0.593 and 0.309 respectively. Whereas the variable Compatibility has a moderate effect size on 4IR skills Acquisition with the value of 0.294 and Relative Advantage has a weak effect size on 4IR Compatibility.

Table 10 *F^2 value*

Variables	4IR Skills Acquisition	Effect Size
Social Systems	0.593	Large
Trialability	0.309	Large
Compatibility	0.294	Moderate
Relative Advantage	0.078	Weak
Low Complexity	-0.189	Negative
Result Demonstrability	-0.110	Negative

Table 10 shows the ranking of factors that influence 4IR Skills acquisition based on input from 93 (after the removal of outliers) restaurant workers in four states in Malaysia (Johor, Selangor, Wilayah Persekutuan and Penang). It can be seen that Social Systems and Trialability have a large effect size, whereas Compatibility has a moderate effect size and Relative Advantage has a weak effect size. The model with F2 values can be observed in Figure 2.

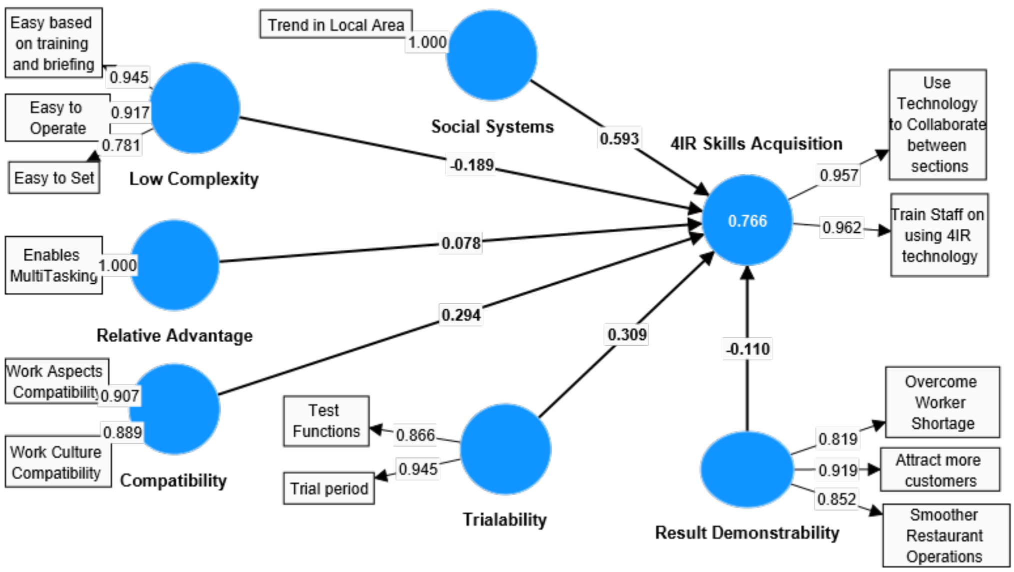

Fig. 2 *Path coefficients with F2 values*

Figure 2 shows the Latent Variables with Path Coefficient values of 0.593 for Social Systems, 0.309 for Trialability, 0.294 for Compatibility, and 0.078 for Relative Advantage respectively towards the Dependent Variable, 4R Skills Acquisition. This implies that these variables can predict the model of 4IR skills acquisition. Low complexity and Result Demonstrability have insignificant values towards the dependent variable, thus implying that these factors cannot predict the model.

6.2.2 Fuzzy Delphi Method Analysis Findings

This study analysed 18 experts due to the heterogeneous composition of the group consisting of 3 vocational colleges trainers in food services and preparation, 7 TVET curriculum developers, 5 academicians specialising in 4IR technologies and 3 restaurant owners/management personnel. Analysis on the experts' views was analysed using a pre-formatted Microsoft Excel spreadsheet developed by Mohd Jamil and Mat Noh (2020). The two main prerequisites that must be followed in the Fuzzy Delphi technique are the Triangular Fuzzy Number and the Defuzzification Process. Triangular Fuzzy Number has two conditions, first the value of Threshold (d) ≤ 0.2 (Chen & Lin, 2002; Chu & Hwang, 2008; Roldán López de Hierro, Sánchez, Puente-Fernández, Montoya-Juárez, & Roldán, 2021; Wan Hamat, Muhamad, Hashim, & Mohamed Yusoff, 2021). Table 11 shows the results of the Fuzzy Delphi Method analysis of survey results from the subsequent survey that was disseminated to a heterogenous sample of 18 TVET curriculum developers, academicians, and skills trainers of 4IR technology and food services. The suggested number of sample experts for Fuzzy Delphi Method analysis is between 10-15 according to Adler and Ziglio (1996).

Table 11 *Fuzzy Delphi method results of factors influencing 4IR skills acquisition*

Item	**Triangular Fuzzy Numbers Condition**		**Defuzzification Process**				**Expert Consensus**	**Acceptance of Element**	**Ranking**
	Threshold d	**Expert Consensus**	**m1**	**m2**	**m3**	**Fuzzy Score (A)**			
Compatibility	0.080	94%	0.833	0.961	0.994	0.930	Accepted	0.930	1
Relative Advantages	0.192	83%	0.789	0.911	0.950	0.883	Accepted	0.883	2
Social Systems	0.132	89%	0.722	0.889	0.967	0.859	Accepted	0.859	3
Trialability	0.182	83%	0.728	0.878	0.950	0.852	Accepted	0.852	4
Result Demonstrability	0.217	83%	0.772	0.894	0.939	0.869	Rejected		
Low Complexity	0.338	6%	0.694	0.817	0.878	0.796	Rejected		

Note:
Condition for Item Acceptance: Triangular Fuzzy Numbers
(1) Threshold Value (d) ≤ 0.2
(2) Percentage of Experts Consensus > 75% Defuzzification Process
(3) Fuzzy Score (A) ≥ α – cut value = 0.5

Based on the FDM analysis results in Table 11, it can be observed that the items for Compatibility, Relative Advantage, Social Systems, and Trialability recorded a value of Threshold (d) ≤ 0.2, where the expert agreement percentage is above 75% and all defuzzification values for items also exceed the value of α - cut = 0.5. However, the items Result Demonstrability and Low Complexity did not meet all these conditions. Although the item Result Demonstrability obtained expert agreement percentage of 83% but its threshold was above 0.217, whereas the item Low Complexity obtained a high threshold value of 0.338 which was above the condition of ≤ 0.2 and also obtained an expert consensus percentage of 6% which is below the acceptable 75% percentage. Even though the α – cut value was above 0.5, the two items were still rejected because they did not meet the condition of threshold value ≤ 0.2.

The result shows that the items other than Result Demonstrability and Low Complexity obtained consensus from the respondents and that the finalized factors influencing 4IR skills acquisition were similar after exclusion from the finalised list based on certain criteria and thresholds. However, there were certain discrepancies in terms of ranking positions.

6.2.3 Synthesis of Findings

Several discrepancies were discovered in the process of synthesizing the findings. In the analysis using PLS-SEM, the variables with large effect sizes were Social Systems and Trialability, whereas the FDM analysis ranked Social Systems and Trialability as the third and fourth rank. The variable Compatibility ranks first in the FDM analysis but has a moderate effect size as presented in the PLS-SEM analysis. The variable Relative Advantage has a weak effect size in the PLS-SEM analysis but is ranked second in the FDM analysis. Table 12 shows a comparison of qualitative and quantitative results regarding these influencing factors.

Table 12 *Comparison between qualitative and quantitative results on factors influencing skills acquisition*

Qualitative Phase Findings (Interviews with Restaurant managerial staff)	Quantitative Phase Findings (Survey with Restaurant Workers and Curriculum Developers/Trainers)	
	PLS-SEM results	FDM results
Low Complexity Relative Advantage	1. Social Systems 2. Trialability 3. Compatibility 4. Relative Advantage	1. Compatibility 2. Relative Advantage 3. Social Systems 4. Trialability

Table 12 compares the qualitative and quantitative findings, revealing that the qualitative analysis mainly identified Low Complexity and Relative Advantage as key influences on skills acquisition, while the quantitative findings from both PLS-SEM and FDM analysis highlighted Social Systems, Trialability, Compatibility, and Relative Advantage. This alignment in factors from both data sets suggests that Social Systems, Trialability, Compatibility, and Relative Advantage are significant factors that influence 4IR skills acquisition.

Low Complexity, which was identified as a factor frequently mentioned in the qualitative phase, is not considered as one of the factors overall because it was not a significant factor in either PLS-SEM and FDM analysis which represents views from the restaurant workers and food service trainers' perspectives in comparison to the views of the managerial staff. Interestingly, Low Complexity was found to be insignificant in the quantitative phase of this study, challenging the idea that lower complexity supports skills acquisition. Imronudin (2023) noted that in industries where technology is intuitive and requires minimal training, complexity has little impact on skills development. While simpler technology is typically linked to ease of use, overly basic systems may fail to engage users, resulting in disinterest (Almaiah et al., 2022). The minimal impact of Low Complexity in this study could be due to the user-friendly nature of technologies in the Food Services Industry. Interviews with managers revealed that tools like robots are specifically designed to be easy for staff at all levels. As one manager put it, “Using the robot is as easy as using a smartphone” (IP 5).

7. Discussion – Aligning TVET Curriculum and Industry Demands

As elaborated in the introduction section of this paper, the findings of this study can guide how the emerging skills related to 4IR technologies' usage can be included in TVET curriculum, namely the NOSS in Malaysia, thus aligning TVET curriculum with current industry demands. To integrate 4IR skills in the NOSS, a piecemeal approach could be applied by gradually updating specific sections of the NOSS. This "piecemeal" method means adding skills in stages rather than overhauling the entire NOSS and curriculum at once. Specifically, updates could be made to the Curriculum of Competency Unit (CoCU) section, or 4IR skills could be embedded in the Core Abilities document, focusing on the main factors that influence skills acquisition when using 4IR technologies.

Based on the findings, the significant factors are Social Systems and Trialability, Compatibility and Relative Advantage. Figure 1 of this paper shows the mapping between the DOI factors to the TOE framework where Social System is mapped to the Environmental factors of TOE, Trialability and Compatibility are mapped to Technological factors of TOE and Relative Advantage is mapped to the Organizational factors of TOE. It is apparent that all TOE factors (Technological, Organisational and Environmental) are significant, therefore, to guide how the 4IR skills can be embedded in the NOSS is by looking at the ranking of the factors in PLS-SEM and FDM analysis. However, the findings showed a discrepancy between the ranking results in PLS-SEM and FDM analysis.

After comparing the two analyses' rankings, Compatibility ranks moderately in the PLS-SEM ranking and ranks first in the FDM analysis, therefore it can be considered as the most significant factor. Compatibility has also been one of the most important factors in previous research that have applied the DOI theory to determine factors that significantly influence technology adoption such as by Lee et al. (2023), and Santiago, Borges-Tiago & Tiago (2024). Compatibility is mapped to the Technological factor of TOE as it is related to the technology's characteristics that further facilitate 4IR skills acquisition. During the qualitative phase's interviews, the managers also highlighted that the 4IR technologies such as robots are used if only the restaurant's setup and size are suitable to accommodate the paths of the robot and in terms of using the online menus rely on the internet capacity of the restaurant's area.

As discussed earlier in Section 3 of this paper, if the factors related to the Technological factor of TOE are considered significant (refer to the mapping between DOI and TOE factors in Figure 1), then the 4IR skills can be embedded in the CoCU section of the NOSS when elaborating the Related Abilities using certain tools and equipment or in this context are the 4IR technologies. Nur Yunus, et al. (2021) have identified in their research that workers can apply what they learned during skills training by ensuring similarity between the training taught and the needs of the real workplace which includes the compatibility of the technology used during training simulation and the actual working environment.

Table 13 presents a visual depiction of the CoCU section in the NOSS of how the 4IR skills can be embedded in the relevant Work Activities. 4IR skills or work activities such as "Carry out robot operational handling," are incorporated within the "Work Activities" columns. The "Related Knowledge" column specifies essential information about robot handling, while the "Related Skills" column lists practical tasks, such as charging and cleaning the robot. The "Attitude/Safety/Environment" column outlines required attitudes, safety practices, and environmental considerations, including communication and PPE use. Lastly, the "Assessment Criteria" column details the skills trainees must demonstrate to be considered competent in this unit. Successfully completing these criteria will verify trainees' competence in handling robots in Food Services.

Table 13 *Sample of simulated CoCu section with embedded 4IR skills*

WORK ACTIVITIES	RELATED KNOWLEDGE	RELATED SKILLS	ATTITUDE/ SAFETY/ ENVIRONMENT	ASSESSMENT CRITERIA
1. Carry out robot operational handling	1.1 Robot functionality 1.2 Robot settings 1.3 Robot daily maintenance which includes: i. Charging ii. Cleaning iii. Storing of robot	1.1 Identify robot functions 1.2 Determine steps to set robot speed and other main functions 1.3 Execute charging of robot 1.4 Execute cleaning of robot 1.5 Execute storing of robot at designated starting point	ATTITUDE • Communicate clearly when obtaining instructions and reporting work progress • Quality conscious. SAFETY • Wear PPE when cleaning robot • Adhere to safety requirements when handling robot. • Apply safe working culture. ENVIRONMENT • Maintain workplace cleanliness and tidiness. • Adhere to waste disposal requirements.	i. Types of robot functions listed. ii. Robot setting procedures explained. iii. Charging procedure explained iv. Type of robot cleaning tools listed. v. Cleaning procedures explained. vi. Robot storage location and procedures explained.

4IR skills = Mentioned in Related Skills of relevant Work Activities

This study has shown how emerging skills such as 4IR skills can be embedded in TVET curriculum by identifying the significant factors influencing skills acquisition when using 4IR technologies. The findings are the result of data triangulation obtained via qualitative and quantitative data collection and analysis. By applying the pragmatic paradigm in the Sequential Exploratory Mixed methods research design, instances of discrepancy in the results can be overcome by comparing the different analysis results to obtain the final decision.

8. Conclusion

It can be summarised that by applying mixed methods, the findings from the qualitative phase and quantitative phase can be used to complement and supplement the information in the final decision of embedding new skills related to technological advancement in the curriculum. This is achieved by carefully analysing the weightage of the significant factors influencing skills acquisition, which in this study, is the compatibility of the technology with the organisation's work processes and working environments. The mixed methods approach also enables the research to analyse the input from a more diverse pool of sample respondents in the qualitative and quantitative phases thus allowing the triangulation of data.

The benefit of aligning TVET curriculum with current 4IR skills demands is to ensure an ongoing alignment of curriculum to meet the dynamic needs of 4IR technology advancement that impacts the skills required by workers in the industry. Thus, by having a guide on how TVET can continuously adapt to changing skills demands allows the trainees and also workers in the industry to keep abreast with potential future developments of 4IR.

In addition, the list of 4IR skills for Food Services industry workers has also been studied in this research as a whole, however, it is not presented in this paper which focuses on presenting the findings of the analysis conducted on factors influencing 4IR skills acquisition.

9. Future Work

The study could be expanded to include other sectors within the Services Industry beyond Food Services, such as Education, Banking, Hospitality, Health Services, Wholesale & Retail, ICT, and Creative Industries. Another avenue for expansion would be to conduct the research according to broader industry clusters, such as Manufacturing, Production (including Agriculture, Mining, and Construction), and Services. This would allow for a comparison of skills needs across major industry clusters, helping to identify the unique and shared skills each cluster requires.

This approach could also aid in identifying transversal skills. Transversal skills are increasingly emphasized in skills frameworks and occupational information portals like the Occupational Information Network (O*Net) under the American Bureau of Labor Statistics, European Skills, Competences, Qualifications and Occupations (ESCO) under the European Commission, Skills Framework (SFw) under Future Skills Singapore, and the Australian Skills Classification (ASC) by Australia's National Skills Commission.

By comparing skills that overlap across different industry clusters, transversal skills which are industry-agnostic can be identified. These types of skills are not specific to a single industry but can be applied across sectors, sometimes with slight contextual adjustments. While generic skills are naturally transversal, certain technical skills, such as safety and health awareness and risk management, are also applicable across industries, requiring some technical knowledge for effective application.

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Conflict of Interest

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

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Associate Professor Dr Azlan Abdul Latib and Evarina Amiron;* ***data collection:*** *Evarina Amiron;* ***analysis and interpretation of results:*** *Evarina Amiron;* ***draft manuscript preparation:*** *Evarina Amiron. All authors reviewed the results and Associate Professor Dr Azlan Abdul Latib approved the final version of the manuscript.*

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