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Developing a Demand-Driven TVET Institution Framework in Malaysia via Fuzzy Delphi Analysis

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Abstract

As Industry 4.0 transforms the workplace, technical and vocational education and training (TVET) institutions are specialised in providing skills and knowledge competencies for a variety of fields. The industrial recruiters reported that they prefer to hire foreigners due to skill mismatches amongst local graduates. Therefore, this study aimed to develop a demand-driven framework for TVET institutions in Malaysia. The Fuzzy Delphi Method (FDM) had been employed to analyse experts' judgements and determine the relevant items. The study questionnaire consisted of three constructs and eight items on a seven-point Likert scale. A total of thirteen experts were selected through the purposive sampling technique. The findings of the FDM analysis indicated a high level of expert agreement, supported by empirical evidence from quantitative data, with percentage values (≥ 75%), threshold ($d \leq 0.2$), and alpha-cut level (α-cut ≥ 0.5). Resultantly, it was found that all items can be used, as expert consensus has been achieved. The framework has implications for students' employability and supports the growth of both industry stakeholders and TVET institutions. The study recommends TVET trainers take a sabbatical to stay abreast of current industry practices and retain the TVET ecosystem with affiliated companies.

Keywords: Demand-Driven, Experts' Consensus, Framework, Fuzzy Delphi, TVET

Introduction

Technical and vocational education and training or TVET is a process that is job-oriented and emphasises industrial practices in various fields. TVET holds an integral part in the educational system to foster economic and social modernization. It imparts skills, expands jobs, improves income, and bestows steady perks on students. In Malaysia, TVET is leveraged to mitigate reliance on skilled foreign workers (Ahmad & Rosnan, 2024). The government is deeply concerned about the unemployment rate, particularly the youth (Fung & Nga, 2023).

The industrial recruiters issued a problem that they prefer to hire foreigners due to mismatches in skills amongst local graduates (Wei & Yew, 2024). Cognizant of this matter, the

government urged higher education, especially TVET institutions, to implement demand-driven systems within their curricula (Yunus et al., 2024). From a business standpoint, education lines are convenient for offering courses based on supply-driven, yet producing graduates' skills not aligning with the available vacancy position (Anafi & Noor, 2024). This disconnect may lead to an underprepared workforce that hinder economic progress (Rus et al., 2023). To confront this issue, industrial and educational institutions must collaborate to ensure that courses are designed to fulfil real world job prerequisites (Ibrahim & Nashir, 2022).

In this regard, the research question for this study is, "What are the elements in the demand-driven TVET framework construct based on experts' consensus?" The objective of this study is to develop a framework for demand-driven TVET institutions in Malaysia. The scope of this study targets academic experts in the Malaysian higher education sector, covering both public and private universities. The respondents are from three expertise backgrounds, namely, TVET, education, and engineering. This study is significant because it addresses the elements in TVET training that align with job market needs, thus leading to better job placement for graduates. The approach is tied to incorporating industry interaction to co-devising courses of study, thereby reducing the workforce's supply and demand mismatch. In the context of TVET institutions in Malaysia, it incorporates educational entities such as technology universities, vocational colleges, training centres, and technical schools. However, they all serve a common purpose, which is to produce skilled manpower and accommodate industry demand. Considering this scenario, the development of a framework is perceived as a potential means of providing clear guidance for the implementation of the TVET system in terms of planning and decision-making.

The outcomes of the study contribute to Malaysian TVET programmes by aiding in the development of the curriculum as well as the skills gaps that employers seek to fill. The findings can substantially strengthen the TVET system through a comprehensive framework that scrutinises purpose, industry demands, challenges, offers to students, execution to achieve objectives, collaboration, graduates' quality assurance, and customer satisfaction. Moreover, these insights can be applied to refine the overall performance and effectiveness of TVET institutions.

Literature Review

By 2025, Malaysia has 1,398 TVET institutes, comprising 701 public and 697 private ones (Khalid et al., 2025). This indicates that they compete to deliver outstanding education and conducive facilities (Jamil et al., 2023). Likewise, during the Fourth Industrial Revolution (IR 4.0), they are encountering swift technological changes in areas like artificial intelligence (AI), robotics, advanced machinery, and Internet of Things (IoT) devices (Fadel & Ishar, 2022). TVET faces problems as student enrolment grows, including potential strain on infrastructure and amplify staff assistance (Hani et al., 2024). Additionally, sustaining a high number of students per lecturer has a profound impact on student learning outcomes (Hassan & Anees, 2024). Larger class sizes obstruct efforts for lecturers to attend to students' requests and build connections (Jamil et al., 2022).

Ergo, the development of a demand-driven framework for TVET is necessary, which focuses on identifying and responding to the optimal operation of the industry (Mohamad et

al., 2023). It entails sharing experiences with the industry and continually updating courses to align with the latest technological advancements (Dwiyanti & Ridwan, 2024). Furthermore, this endeavour also seeks to match TVET curricula with current career prospects (Enamudu et al., 2024). The strategy calls for active engagement of employers and educational institutions in identifying skills gaps and ensuring that academic syllabuses are designed to produce graduates with the competencies sought by the workforce (Gani & Halim, 2024).

The reason is that, to thrive, TVET readiness must entice students and offer study programmes that are relevant to current industry needs (Hassan et al., 2024). The key to a demand-driven approach is a reliable student-centred system that prioritises career development (Chang, 2023). The involvement of the industrial sector in TVET training also reduces the mismatch between graduates' skills and job market demand (Syamil & Bassah, 2022). Both students and employers' benefit from a streamlined transition from education to employment (Hermans et al., 2024). This synergy promotes economic growth by evolving the expectation of the job market, ensuring that graduates are well-prepared for future complications (Xin et al., 2024). Consequently, employers who believe in the TVET quality will recruit and pay them appropriately (Jamaludin et al., 2023). These two facets are essential for the workers, since they contribute to their overall career expansion and satisfaction (Pirzada, 2023). When employees sense appreciation, they are more prone to remain devoted to their positions and perform well (Matabane et al., 2022).

A TVET demand-driven learning system, prioritises aligning content, teaching methods, and resources with the stakeholders' preferences (Gupta et al., 2024). This framework caters to quality and regulation of employer requirements (Qiong et al., 2024). The system enables individuals to fulfil the stipulations imposed by the job market, notably those who are adaptable in the fast-paced industrial transformation (Azid et al., 2023). It is important for graduates to possess multitasking abilities, entrepreneurial thinking, fluent languages, a flair for innovative ideas, and creativity (Zainudin et al., 2024). These traits are required for enduring the complexities and adversities at the workplace (Gangoso, 2023).

Methodology

This study employed the Fuzzy Delphi Method (FDM) to secure expert consensus regarding the constructs and elements of the framework. A survey form was utilised as a research tool and distributed to the identified experts. Purposive sampling, a commonly used non-probability technique in qualitative research, was conducted for the purpose of selecting the expert panel.

Meanwhile, consensus analysis via fuzzy set theory involves converting expert opinions from the Likert scale to binary degrees (0, 1). This fuzzy enables the judgements to be represented on average in a more nuanced way. The FDM has been applied in various fields where it helps manage uncertainties and vagueness. There are seven steps in FDM, namely expert panel selection, fuzzification linguistic scale, calculation of fuzzy average, threshold value determination, alpha aggregation, defuzzification process, and fuzzy ranking analysis.

Research Instrument

The research instrument comprises a questionnaire form with two sections: respondent demographics and evaluation. The instrument was constructed using inputs from existing literature, prior research findings, and the researcher's experiential knowledge. As an initial step in confirming the instrument's accuracy and validity, content and language validation was acquired from scholars with expertise relevant to the study's scope. The prototype demand-driven TVET framework contains three constructs (input, process, and output) and eight items to be assessed, consisting of purpose, industry demands, challenges, offers to students, execution to achieve objectives, collaboration, graduates' quality assurance, and customer satisfaction. Expert agreement was measured with a seven-point linguistic scale, resulting in more precise outcomes as illustrated in Table 1.

Table 1
Linguistic Variable Scale

Linguistic Variable	**Fuzzy Scale**	**Likert Scale**
Strongly disagree	(0.0,0.0,0.1)	1
Somewhat disagree	(0.0,0.1,0.3)	2
Disagree	(0.1,0.3,0.5)	3
Neutral	(0.3,0.5,0.7)	4
Agree	(0.5,0.7,0.9)	5
Somewhat agree	(0.7,0.9,1.0)	6
Strongly agree	(0.9,1.0,1.0)	7

Analyzing Fuzzy Delphi

Step 1: Expert Panel Selection

In this step, a panel of 13 qualified researchers was selected who adhered to the criteria of position, university location, scope of expertise, and duration of experience. According to Jones and Twiss, the recommended expert cohort for FDM ranges from 10 to 50 persons, which may suffice (Jones & Twiss, 1978). As to the factor of location distance, the expert panel was invited to participate by email. Indeed, email provides numerous advantages, including speed, accessibility, cost-effectiveness, time savings, and the ability to record written communication. It's a convenient way to reach individuals or large groups. Email also facilitates file sharing by allowing users to attach files and distribute them to recipients.

Step 2: Fuzzification Linguistic Scale

The second step is evaluating the linguistic scale. This process, known as fuzzification, converts the linguistic variables into triangular fuzzy numbers. These numbers represent potential values through a defined membership function. They are characterised by a triplet point designated as m1, m2, and m3. Subsequently, to transform linguistic variables into fuzzy numbers, a fuzzy scale is implemented using a triangular fuzzy number. Figure 1 displays graph representing the mean triangular distribution plotted with respect to the triangular value, which contains the three values defining the triangular fuzzy number. The triangles mean versus the triangular value graph, whereby m1 corresponds to the minimum value, m2 to the moderate value, and m3 to the maximum value.

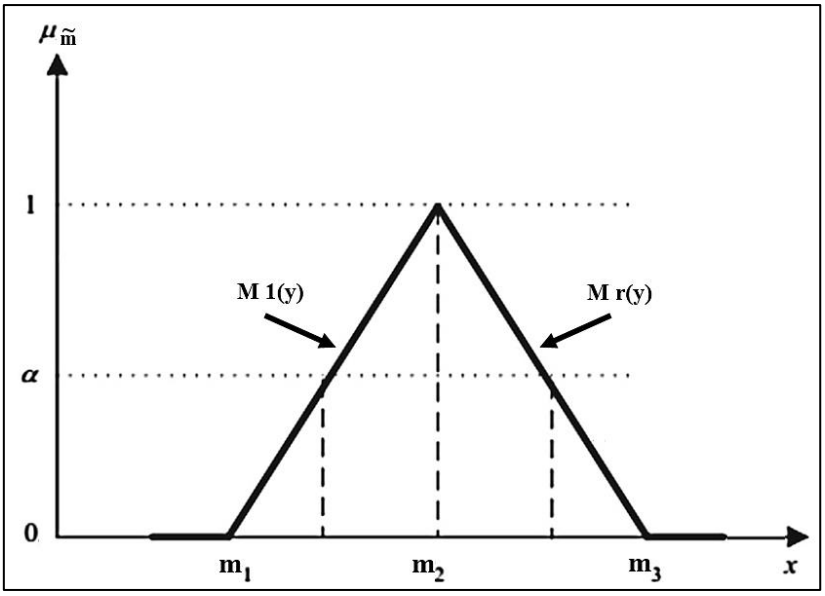

Figure 1. Triangular Fuzzy Number

Step 3: Calculation of Fuzzy Average

The third step is fuzzy average calculation, where the responses obtained from the expert panel are converted from a Likert scale to a fuzzy scale using Equation 1.

$$M = \frac{\sum_i^n = mi}{n} \tag{1}$$

Step 4: Threshold Value Determination

Step four involves determining the threshold value (d). The threshold value matters because it stands for the minimum point in the process of quantifying the amount of expert concurrence. Equation 2 is used to determine the threshold value for the fuzzy numbers m = (m1, m2, m3) and n = (n1, n2, n3).

$$d(m,n) = \sqrt{\frac{1}{3}[(m_1 - n_1)^2 + (m_2 - n_2)^2 + (m_3 - n_3)^2]} \tag{2}$$

Consensus among experts is deemed to have been attained if the threshold value is less than or equal to 0.2. Meanwhile, for consensus to be established, expert agreement on each item must be 75% or exceed. In cases where the threshold value ($d \leq 0.2$) and the minimum agreement level (≥ 75%) are unaccomplished, a second round must be initiated.

Step 5: Alpha Aggregation

The fifth step is to perform alpha aggregation on the fuzzy set to calculate the α-cut level by using Equation 3.

$$A = \begin{bmatrix} A_1 \\ A_2 \\ \vdots \\ A_m \end{bmatrix} di\ mana\ A = r_{i1} \times w_1 + r_{i2} \times w_2 + \cdots \cdots r_{in} \times w_n$$

(3)

Alpha aggregation, often known as the aggregation operator (corresponding to α-cut), is a way to merge the fuzzy sets. The process involves intersecting the fuzzy set at multiple alpha levels, thereby leading to a clear representation of the fuzzy set. Typically, this technique is used in decision-making because it makes it easier to analyse complex and vague data.

Step 6: Defuzzification Process

Defuzzification process constitutes the sixth step of the procedure. The process is intended to extract a discrete number from the fuzzy aggregate group output. It serves to convert the fuzzy inference result into a precise data point. In other words, a decision-making algorithm is applied to extract the optimal value from the fuzzy set. This process is conducted by using Equation 4.

$$A_{max} = \frac{1}{3}(m_1 + m_2 + m_3)$$

(4)

The fuzzy set of numbers will be transformed into a set with membership degrees between 0 and 1 into a single definite number. Should the (A) value fall below the α-cut value of 0.5, the item is considered to lack expert agreement and will be discarded. This is because the α-cut value denotes the midpoint between 0 and 1, implying that the (A) value below 0.5 clarifies a lack of unanimity within the expert panel.

Step 7: Fuzzy Ranking Analysis

The final step of FDM is the fuzzy ranking analysis. The ranking analysis is undertaken based on the outcomes of the defuzzification values (A), with the highest score assigned the top position within the constructed framework. The scores are utilised to rank items according to the collective judgement of experts. The primary intention is to generate the relative order of fuzzy values, indicating which items are more or less desirable. Fuzzy ranking is applied to compare and rank fuzzy values, identifying their relative order for evaluating items in the framework decision. The mean of the (A) value is used as an indicator in the positioning process, and prioritising the most important items takes precedence in the framework development.

Results

Expert Profile

A total of 13 experts who were educators from Malaysian universities formally agreed over email to participate as a panellist. Table 2 shows the experts' profiles, including their positions and experience in fields relevant to the study.

Table 2
Experts Profiles

Expert	Designation	Expertise	University
E1	Professor	Computer Engineering	UNITEN
E2	Professor	Nanomaterial Engineering	MMU
E3	Professor	Education	UiTM
E4	Associate Professor	TVET	UTHM
E5	Associate Professor	TVET	UUM
E6	Associate Professor	TVET	UPSI
E7	Associate Professor	Education	UNIMAS
E8	Associate Professor	Engineering Education	Sunway University
E9	Associate Professor	Electrical Engineering	UNISEL
E10	Associate Professor	Mechanical Engineering	UTP
E11	Senior Lecturer	TVET	USM
E12	Senior Lecturer	TVET	USM
E13	Senior Lecturer	Civil Engineering	UTAR

The criteria for selecting experts featured working at a public or private university, having more than ten years of experience, being a faculty member, conducting continuous research, publishing papers and books, being involved in organisational management, and mastering the language of the research instrument. The experts were contacted through official email. Once they agreed to be a part of the expert panel, they were given the questionnaire and submitted it in less than three months. Prior to deploying the survey, the form underwent both face validity and content validity checks. The questionnaire form has undergone a review process to verify its relevance and that the content accurately represents the intended purpose of the measurement. Face validation, in this context, assesses whether the form appears to measure what it's supposed to, while content validation assesses if the questions adequately cover the relevant aspects of the construct being measured.

Fuzzy Delphi Analysis

In this work, the findings are presented through three constructs and eight items in developing a demand-driven TVET institution framework. The constructs are input (items 1-3), process (items 4-6), and output (items 7-8). The items include purpose, industry demands, challenges, offers to students, execution to achieve objectives, collaboration, graduates' quality assurance, and customer satisfaction.

Construct 1 (Input)

Table 3 points out the fuzzy Delphi analysis results regarding the functionalities of construct 1 (input), as agreed upon by the experts. There are three items: purpose, industry demands, and challenges.

Table 3
Analysis Results on Input Construct

Statistics	Item 1	Item 2	Item 3
Value of the item	0.154	0.081	0.060
Item < 0.2	11	12	13
% Of item < 0.2	85%	92%	100%
Defuzzification	0.900	0.936	0.946
Ranking	7	6	3
Status	Accepted	Accepted	Accepted
Value of the construct	0.098		

Construct 2 (Process)
Table 4 displays the fuzzy Delphi score value for construct 2 (process), which consists of three items: offers to students, execution to achieve objectives, and collaboration, respectively.

Table 4
Analysis Results on Process Construct

Statistics	Item 4	Item 5	Item 6
Value of the item	0.181	0.067	0.033
Item < 0.2	10	12	13
% Of item < 0.2	77%	92%	100%
Defuzzification	0.879	0.944	0.956
Ranking	8	5	1
Status	Accepted	Accepted	Accepted
Value of the construct	0.094		

Construct 3 (Output)
The analysis results for construct 3 (Output) are presented in Table 5, encompassing two items: graduates' quality assurance, and customer satisfaction.

Table 5
Analysis Results on Output Construct

Statistics	Item 7	Item 5
Value of the item	0.033	0.056
Item < 0.2	13	12
% Of item < 0.2	100%	92%
Defuzzification	0.956	0.946
Ranking	1	3
Status	Accepted	Accepted
Value of the construct	0.045	

Expert Consensus
Table 6 summarises the whole analysis findings of the expert consensus and construct ranking. The study instrument comprises eight items categorised into three constructs, namely (i) input, (ii) process, and (iii) output. The data were analysed by using the Delphi fuzzy

triangle numbering method, while the hierarchical position of each item was determined through the defuzzification process.

Table 6
Expert Consensus and Construct Ranking

Construct/Item	Fuzzy score (A)	Expert consensus	Ranking
Construct 1: Input Item			
1. Purpose	0.900	85%	7
2. Industry demands	0.936	92%	6
3. Challenges	0.946	100%	3
Construct 2: Process			
4. Offers to students	0.879	77%	8
5. Execution to achieve objectives	0.944	92%	5
6. Collaboration	0.956	100%	1
Construct 3: Output			
7. Graduates' quality assurance	0.956	100%	1
8. Customer satisfaction	0.946	92%	3
Value of the construct	0.083		
Average of % consensus	92%		

All items, hence, met the set acceptance parameters. The analysis revealed that the expert panel unanimously accepted all presented items, with consensus values indicating a high level of significance. Besides, the panel agreed on the priority hierarchy of the developed items.

Final Framework

From the data collected, it emerged that the prototype framework design has achieved expert consensus. Data analysis indicated that all fuzzy specifications were met, specifically that the (d) value was under 0.2, the degree of agreement among experts surpassed 75%, and the defuzzification value (alpha cut) was at least 0.5. Figure 2 depicts the final framework that all 13 experts have agreed upon.

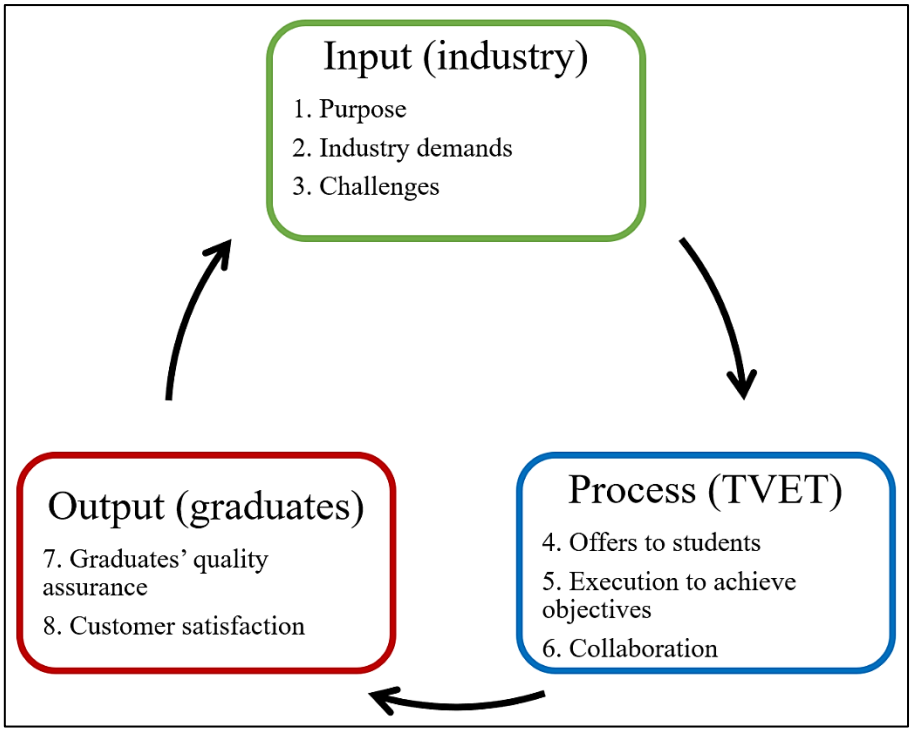

Figure 2. The Final TVET Institution Framework

Discussion

The expert panel without opposition accepted all items with consensus values indicating high significance, effectively addressing the research question. The analysis revealed that 'collaboration' and 'graduates' quality assurance' received the highest levels of consensus out of all items. Collaboration between industry and institutions is essential to tackling the persistent hurdles of skills mismatch and unemployment rates in TVET graduates (Jie & Yasin, 2022). Meanwhile, graduates' quality assurance means that high quality TVET training modules produce graduates who earn industry trust, paving the way for partnerships, internships, and job placements (Niyonasenze et al., 2025).

The second highest-ranking items were 'challenges' and 'customer satisfaction'. In terms of challenges, TVET faces numerous obstacles, including difficulties in keeping pace with industry needs, changes in industrial technology, limited training facilities, and insufficient resources allocated for updating high-tech machinery (Ridzuan & Junaidi, 2023). The customer satisfaction factor, particularly student satisfaction, reflects how students perceive and evaluate their experiences within a TVET setting (Haminuddin et al., 2024). Satisfaction is influenced by a vast array of factors, including academic quality, non-academic services (such as food and facilities), enforcement of rules, and the treatment by management (Mahlangu & Mtshali, 2024). By concentrating on improving these factors, the institution boosts student retention, loyalty, and ultimately, their overall success in entering the workforce (Makinde & Bamiro, 2023).

The next ranking was 'execution to achieve objectives' item. It relates to the effective implementation and achievement of objectives in TVET institutions, which require strategic plans (Saad et al., 2024). TVET management is responsible for a wide range of duties, including outlining the vision, mission, and goals, as well as curriculum accreditation, personnel administration, and financial planning (Chear & Arifin, 2024). Followed by the item 'industry

demand'. In Malaysia, industry demand for TVET is high due to the increasing need for skilled workers in myriad sectors (Amin et al., 2023). TVET institutes serve as the foundation for supplying manpower to meet industrial demands and support economic development (Minghat et al., 2022). TVET has been created to cultivate and prepare students to work independently, without requiring much supervision (Nordin & Omar, 2024). TVET students are trained to face a real job environment from the first day of class, whether they are learning theory, doing hands-on work, repairing machinery, programming code, or conducting lab tests (Mutebi & Ferej, 2023).

According to experts, the least favourable items are 'purpose' and 'offer to students'. Both items are subject to modification and will vary depending upon how the institute operates. The main purpose of TVET is to provide skills-specific learning opportunities to enable students to get jobs or start businesses (Sulaiman et al., 2024). TVET programmes cater to vocational training as an alternative academic track, which underlines job descriptions and industrial standards (Nor & Ismail, 2024). TVET institutions offer tertiary education to school leavers at certificate, diploma, and degree levels through several ministries (Kamarulzalis, 2024). They are equipped with a range of facilities, including workshops, laboratories, classrooms, hostels, libraries, cafeteria, auditorium, halls, administrative buildings, and sports areas (Hamid et al., 2023).

Conclusion

Along with the industrial shift accelerating, TVET institutions ought to understand how industrial changes impact their roles. This understanding is geared towards providing students with the skills and knowledge needed by the current workforce and in years to come. The study developed a demand-driven framework for TVET institutions, suggesting a systematic way for TVET to maintain stability and vibrancy. Starting from the core purpose of establishment until student graduation, this TVET framework comes with all the bells and whistles. The framework has three constructs, which are input, process, and output. The findings of the FDM analysis revealed that all eight items from the three constructs attained expert consensus, thereby signifying that the research question and research objective have been finalised. The framework comprises several key elements, including its purpose, industry demands, challenges, offers to students, execution to achieve objectives, collaboration, graduates' quality assurance, and customer satisfaction.

The significance of this framework is that it serves not only as a guide per se but also as a roadmap for development, improvement, and consistency to maximise TVET benefits. In fact, the study impacts the students, institutions, stakeholders, workforce, and employer by providing a viable framework that perpetually bridges the gap between TVET and industrial sectors. Albeit changes in the industry's expectations of workforce capabilities over time are inevitable, it is recommended that TVET institutions adopt the proposed framework due to its inherent adaptability, allowing for continuous alignment with evolving industry constraints. Ongoing reviews and stakeholder engagement should be institutionalised to prevent unforeseen circumstances that may impede the TVET's headway from revising upcoming threats in a timely manner.

Finally, pertaining to the ubiquity of foreign workers, the conundrum shall be alleviated with specific industry training for workers who are still ambiguous in their work

skills. The study recommends TVET trainers take a sabbatical to stay abreast of current industry practices and retain the TVET ecosystem with affiliated companies.

Appendix

MMU	Multimedia University
UiTM	MARA Technological University
UNIMAS	University of Malaysia, Sarawak
UNISEL	University of Selangor
UNITEN	National Energy University
UPSI	Sultan Idris Education University
USM	University of Science Malaysia
UTAR	Tunku Abdul Rahman University
UTHM	Tun Hussein Onn University of Malaysia
UTP	PETRONAS University of Technology
UUM	Northern University of Malaysia

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