

Fostering a Synergistic Approach to Curriculum Development and TVET-Engineering Qualifications

Affandi, H. M.^{1,2*}, Sohimi, N. E.^{1,2} Subri, U. S.³, Lazaro M. H.⁴ Yunus, F.A.N.⁵ & Yunus, S.N.M.^{1,2}

¹ Department of Engineering Education, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, 43600 Bangi, MALAYSIA

² Kumpulan Penyelidikan Universiti Dinamika TVET, Universiti Kebangsaan Malaysia, 43600 Bangi, MALAYSIA

³ School of Education Studies, Universiti Sains Malaysia, 11800 Pulau Pinang, MALAYSIA

⁴ Department of Education, Stockholm University, SWEDEN

⁵ Faculty of Technical and Vocational Education, Universiti Tun Hussein Onn Malaysia, 86400 Batu Pahat, Johor, MALAYSIA

*Corresponding Author: haryantima@ukm.edu.my
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Abstract

The involvement of various stakeholders, aligning diverse interests, and evolving industry requirements are some areas that need careful consideration. The dynamics of power and authority between collaborating partners can affect the efficacy of the collaborative relationship; hence, further study is required to identify obstacles in such partnerships and propose solutions for overcoming them. This study aims to build a collaboration paradigm between the TVET engineering sector and the industry, emphasizing curriculum development and TVET engineering credentials. This quantitative study employs a survey to collect information from 115 Malaysian technologists in three fields. Simple random selection ensures accurate demographic representation and an even distribution of bias. Four experts developed and validated a questionnaire. Data was evaluated using PLS-SEM 3.3.9 software, algorithms, bootstrapping, and blindfolding techniques. The measurement model evaluates the items' precision under validity and reliability requirements. The results indicate a significant relationship between the certification system and curriculum development. The model has a high predictive power value with a significant contribution from the free extract. The influence of size is likewise considerable, but the effect of curriculum TVET is minor. The findings provide valuable insights into the predictive validity of the model and its possible curriculum development applications. A deliberate effort is required to overcome obstacles such as lack of coordination, scarce resources, and low public awareness.

1. Introduction

According to The Asia Foundation, industrialized and developing nations increasingly realize the potential of technical and vocational education and training (TVET) to drive national socio-economic growth (2022). TVET's

function has shifted from just training employees for entry-level employment to becoming a crucial instrument for sustainable development through supporting the formation of human capital for industrialization. This shift in viewpoint has been significantly influenced by the evolution of the labor market and the changing nature of work (Ahmad, 2021). TVET, which is fundamentally an occupation-focused training approach, emphasizes industrial methods to produce competent labor in specific fields. The TVET framework must be linked with current employment requirements in producing competent labor, emphasizing practical components, psychomotor skills, and industry-focused training (Ahmad, 2021).

Scholars have advocated for policy reform to build a comprehensive TVET curriculum with cultural linkages for industrial growth (D. et al., 2021). However, integrating the academic curriculum with the demands of business is a concept that has been the subject of extensive debate within the field of TVET. Understanding the role of each stakeholder in developing and implementing management systems is essential for productive collaboration between educational and training institutions and the business sector. This engagement must be aimed toward collaborative decision-making for the organization's and, ultimately, the nation's benefit (Nevin, 2014; Rouke et al., 2014; Scandura, 2015; Ivascu et al., 2016; and Azali, 2018).

According to Norazimah (2013), collaboration is a relationship that uses the knowledge and skills of educational and training institutions and the industry. Thus, the partnership functions as a cooperative network that aims to create a balanced ecosystem in the job and training sectors. Multiple studies demonstrate the significance of such partnerships for accomplishing the goal of generating a competent workforce (Miller et al., 2009; Heinemann et al., 2009; Ramli, 2011; Mohtadi et al., 2014; Shamsudin et al., 2015; Abdul Wahid, 2015; Belyaeva et al., 2017; and Azali, 2018). Furthermore, Subri et al. (2022) suggest that strategic cooperation between educational and training institutions and the industry is essential for producing a skilled workforce that fulfills industry requirements. The participation of TVET institutions and industry in reskilling and upskilling trainers is crucial to this relationship since it ensures that TVET students obtain current technical knowledge (Yadav & Shrivastava, 2015).

However, forming and maintaining public-private partnerships required both sides' open expression of interests, beliefs, and goals. This level of transparency is critical for successful strategic relationships at both the individual and institutional/organizational levels. TVET institutions and companies play a crucial role in bridging the skills gap and lowering unemployment among TVET graduates by providing them with creativity, problem-solving abilities, and a dedication to lifelong learning (Getahun, M., 2018). Despite these benefits, the relationship between industry and academia is challenging. Identifying the obstacles to such cooperation and developing techniques to overcome them will be critical aspects of future studies. The participation of numerous stakeholders, the alignment of varied interests, and the ever-evolving nature of industrial requirements are a few areas that demand careful study. Furthermore, it is crucial to deliberately handle the dynamics of power and authority between the cooperating parties, as they can significantly impact the efficacy of the collaborative partnership. Therefore, this study aims to develop a collaboration paradigm between the TVET engineering sector and the industry, emphasizing curriculum development and TVET engineering credentials.

2. Navigating the TVET-Engineering Curriculum: An Overview

The Technical and Vocational Education and Training (TVET) system is experiencing considerable changes in some nations, including Malaysia, particularly in its curriculum and delivery methods (Ministry of Higher Education, 2017). However, a thorough study reveals several significant flaws. Existing TVET programs in Malaysia are primarily supply-driven, and there appears to be an insufficient emphasis on matching training with actual labor market needs (Ismail & Abiddin, 2014). This strategy has resulted in a mismatch between the abilities of TVET graduates and those required by employers, a problem mainly attributable to the need for industry input in curriculum creation (Yaakob, 2017). Malaysia has made tremendous achievements in improving the TVET engineering curriculum despite the problems mentioned earlier. The TVET Engineering program has been accredited by the Technologists and Technicians Act 2015 (Act 768). The Malaysian Board of Technologies (MBOT) and the Board of Engineers Malaysia (BEM) have implemented the Regulations of the Registration of Engineers Act (1967).

This project recognizes these organizations' efforts to enhance the quality of TVET programs. However, the need for a balanced TVET curriculum that includes technical and non-technical components remains. Increased industry participation in curriculum development is critical for aligning skills training with industry expectations. The collaboration between industry and academia in developing the TVET curriculum will facilitate the formation of knowledge with the support of experts and experienced persons in the industry that can give the right direction to enthusiastic, intelligent students and make them future experts (Dhamdhare, 2015). Historically, the Department of Skills Development (DSD) for the skills sector and the Malaysian Qualifications Agency (MQA) for the vocational and technical sectors jointly controlled the academic sector and ensured the quality of TVET programs in Malaysia. These functions have been concentrated under the DSD in recent years, culminating in the establishment of the Malaysian Qualifications Framework (MQF) in 2017. This effort aims to create a more

cohesive framework that encompasses the categories of skills, vocational education, and technical education under the umbrella of TVET.

The difficulty of ensuring uniform quality across all TVET courses, regardless of their discipline, continues despite the simplification of accreditation under this new system, which recognizes undergraduate degrees. The Code of Practice for TVET Program Accreditation (COPTPA) spearheads efforts to standardize the TVET framework, ensuring that all TVET programs adhere to and uphold quality standards. However, a competent TVET education system's effectiveness depends on infrastructure, resources, and the curriculum. To be successful, TVET institutes must have sufficient facilities for teaching and learning. Such facilities include classrooms, learning support facilities, information resources such as libraries, computer and IT systems, labs, workshops, and other equipment. Unfortunately, many TVET teaching and training materials are usually outdated and unrelated to the skills required for growth. To overcome this issue, industry representatives must play a more active role in developing the TVET curriculum.

The Ministry of Education (MOE, 2021) proposed strengthening relationships between colleges and industry to equip institutions with training facilities and tailor training programs to the demands of diverse industries. Moreover, the collaboration between industry and academia in developing TVET will facilitate the formation of knowledge with the support of experts and experienced persons in the industry that can give the right direction to enthusiastic, intelligent students and make them future experts (Dhamdhare, 2015). Thus, the public-private partnership model was adapted for this research. The importance of a public-private partnership is that it allows for a simultaneous increase in investment support for higher education (due to joint public and private financing) and an increase in the effectiveness of university management (Termes et al., 2020; Barrera Osorio et al., 2022). The quality of vocational training (Olmedo Moreno et al., 2021; Vanderburg et al., 2022) and the ease of finding skilled employees (Halili et al., 2022; Maddah et al., 2023) significantly influence the development of higher education in the social and investment model of economic growth, according to similar studies. All these variables in these variables in this study were developed from the Final Report for Regional PPP New Models (2017), Dadang Hidayat Martawijaya (2012), Hadromi (2018), Wiriadidjaja et al. (2019), Sutopo (2017), Seel & Phuong (2020), European Union (2014), Phalasoan (2017), Bui Van Hong & Nguyen Thi Luong (2018), European Union (2018), Choy et al. (2004), Ferns (2019), Haukka (2007), Euler (2013), Manuela Epure (2017), Thomas Deissinger (2015), Huynh Chau Duy (2019), European Union (2017), and Littooij Siep & Todd Davey (2016).

3. Methodology

This survey-based study employs quantitative methodology to gather data and achieve its objectives. The sample of this study involved 115 technologists in three fields: mechanical, electrical, electronic, and civil. This study employed a basic random sampling technique. This study used random sampling to ensure the sample was representative of the population and to evenly distribute any bias among the selected individuals (Creswell, 2012). Four mechanical, electrical, electronic, and civil engineering specialists have validated the questionnaire designed and adapted from prior studies. The instrument of this study was designed in two major parts: Part A is respondent demography, and Part B is the development of Malaysian TVET-engineering institutions and industry partnership models. Part A consists of 4 items: job or position, organization name, expertise, and working experience (years).

Meanwhile, Part B has 27 items measuring five variables: Accreditation Body, Industry Role, Teaching and Learning, Element Improvements in Curriculum, and Competency Certificate. The acquired data were analyzed using the PLS-SEM 3.3.9 program, utilizing the algorithm, bootstrapping, and blindfolding methods. The measurement model is undertaken to establish the extent to which the items measure what should be measured, their accuracy in reflecting a construct, and whether they meet the validity and reliability criteria (Ummu Sakinah, 2020).

4. Results

This study utilized a PLS-SEM approach to analyze (a) convergent validity and (b) discriminant validity, each of which has six analyses: external loading, (ii) composite reliability, (iii) average variance extracted (AVE), (iv) Fornell-Larcker, (v) cross-loading, and (vi) heterotrait-monotrait ratio (HTMT). In the meantime, the testing of the structural model includes the examination of (i) multicollinearity (inner VIF), (ii) path coefficient, (iii) R square (R²), (iv) size impact (f²), and (v) predictive relevance (Q²).

4.1 Convergent Validity

The values of (i) outer loading, (ii) composite reliability, and (iii) average variance extracted (AVE) demonstrate the convergence validity. The external load, or outer load, is the standard load that connects the factor to the indicator variable. If the value of AVE is more significant than 0.50, we should consider any load values that fall between 0.50 and 0.70 (Hair et al., 2016). While composite reliability is an alternative to Cronbach's alpha as a

convergent validity test in a reflective model, the composite reliability should be >0.70 for a model aimed at authentication (Hair et al., 2016). Finally, the AVE can also test for convergence and differentiated legitimacy. It represents the average community for every latent factor in a reflective model. In a reproductive model, the AVE should be >0.50 (Hair et al., 2016). This means that the factor should explain at least half of the variation in each indicator. An AVE that is <0.50 means that the error variance is beyond the variation described. Table 1 shows that all external loading values, composite reliability, and AVE for each construct have fulfilled the required conditions of a load value >0.50, composite reliability >0.70, and AVE > 0.50. Table 1 shows that all external loading values, composite reliability, and AVE for each construct have fulfilled the required conditions of a load value >0.50, composite reliability >0.70, and AVE >0.50.

Table 1 Outer loading value, composite reliability (CR) and AVE

No.	Sub-Construct	Elements	Items	Outer loading >0.50	Composite Reliability >0.70	AVE >0.50
1	TVET Qualification System – Engineering	Accreditation Body	PKKBAccreditation1	0.696	0.826	0.615
			PKKBAccreditation2	0.836		
			PKKBAccreditation3	0.814		
		Industry Role	PKKPIndustry1	0.902	0.979	0.839
			PKKPIndustry2	0.925		
			PKKPIndustry3	0.947		
			PKKPIndustry4	0.942		
			PKKPIndustry5	0.921		
			PKKPIndustry6	0.887		
			PKKPIndustry7	0.857		
2	TVET-Engineering Curriculum	Teaching and Learning Methods	PKKPnP1	0.931	0.957	0.848
			PKKPnP2	0.915		
			PKKPnP3	0.934		
			PKKPnP4	0.903		
		Elements Improvement in the curriculum	PKKElementK1	0.916	0.968	0.792
			PKKElementK2	0.911		
			PKKElementK3	0.912		
			PKKElementK4	0.696		
			PKKElementK5	0.91		
			PKKElementK6	0.935		
PKKElementK7	0.964					
PKKElementK8	0.848					
Competency Certificate	PKKCertificateK1	0.982	0.935	0.829		
	PKKCertificateK2	0.922				
	PKKCertificateK3	0.82				

4.2 Discriminant Validity

Measuring discriminant validity is based on (i) Fornell-Larcker, (ii) cross-loading, and (iii) heterotrait-monotrait (HTMT) Fornell-Larcker.

4.2.1 Fornell-Larcker

This analysis compares the square root value of AVE with the construct correlation value, indicating the highest value in any column or row compared to the highest correlation value for any other construct (Hair et al., 2016). This method is based on the view that the latent variable should explain the item variant better than the variant for other latent variables. Table 2 shows the higher square root values of AVE compared to the correlation values for each of the other constructs.

Table 2 Fornell-Lacker

Sub-construct	Accreditation Body	Competency Certificate	Element Improvements	Industry Role	Teaching & Learning
Accreditation Body	0.786				
Competency Certificate	0.355	0.911			
Element Improvements	0.176	0.836	0.89		
Industry Role	0.229	0.807	0.88	0.936	
Teaching & Learning	0.179	0.783	0.807	0.93	0.921

4.2.2 Heterotrait-Monotrait (HTMT)

In the appropriate model, the heterotrait correlation should be smaller than the monotrait correlation, where the HTMT ratio should be <1.00 (Hair et al., 2016). Hence, this study's heterotrait-monotrait (HTMT) ratio has been achieved with all values being <1.00 , as illustrated in Table 3.

Table 3 Heterotrait-Monotrait (HTMT)

Sub-construct	Accreditation Body	Competency Cert	Element improvements	Industry Role	Teaching & Learning
Accreditation Body					
Competency Cert	0.423				
Element improvements	0.238	0.884			
Industry Role	0.239	0.856	0.918		
Teaching & Learning	0.223	0.846	0.95	0.971	

4.3 Structural Model Testing

Structural model testing involves the analysis of i) internal VIF or Multicollinearity (Inner VIF), (ii) structural model coefficient (β), (iii) determination coefficient (R square, R^2), (iv) size effect (f^2), and (v) predictive relevance, Q^2 .

4.3.1 Internal VIF or Multicollinearity (Inner VIF)

A multicollinearity test determines whether the independent variables are redundant. Collinearity is said to exist in the case of $VIF < 5.00$ (Hair et al., 2016). The results of multicollinearity analysis in this study are presented in Table 4, which shows that all VIF test values are < 5.00 . Therefore, each variable has met the appropriate VIF criteria.

Table 4 Internal VIF or multicollinearity (Inner VIF)

Construct	Curriculum Development
Curriculum TVET	4.989
Qualification System	3.889

4.3.3 Path coefficient (β)

The β value of each route in the hypothesis model is calculated; the greater the value of β , the more significant the impact on endogenous latent construction. However, the β values need to be verified for significance through the T- T-statistical tests, where the T value should exceed 1.645 for a one-tailed study (Hair et al., 2016). In order to test the importance of path coefficients and T-statistics, a bootstrapping procedure is performed. Table 5 shows that the Qualification system construct has the highest path coefficient of $\beta = 0.854$ compared to other extracts.

Table 5 Path coefficient (β)

Construct	Mean (M) / Beta (β)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values
Curriculum TVET → Curriculum Development	0.039	0.141	0.346	0.73
Qualification system → Curriculum Development	0.854	0.141	5.96	0

Meanwhile, the predicted hypotheses of this study are H1: The qualification system factor has a significant relationship with affecting curriculum development with $p = 0.00 < 0.05$.

4.3.4 R Square (R^2)

The contribution value of all variables can be seen through the R square (R^2) values. The value of $R^2 > 0.67$ is substantial, $R^2 > 0.33$ is moderate, and $R^2 > 0.19$ is weak (Hair et al., 2016). The result shows that the model of this study has a substantial predictive power value of $R^2 = 0.787$ (mentioned in the abstract as 0.787%), where the value of free extract contribution is high. This means that the R^2 value suggests that the independent constructs in relation to the dependent construct of the research can explain 78.7% of variants.

4.3.5 Size Effect (f^2)

The side effects can also be evaluated in three sizes, where $0.00 \leq f^2 < 0.15$ is small, $0.15 \leq f^2 < 0.35$ is moderate, and $f^2 \geq 0.35$ is large (Hair et al., 2016). Therefore, the analysis result in Table 6 shows that the qualification system has a strong impact, with the value of $f^2 = 0.46$. Meanwhile, Curriculum TVET has a weak effect of $f^2 = 0.023$.

Table 6 Size effect (f^2)

Construct (exogenous)	Endogenous	R^2 included	R^2 excluded	f^2
Qualification system	Curriculum Development	0.787	0.689	0.460094
	Curriculum Development	0.787	0.782	0.023474

4.3.6 Predictive Relevance (Q^2)

The measured Q^2 value must be greater than zero for specific endogenous latent constructions (Hair et al., 2016). Therefore, the blindfolding analysis result in Table 7 shows that $Q^2 = 0.601$ and that this value meets the Q^2 criteria of $Q^2 > 0$. This value proves that the model is predictively relevant. Figure 1 shows the structural model of the curriculum development model that has been developed.

Table 7 Predictive relevance (Q^2)

Variable	SSO	SSE	$Q^2 (= 1 - SSE/SSO)$
Curriculum Development	342	136.575	0.601

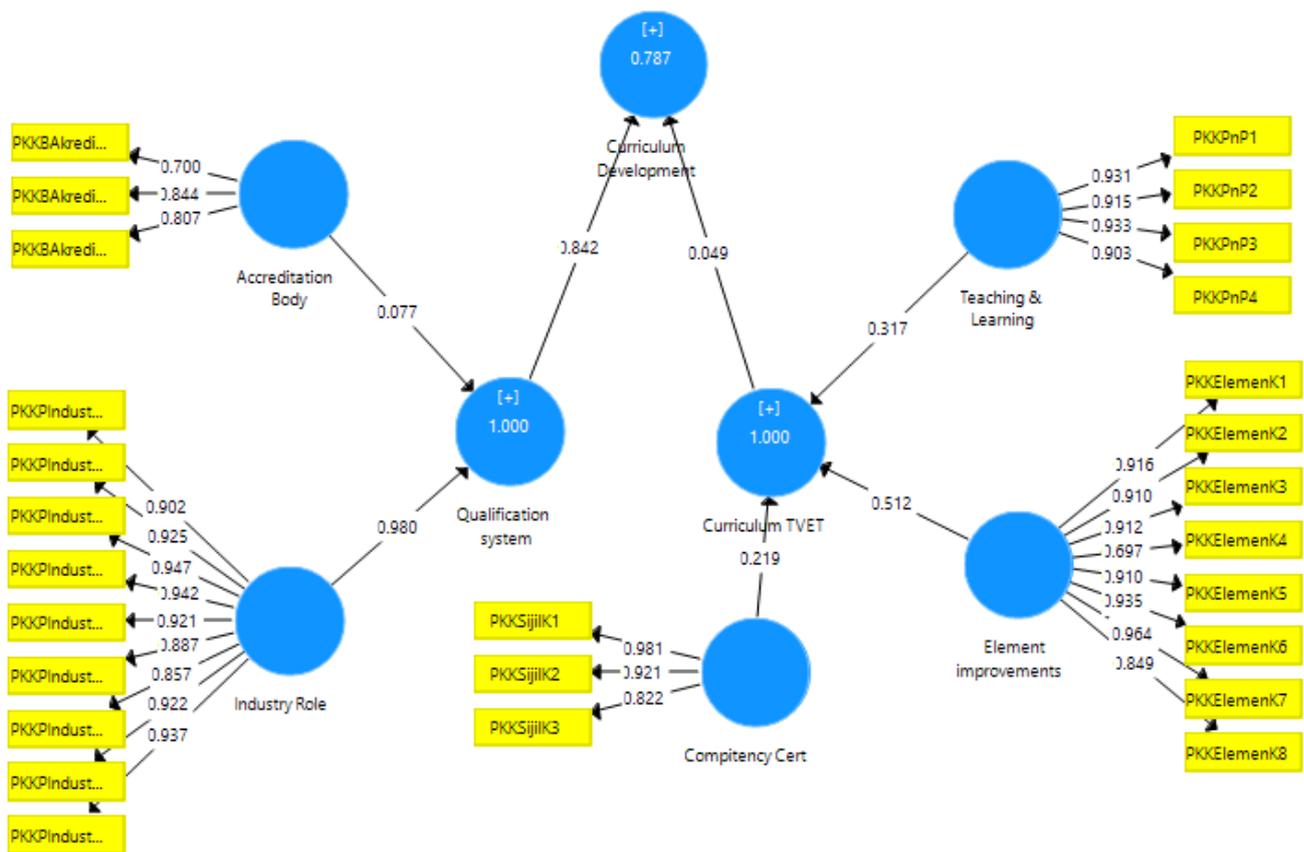


Fig. 1 TVET – Engineering governance structure model

5. Discussion

The findings from the blindfolding analysis (Table 8) demonstrate that the constructed model for curriculum development has predictive validity, as indicated by a Q2 value of 0.601. This value, meeting the $Q2 > 0$ criterion, validates the model's capacity to anticipate outcomes accurately. Figure 1 visually depicts the structural model of the curriculum development model, highlighting the components and interactions. This discussion delves into the model's predictive validity implications and potential applications within the curriculum development sector.

The qualification system plays a crucial role in shaping educational institutions' curricula. It comprises a set of requirements, standards, and evaluations that determine if a student has attained a certain level of knowledge, skills, or competence in a specific field or subject. This system primarily impacts curricula by aligning assessment requirements. For instance, if assessments emphasize specific skills or areas of knowledge, the curriculum should adjust to reflect these priorities, ensuring students are well-prepared (Mouzakitis, 2015). Moreover, the qualification system can influence curriculum content choices. The curriculum must integrate particular content or topic areas mandated by the system.

Additionally, the certification system's defined learning outcomes often influence the curriculum. These outcomes specify the knowledge, skills, and competencies that learners must achieve, guiding the curriculum design to meet these objectives. The qualification system also dictates the types of assessments used to evaluate student performance, incorporating learning activities and assignments into the curriculum to prepare students for various assessment methods like written exams, practical assessments, and projects (Mouzakitis, 2015).

However, the system's effectiveness can be hindered by obstacles such as a lack of coordination and collaboration among stakeholders, leading to a mismatch between the skills of TVET graduates and industry requirements (Paryono, 2017). The qualification system sets the time allocation, which refers to the minimum hours or credits needed for program completion or certification. The curriculum must allocate enough time to cover the required material, allowing students to meet these time-based criteria. Resource constraints significantly impact the quality and effectiveness of TVET programs and the development and implementation of competency-based curricula (Paryono, 2017). When designing curricula, educational institutions must consider the qualification system to ensure that students are adequately prepared and meet the system's requirements. Despite these challenges, educational institutions must balance meeting qualification criteria and providing a well-rounded education that fosters critical thinking, creativity, and various essential skills for modern society.

Industry participation in TVET is indispensable for promoting lifelong learning and aligning education with labor market needs. For example, a robust governance framework in Malaysia is essential for TVET-engineering institutions, where increased business contributions can significantly enhance the TVET system (Alias & Hassan, 2013). Business involvement, such as sharing infrastructure, participating in on-the-job training, dual national training schemes, and sponsoring apprenticeships, can bridge the gap between academic and vocational education. This collaboration ensures that training aligns with industry skill needs and fosters partnerships between educational institutions and businesses (Siddiky & Uh, 2020).

Recent literature highlights the importance of industry collaboration in developing IR4.0 skills for TVET. A study by Mustapha, Saari, and Jalaludin (2023) emphasizes that the industry should be extensively involved in curriculum development and the teaching and learning approaches of TVET. They recommend that TVET institutions create platforms to accept industry opinions and appoint experts from industries for skills development. This collaboration is essential for developing students' employability skills and sharing resources, including skills, knowledge, facilities, and funding (Mustapha et al., 2023). Another study by Stella, Ahmed, and Simon (2022) on TVET institutions and industry collaborative practices in Kenya revealed that TVET institutions know the skills needed but need more collaboration with the industry. The study suggests that TVET institutions form partnerships with specific industries to support laboratory instruction and incorporate industry skills into laboratory practices (Stella et al., 2022).

In conclusion, the certification system and industry participation are crucial for effective TVET implementation. These elements impact curriculum development, promote lifelong learning, and bridge the academic and vocational education gap. Overcoming obstacles such as lack of coordination, resource scarcity, and low public awareness is essential for expanding and enhancing TVET programs, ensuring they prepare students for employment, contributing to economic growth, and promoting social inclusion in a dynamic global market.

6. Conclusion

Effective implementation of TVET programs hinges on a robust certification system and active industry participation. These elements significantly impact curriculum development, lifelong learning, and the integration of academic and vocational education. The results show that the qualification system heavily influences this model, ensuring alignment with assessment requirements and learning outcomes, which is crucial for adequately preparing students. Furthermore, the findings provide valuable insights into the predictive validity of the model and its potential applications in curriculum development. The qualification system shapes curricula, promotes lifelong learning, and bridges academic and vocational education gaps. However, overcoming obstacles such as lack of coordination, scarce resources, and low public awareness requires deliberate effort. Higher education institutions must proactively align their curricula with certification system criteria, and industry needs to ensure students are appropriately educated, and their skills meet labor market expectations.

The practical contributions to TVET practices include enhanced curriculum alignment with certification standards and industry requirements, ensuring that graduates possess the necessary skills and knowledge to succeed in the labor market. Promoting lifelong learning principles within TVET programs encourages continuous skill development and adaptability among students, which is essential in a rapidly changing job market. Strengthening industry partnerships through increased industry participation in TVET programs, such as sharing resources, providing on-the-job training, and sponsoring apprenticeships, enhances the practical relevance of education and ensures that training meets current industry standards. Developing a robust governance framework for TVET institutions ensures effective collaboration between educational institutions and industry, fostering a supportive curriculum development and implementation environment. Addressing resource constraints by identifying and overcoming limitations, such as outdated facilities and materials, through industry collaboration and government support can significantly improve the quality and effectiveness of TVET programs.

Moreover, overcoming existing obstacles and fostering a supportive environment is essential for expanding and enhancing TVET programs, ensuring they prepare students for employment, contribute to economic growth, and promote social inclusion in a dynamic global market. The emphasis on industry participation in TVET necessitates a robust governance framework and enhanced collaboration between educational institutions and industry. Critical factors for improving TVET include increased business contributions, on-the-job training, and sponsorships. Thus, further research is suggested to explore the engagement of TVET-engineering institutions with industry to improve curriculum development and align it with certification standards to meet industry demands. A holistic and dynamic approach to fostering collaborations between TVET institutions and industries can significantly contribute to a nation's socio-economic development by producing a competent and skilled workforce ready to meet the challenges of a changing labor market

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Conflict of Interest

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

Author Contribution

The authors confirm contribution to the paper as follows: **study conception and design:** Haryanti Mohd Affandi, Lázaro Moreno Herrera; **data collection:** Nurul Eizzaty Sohimi; **analysis and interpretation of results:** Nurul Eizzaty Sohimi, Ummu Sakinah Subri, Faizal Amin Nur Yunus; **draft manuscript preparation:** Haryanti Mohd Affandi, Nurul Eizzaty Sohimi, Siti Noranis's Mohd Yunus. All authors reviewed the results and approved the final version of the manuscript.

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