Jurnal Inovasi Teknologi Pendidikan
Volume 12, No. 2, June 2025 (231-242)
Online: http://journal.uny.ac.id/index.php/jitp

Strategic decision-making in TVET higher education: Applying the fuzzy delphi technique to foster inclusive digital pedagogy in Indonesia-Malaysia

Harris Pinagaran Nasution [1] *, Mohd Ridhuan Mohd Jamil [2], Mohd Muslim bin Md. Zalli [2], Vivianti Novita [1], Nursiah [1], Suri Purnami [1], Nurulrabihah Mat Noh [3], Nadzimah binti Idris [2]
[1] Politeknik Negeri Medan, Indonesia.
[2] Universiti Pendidikan Sultan Idris, Malaysia.
[3] Institut Pendidikan Guru Kampus Bahasa Melayu, Malaysia.
* Corresponding Author. E-mail: harrisnasution@polmed.ac.id

ARTICLE INFO

Article History
Received:
15 June 2025;
Revised:
14 July 2025;
Accepted:
14 July 2025;
Available online:
30 June 2025.

Keywords
Digital pedagogy; Fuzzy Delphi technique; Inclusive education; Southeast Asia; TVET

ABSTRACT

The rapid digitalization of education demands inclusive pedagogical strategies, especially within Technical and Vocational Education and Training (TVET), to ensure equitable learning opportunities. This study focuses on post-secondary students and aims to identify the competencies required by educators in implementing inclusive digital pedagogy. It also serves as a foundational reference for future in-depth research. The study examines the strength of consensus among expert groups from Indonesia and Malaysia regarding inclusive digital pedagogy using the Fuzzy Delphi Technique (FDT). A purposive sampling technique was employed to select 30 experts from Indonesia and Malaysia. The selection criteria included academic qualifications, professional experience in TVET and digital pedagogy, and prior involvement in educational research or policy-making, in identifying and prioritizing key components, including infrastructure and training, digital skills development, accessibility, student-centered approaches, employer engagement, and personalized learning. Data analysis utilizing triangular fuzzy numbers revealed a strong consensus, highlighting the foundational role of infrastructure and innovative pedagogical practices aligned with industry needs. The findings contribute a comprehensive framework for enhancing digital inclusivity in Southeast Asian TVET contexts and demonstrate the effectiveness of FDT in consensus-based educational research. Future research is recommended to empirically validate the proposed framework in real classroom settings and to investigate its adaptability across different cultural environments in the ASEAN region.

How to cite:
Nasution, H. P., et al., (2025). Strategic decision-making in TVET higher education: Applying the fuzzy delphi technique to foster inclusive digital pedagogy in Indonesia-Malaysia. *Jurnal Inovasi Teknologi Pendidikan*, *12*(2), 231-242. https://doi.org/10.21831/jitp.v12i2.86318

INTRODUCTION

Inclusive digital pedagogy has emerged as a critical global priority, especially in the rapidly evolving field of education. The increasing reliance on digital technologies in educational systems necessitates addressing diverse learners' needs, ensuring equity, and fostering active participation (UNESCO, 2020). This is particularly significant for Technical and Vocational Education and

Training (TVET), where learners often come from varied socio-economic and educational backgrounds (Cheng & Lin, 2002). A well-rounded approach to digital pedagogy can help bridge gaps in accessibility and ensure that all learners benefit from technological advancements. As TVET becomes central to workforce development, addressing inclusivity in digital learning is more pressing than ever.

Technical and Vocational Education and Training (TVET) plays a critical role in preparing individuals with the practical and technical competencies required by the contemporary workforce, especially as the education sector transitions toward the paradigm of the Industrial Revolution 5.0. The elements of knowledge and the latest learning strategies in TVET pedagogy can produce graduates to meet the needs of the industry (Lubis, 2010).

The rise of AI in education is propelled by its capacity to process vast amounts of data and generate insights that inform personalized learning pathways (Rane et al., 2025). While the integration of digital tools has become more widespread to enhance learning outcomes, significant challenges related to inclusivity persist. Technology tailored to meet the unique needs of diverse students is essential for promoting inclusion. When supported by inclusive policies, teacher training, and pedagogy, digital tools can help reduce barriers to inclusive education (Gottschalk & Weise, 2023).

Despite efforts to digitalize education, significant gaps remain in access and inclusivity. Learners from marginalized communities often face barriers such as inadequate internet access, limited digital literacy, and a lack of supportive infrastructure (OECD, 2021). In Indonesia and Malaysia, these challenges are pronounced, with TVET institutions catering to a diverse population with varying levels of preparedness for digital learning (Hani et al, 2024). Bridging this digital divide is crucial for ensuring equitable opportunities in education and workforce readiness, especially in a region with complex socio-economic dynamics.

The Southeast Asian context presents unique challenges and opportunities for inclusive digital pedagogy, driven by the region's socio-economic diversity and rapid digital transformation. Factors such as rapid urbanization, economic disparities, and culturally diverse populations necessitate context-sensitive and adaptive approaches to digital education. Urban centers in Southeast Asia are experiencing accelerated technological integration, but rural and underserved areas often lag due to limited infrastructure and access to digital resources (OECD, 2021). This digital divide creates significant barriers to inclusive education, particularly in Technical and Vocational Education and Training (TVET), which often caters to learners from varied socio-economic backgrounds.

Indonesia and Malaysia, as prominent players in the region's TVET landscape, have recognized the need to integrate inclusive digital pedagogical practices to enhance educational equity and quality. Both nations have made commendable progress in digitalizing their education systems, with initiatives such as Malaysia's Digital Economy Blueprint and Indonesia's focus on increasing digital literacy (Hani et al, 2024). However, these advancements are unevenly distributed, leaving gaps in access and inclusivity that hinder equitable participation. Comprehensive frameworks that prioritize inclusivity and address these disparities are essential for leveraging the full potential of digital transformation in education. Such frameworks must account for regional disparities, cultural nuances, and the specific needs of TVET learners, enabling both nations to build resilient and inclusive education systems that prepare students for the demands of a globalized workforce (UNESCO, 2020).

The implementation of inclusive digital pedagogy requires a strategic approach that takes into account the diverse backgrounds and experiences of students so that equal learning processes and outcomes will be created. One key strategy is to design learning development that can combine various pedagogical perspectives, fair assessments, and collaboration-based learning. Designing learning development ensures that every student gets equal access to education and equips them to be able to face changes in the world and contribute as agents of social transformation. In addition, another important strategy is the implementation of inclusive and differentiated assessments, which provide equal opportunities for all students to actively participate and achieve their learning goals (Hashim et al., 2019).

Inclusive pedagogy is based on the principle of meeting diverse learning needs, ensuring equitable access to education, and creating a participatory learning environment. Digitalisation, both

in the educational and industrial context, creates massive opportunities to make learning in TVET institutions more demand-driven and adequate to serve the purpose of producing highly skilled graduates (Kuntadi et al., 2022). Digital pedagogy, when combined with inclusivity principles, has the potential to transform TVET education by addressing individual learner needs while leveraging technology to enhance engagement and outcomes.

The Fuzzy Delphi Technique offers a robust methodological approach to achieve consensus on critical elements of inclusive digital pedagogy. This method integrates expert opinions to identify key factors and prioritize their implementation based on collective agreement (Hsu & Sandford, 2007). By applying this technique in the Indonesian-Malaysian context, this study ensures that the identified elements are both culturally relevant and practically applicable. Its adaptability makes it particularly suitable for addressing the complexities of TVET education in Southeast Asia.

Indonesia and Malaysia share similarities in their TVET landscapes, including diverse populations and rapidly expanding digital economies. However, differences in governance, infrastructure, and cultural contexts influence the adoption of inclusive digital pedagogy. While Malaysia has made significant progress in integrating digital tools within TVET curricula, Indonesia faces challenges such as limited infrastructure in rural areas. Understanding these differences is critical for developing tailored strategies that address the unique needs of both nations. Policymakers in both countries play a central role in fostering inclusive digital pedagogy in TVET. Strategic investments in infrastructure, teacher training, and digital resources are vital for creating an equitable learning environment. Policies that promote public-private partnerships can further enhance resource availability and ensure alignment with industry needs. Both nations have introduced initiatives to digitalize education, but gaps in implementation highlight the need for continuous evaluation and adaptation.

A related study, "Transforming Inclusive Digital Pedagogy in Malaysian Tertiary TVET: Adapting to a New Educational Landscape", provides a valuable contextual reference by examining how Malaysian institutions have responded to the demand for digital inclusivity in TVET (Jamil et al., 2024). However, while that study focused on a single country perspective and emphasized institutional adaptation, the current study broadens the scope by incorporating a cross-country comparison between Indonesia and Malaysia. Furthermore, the study uses the Fuzzy Delphi Technique (FDT) to systematically gather and analyze expert consensus, allowing for the formulation of a robust and participatory framework for inclusive digital pedagogy.

This study aims to develop a consensus-driven framework for inclusive digital pedagogy in Indonesian-Malaysian TVET. It identifies key elements through expert input and prioritizes them using the Fuzzy Delphi Technique. The subsequent sections outline the study's methodology, findings, and implications, offering a comprehensive analysis of inclusive digital pedagogy tailored to the needs of both nations.

This study seeks to build a consensus-driven framework for inclusive digital pedagogy in the context of Indonesian and Malaysian TVET systems. By utilizing the Fuzzy Delphi Technique (FDT), this study systematically identifies and prioritizes important pedagogical elements based on expert insights. In addition to offering a practical and contextually responsive model for advancing equitable digital education, this study also contributes a participatory methodological approach that encourages cross-national collaboration in shaping inclusive teaching practices.

METHOD

This study uses the Fuzzy Delphi Technique to identify and rank the main components of inclusive digital pedagogy in TVET higher education in Indonesia and Malaysia. The Fuzzy Delphi Technique is widely recognized for its capacity to achieve expert consensus on complex issues through systematic data collection and analysis (Hsu & Sandford, 2007). Figure 1 is the research design and steps using the fuzzy technique.

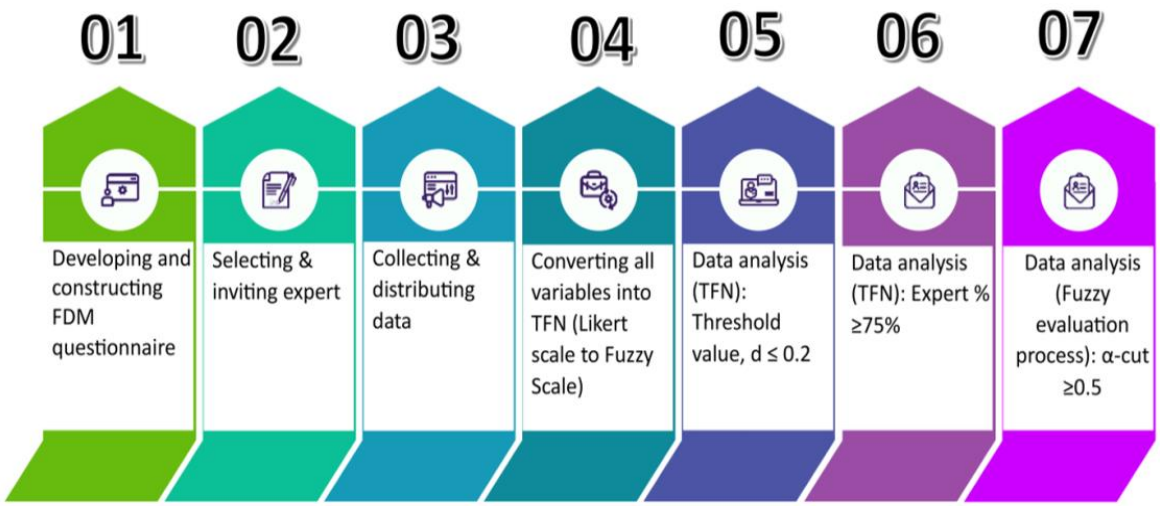

Figure 1. Fuzzy Delphi Data Collection and Data Analysis

Its integration of fuzzy logic ensures precision and minimizes ambiguity in decision-making processes (Habibi et al., 2014). By leveraging this approach, the study ensured that the framework developed was both rigorous and relevant to the context of TVET education.

This study involved 30 experts from both Indonesia and Malaysia, selected through purposive sampling to ensure that participants possessed relevant expertise and experience in the fields of TVET and digital pedagogy (Creswell & Poth, 2018). The inclusion criteria required a minimum of five years of academic or professional experience in areas such as technical education, digitalization, or TVET instruction. This diverse and knowledgeable expert panel formed the foundation for applying the Fuzzy Delphi Technique (FDT), which was used to systematically process and synthesize expert opinions to reach consensus on key elements of inclusive digital pedagogy. This selection process ensured a diverse and knowledgeable panel capable of providing informed insights.

Table 1 provides a detailed demographic profile of the experts participating in the study, showcasing their diverse backgrounds and extensive experience. Among the Indonesian experts, the majority were male (60%), while 40% were female, highlighting a significant representation of women in technical and vocational fields. This balance is crucial in promoting gender inclusivity within TVET, as it ensures that diverse perspectives are incorporated into the analysis. In Malaysia, male experts constituted 70% of the participants, with females accounting for 30%, reflecting a slightly higher male dominance in the Malaysian TVET sector. These gender distributions align with broader trends in STEM and vocational education, where male representation often exceeds female representation (OECD, 2021). The inclusion of female experts in both countries underscores the study's commitment to diversity and inclusivity.

Table 1. Experts' Demographic Information

No.	Demographic	Statement	N	Percentage
Indonesia Expert				
1	Gender	Male	6	60%
		Female	4	40%
2	Experience (Academic)	5-9 Years	1	10%
		10-14 Years	-	-
		15 Years and above	9	90%
3	Expertise	Business Administration	5	50%
		Mechanical Engineering	1	10%
		Accounting	1	10%
		Electrical Engineering	2	20%
		Computer and Informatics	1	10%
Malaysian Expert				
4	Gender	Male	7	70%
		Female	3	30%

No.	Demographic	Statement	N	Percentage
		5-9 Years	3	30%
5	Experience (Academic)	10-14 Years	5	50%
		15 Years and above	2	20%
		Engineering Education (Lecturer)	4	40%
6	Expertise	TVET Educator with Certified SKM Level 3	4	40%
		Digitalization Education (Lecturer)	2	20%

In terms of experience, most participants from both countries had over 15 years of academic or professional expertise, indicating their in-depth understanding of TVET and digital pedagogy. Notably, 90% of Indonesian experts fell into this category, while Malaysian experts displayed a more varied distribution, with 50% having 10-14 years of experience and 20% with over 15 years. This diversity in experience levels enriched the data by incorporating both seasoned perspectives and insights from mid-career professionals. The fields of expertise were equally diverse; Indonesian experts were predominantly from business administration (50%), mechanical engineering (10%), electrical engineering (20%), accounting (10%), and computer and informatics (10%). In contrast, Malaysian experts were primarily TVET educators (40%) and specialists in engineering education (40%), with a smaller proportion focusing on digitalization in education (20%). This blend of technical and pedagogical expertise ensured a holistic understanding of inclusive digital pedagogy within TVET contexts.

The study utilized a structured questionnaire to gather data from the experts. The instrument employed in this study was adapted from a validated framework, questionnaire with a Likert scale level divided into 7 levels of statements including the following: strongly disagree (1), strongly disagree (2), disagree (3), moderately agree (4), agree (5), strongly agree (6), strongly agree (7). For the statement elements regarding digital pedagogy in TVET, experts were asked to express their opinions on each item.

Table 2. Questionnaire Instrument

No.	Elements of Digital Pedagogy in Higher Education TVET	Agreement Scale						
		1	2	3	4	5	6	7
1	Accessibility and Accommodation							
2	Personalized Learning							
3	Digital Pedagogy Skills							
4	Employer Engagement							
5	Infrastructure and Training							
6	Student-Centered Approach							
7	Digital Skills Development							

This prior research served as a foundational reference in developing the instrument (Jamil et al., 2024). Experts rated the elements on a Likert-type scale, with their responses analyzed to compute threshold values, fuzzy scores, and consensus percentages. This approach facilitated a nuanced understanding of expert opinions.

The Fuzzy Delphi Technique employs a three-step evaluation process: data fuzzification, calculation of fuzzy scores, and defuzzification (Hsu & Sandford, 2007). In this study, the fuzzification step converted expert ratings into triangular fuzzy numbers to account for variability in their responses. The second step calculated fuzzy scores for each element, followed by defuzzification to derive crisp values for interpretation. This rigorous process ensured consistency and reliability in the analysis.

The fuzzy scales allow the researcher to identify the range of possible scores that reflect the experts' opinion instead of the single score provided by the traditional scale (Li, 2013). The study established clear criteria for consensus based on threshold values, fuzzy scores, and expert agreement percentages. A threshold value (d) ≤ 0.2 indicated a strong level of consensus, while a minimum agreement of 75% was required for an element to be accepted (Habibi et al., 2014). Additionally, fuzzy scores exceeding 0.5 were deemed significant, ensuring that only highly relevant elements were included in the framework.

To ensure the validity and reliability of the questionnaire, a pilot test was conducted with a separate group of TVET experts. Feedback from the pilot group led to minor revisions in the questionnaire, enhancing its clarity and comprehensiveness. This step aligned with best practices in survey design, which emphasize the importance of instrument validation to enhance data quality (Creswell & Poth, 2018). Jamil et al., (2024) stated that expertise was acknowledged when someone had gained over five years of experience in their field. This time-based criterion recognizes the level of expertise and real-world understanding that accompany long-term involvement in a specific field. Most participants from both countries had more than 5 years of academic or professional experience in TVET higher education, demonstrating their deep understanding of digital pedagogy. In the Fuzzy Delphi Method, the focus is on a purposive sample of experts who possess substantial knowledge, practical experience, and expertise in the relevant domain. The selection of these experts is guided by defined criteria, including academic qualifications, professional involvement, fieldwork, and scholarly contributions. As such, the number of participants in an FDM study does not follow traditional sample size conventions. Adler & Ziglio (1996) suggest that a panel of 10 to 15 experts is adequate, provided that the selection process is rigorous and well-justified. Unlike traditional quantitative methods that rely on inferential statistics and internal consistency measures such as Cronbach's Alpha, the FDM assesses validity and reliability through the level of expert agreement using a Likert scale adapted with fuzzy logic principles. Each item is analyzed using fuzzy number techniques to determine thresholds, consensus percentages, and ranking priorities. As Saedah et al., (2020) emphasize, reliability in such methods is embedded within the consensus patterns among expert responses.

Given the diverse socio-economic and educational contexts of Indonesia and Malaysia, the study considered regional disparities in digital access and infrastructure. Experts provided insights into these contextual factors, ensuring that the identified elements were both practical and culturally relevant. This contextualization strengthened the applicability of the findings to the Indonesian-Malaysian TVET landscape.

The study adhered to ethical guidelines for research involving human participants. Experts provided informed consent, and their anonymity was maintained throughout the study. Ethical approval was obtained from institutional review boards in both countries, ensuring compliance with international research standards (Flick, 2018). This ethical framework underscored the study's commitment to integrity and transparency.

RESULTS AND DISCUSSION

Results

The study identified seven key elements of inclusive digital pedagogy in Indonesian-Malaysian TVET higher education. These elements achieved a high level of expert consensus and were ranked based on their fuzzy scores and expert agreement percentages. The identified elements of Table 2 outline the results, providing detailed insights into the rankings and consensus levels.

All elements surpassed the threshold value for acceptance ($d \leq 0.2$), demonstrated a fuzzy score greater than 0.5, and achieved at least 75% expert agreement, indicating robust consensus. Table 3 summarizes the ranking, fuzzy scores, threshold values, and consensus levels.

Table 3. Findings for Elements of Inclusive Digital Pedagogy for Indonesian and Malaysian TVET

No.	Elements of Inclusive Digital Pedagogy for Indonesian-Malaysian TVET	Triangular Fuzzy Numbers Condition		Fuzzy Evaluation Process Condition				Expert Consensus	Ranking
		Threshold Value, d	Percentage of Experts' Consensus, %	m1	m2	m3	Fuzzy Score (A)		
1	Accessibility and Accommodation	0.095	80.0%	0.730	0.880	0.960	0.857	Accepted	3
2	Personalized Learning	0.118	80.0%	0.680	0.855	0.960	0.832	Accepted	7

No.	Elements of Inclusive Digital Pedagogy for Indonesian-Malaysian TVET	Triangular Fuzzy Numbers Condition		Fuzzy Evaluation Process Condition				Expert Consensus	Ranking
		Threshold Value, d	Percentage of Experts' Consensus, %	m1	m2	m3	Fuzzy Score (A)		
3	Digital Pedagogy Skills	0.137	100.0%	0.690	0.860	0.965	0.838	Accepted	6
4	Employer Engagement	0.143	90.00%	0.700	0.870	0.965	0.845	Accepted	4
5	Infrastructure and Training	0.061	100.00%	0.760	0.910	0.980	0.884	Accepted	1
6	Student-Centered Approach	0.107	100.00%	0.680	0.865	0.975	0.840	Accepted	5
7	Digital Skills Development	0.129	100.00%	0.730	0.890	0.975	0.865	Accepted	2

Infrastructure and training emerged as the most critical components, receiving the highest fuzzy score and full consensus, indicating their fundamental importance in supporting other elements of digital pedagogy. Digital skills development followed closely, highlighting the importance of equipping learners with the competencies needed to navigate digital learning environments. Accessibility and accommodation were emphasized as critical to ensuring equitable participation, especially for underserved learners. Employer engagement and student-centered approaches were prioritized for their role in aligning educational practices with workforce needs and learner preferences. The last two elements, ranked digital pedagogy skills and personalized learning, were also identified as critical to supporting differentiated instruction and enhancing the adaptability of learning environments. These seven elements form the basis for a comprehensive and inclusive digital pedagogy framework tailored to the diverse contexts of Indonesian and Malaysian TVET higher education.

As explained in the table above, Infrastructure and training emerged as the top-ranked elements, with a fuzzy score of 0.884 and unanimous consensus among experts (100%). The infrastructure and training priorities reflect their fundamental impact in enabling other elements of inclusive digital pedagogy. Experts emphasized the need for equitable access to digital tools and comprehensive professional development for educators (Hani et al, 2024).

Digital skills development ranked second, achieving a fuzzy score of 0.865 with 100% consensus. Technology has revolutionized teaching methodologies, offering personalized and interactive learning experiences that cater to diverse learning styles (Subroto et al., 2023).

Accessibility and accommodation, ranked third (fuzzy score = 0.857), was also highlighted as important. Experts pointed out that without accessible resources and accommodation, inclusive practices cannot be fully realized, especially for higher education learners from underserved communities. Employer engagement (ranked fourth, fuzzy score = 0.845) and a student-centered approach (ranked fifth, fuzzy score = 0.840) were identified as critical elements in aligning TVET curricula. Employer engagement ensures that digital pedagogy aligns with industry needs, bridging the gap between education and employment (Jamil et al., 2024). Meanwhile, a student-centered approach emphasizes the importance of tailoring educational experiences to individual learner needs, fostering greater engagement and inclusivity.

Digital pedagogy skills and personalized learning, ranked sixth and seventh, respectively, are recognized as integral components of inclusive digital pedagogy. Digital pedagogy skills (fuzzy score = 0.838) equip educators with innovative teaching strategies and technological competencies necessary for effective instruction (Salmon, 2013). Personalized learning (fuzzy score = 0.832), on the other hand, addresses the diverse needs of learners by enabling flexible and adaptive teaching methods.

Infrastructure and training emerged as the most critical components, achieving the highest fuzzy score and unanimous expert consensus, underscoring their foundational role in enabling all other elements of digital pedagogy. Accessibility and accommodation were also highlighted as

pivotal in ensuring inclusive participation, particularly for marginalized and underserved student populations. Additionally, employer engagement and learner-centered approaches were prioritized for their capacity to align educational practices with industry demands and individual learner needs.

Although ranked lower, digital pedagogy skills and personalized learning were still considered vital, contributing to differentiated instruction and enhancing the adaptability of learning environments. Collectively, these seven elements establish a robust and inclusive framework for digital pedagogy, responsive to the unique educational contexts of TVET higher education in Indonesia and Malaysia.

Discussion

Infrastructure and training emerged as the most critical elements, underlining their foundational importance in Indonesian-Malaysian TVET. Robust infrastructure, including access to digital tools and internet connectivity, is essential to ensure equitable learning opportunities (UNESCO, 2020). Many educators highlighted the importance of ongoing and comprehensive training to increase their confidence and skills in utilizing technology effectively for teaching purposes (Subroto et al., 2023). Educators and students encountered comparable issues with internet connectivity characterized by slow and unstable access, along with increased costs. Despite these challenges, their commitment to continuing online teaching and learning remained strong (Johari et al., 2024).

Digital skills development ranked as the second most significant element, reflecting its vital role in preparing TVET learners for the demands of the Fourth Industrial Revolution. Experts stressed the importance of equipping students with practical digital competencies, such as data literacy, programming, and problem-solving (Cheng & Lin, 2002). Vocational education possesses unique characteristics that require specialized approaches. It focuses on preparing students for specific careers, such as assistant technicians, technicians, or supervisors in various industries (Febriana et al., 2023). The findings reinforce the need for TVET institutions to integrate digital skills training into curricula, ensuring that students are prepared for both current and future workforce demands. To achieve this, educators must receive effective training on using digital tools to enhance learning outcomes and create inclusive learning environments (Bong & Chen, 2024).

Accessibility and accommodation were identified as key elements in fostering inclusivity, particularly for underserved populations in rural areas. Experts noted that physical and digital barriers, such as limited internet access and inadequate devices, significantly hinder equitable participation in digital learning (OECD, 2021). To address these challenges, TVET institutions must adopt strategies like subsidized technology programs and adaptive digital tools (Ahmad et al, 2020). Prioritizing accessibility is essential to bridging the digital divide and ensuring that all learners, regardless of socioeconomic status, can benefit from digital pedagogy.

Employer engagement ranked fourth, highlighting its crucial role in aligning TVET curricula with industry needs. Experts emphasized that active collaboration with employers ensures the relevance of digital pedagogy, helping students acquire job-ready skills. For instance, partnerships with industry leaders can provide insights into emerging technologies and practical applications, enhancing the employability of TVET graduates (Hani et al. 2024). This element underscores the need for sustained dialogue between education providers and industry stakeholders to create a workforce equipped for modern challenges. Good implementation of digital learning innovation will improve the quality of higher education and vice versa (Dewi & Kristanto, 2025).

Student-centered approaches were ranked fifth, reflecting their significance in promoting active engagement and personalized learning. Experts highlighted that learner-centered strategies, such as problem-based learning and flipped classrooms, foster critical thinking and adaptability (Salmon, 2013). These methods also accommodate diverse learning styles, making education more inclusive (Florian & Hawkins, 2011). Preparing students for workforce readiness is primarily the responsibility of universities. However, collaboration with industry is essential to establish benchmarks and standards that define the skill sets to be developed during their education (Kuntadi et al., 2022). However, the students experience a high level of stress and anxiety from online learning because of a lack of knowledge, skills, and unfamiliarity with the digital learning environment.

(Thomas, 2022). By empowering students to take ownership of their learning journeys, TVET institutions can create environments that are both supportive and responsive to individual needs.

Experts noted that educators must adopt innovative teaching strategies, such as gamification and interactive simulations, to enhance student engagement (Cheng & Lin, 2002). Nevertheless, the TVET Teacher Education programme needs to be revised so that the training provided for the future TVET educators may be able to help the country to achieve its mission and vision to be a developed country with high income by providing high-quality TVET educators (Hamdan et al., 2020). The teaching and learning competence of lecturers contributes to enhancing the performance of planning and deploying digital tools and resources in the teaching process, as well as managing and coordinating teaching strategies appropriately, thereby increasing student learning value (Dang et al., 2024).

Technology's rapid advancement has revolutionized our lives and work, creating a growing demand for a digitally skilled workforce (Hani et al, 2024). As human resources in education, educators play a critical role in supporting educational goal attainment. No matter how complex and perfect, the use of facilities, technology, and media does not guarantee the attainment of educational goals if not balanced with the abilities (Gunawan et al., 2024). Vocational education graduates must have various skills needed in work and industry because the nature of education prepares graduates to work (Febriana et al., 2023).

Personalized learning was identified as the seventh key element, emphasizing its role in catering to diverse learner needs. Education 4.0 and the emerging Education 5.0 lead a major shift in learning, where Artificial Intelligence (AI) helps create more personalized and flexible learning experiences (Rane et al., 2025). Implementing a learning management system in the education sector has become necessary at various levels of education, from primary school to higher education (Garad et al., 2021). Personalized learning also aligns with global trends in education, which advocate for flexible and learner-centered approaches to teaching.

The identified elements collectively form a comprehensive framework for inclusive digital pedagogy in Indonesian-Malaysian TVET, addressing a range of challenges such as infrastructure gaps, skill development, and personalized learning. Infrastructure and training are foundational, as they enable educators and students to access and utilize digital tools effectively. Although teachers have experience in teaching, a lack of skills in interactive technology tools can cause students to gain no benefit and struggle to keep up with their learning (Jaya et al. 2022).

By investing in robust digital infrastructure and professional development, policymakers can ensure that TVET institutions are equipped to support equitable digital education (Jamil et al., 2024). Digital skills development complements these efforts, preparing learners to navigate the complexities of the Fourth Industrial Revolution while fostering adaptability and lifelong learning (Cheng & Lin, 2002). This alignment of resources and skills underscores the interdependence of the framework's elements in promoting inclusivity.

The framework highlights a learner-centered approach by integrating accessibility, employer engagement, and personalized learning. Ensuring accessibility through adaptive technologies and subsidized digital tools helps bridge the digital divide in underserved regions (OECD, 2021). Overall, this study emphasizes the importance of strategic planning, targeted investments, and collaborative efforts between educators, policymakers, and stakeholders to address the challenges and maximize the opportunities presented by technology in education (Subroto et al., 2023).

AI-supported personalized learning further enhances inclusivity by addressing individual learner differences (Salmon, 2013). Furthermore, research on the role of technology in inclusive education in Indonesia advocated for equitable access and adaptive curricula, echoing the study's policy recommendations.

CONCLUSION

This study used the Fuzzy Delphi Technique (FDT) to systematically identify and prioritize critical elements of inclusive digital pedagogy in the Indonesian-Malaysian TVET higher education landscape. Through structured expert input and triangulated data analysis using fuzzy logic, the study

developed a consensus-driven framework that is based on statistical rigor and contextual relevance. The FDT methodology proved highly effective in capturing nuanced expert perspectives and minimizing ambiguity in complex and culturally diverse decision-making. The findings revealed seven key components, starting with infrastructure and training as the top priority, followed by digital skills development, accessibility, student-centered approaches, employer engagement, digital pedagogy skills, and personalized learning. These elements collectively address the digital divide, pedagogy gap, and industry demands prevalent in Southeast Asian TVET higher education.

Methodologically, this study contributes to the growing application of the fuzzy Delphi approach in educational research, demonstrating its suitability for cross-border studies, policy formulation, and curriculum planning. By leveraging this participatory and iterative technique, this study also encourages evidence-based practices in the strategic transformation of TVET higher education. Further research is recommended in several key areas. First, empirical studies should be conducted to implement and evaluate the proposed framework in actual classroom environments to assess its practical effectiveness and impact on learning outcomes. Second, longitudinal research could explore the sustainability and evolution of inclusive digital pedagogical practices over time. Third, comparative studies involving other ASEAN countries would be valuable in examining the framework's adaptability and cultural responsiveness across different regional settings.

ACKNOWLEDGEMENT

We would like to thank the support from the Center for Research and Community Service (P3M) department of the educational institution, Medan State Polytechnic, Indonesia. This research also collaborates with the educational institution, University Pendidikan Sultan Idris (UPSI), Malaysia.

REFERENCES

Adler, M., & Ziglio, E. (1996). *Gazing into the oracle: The Delphi method and its application to social policy and public health*. Jessica Kingsley Publishers.

Bong, W. K., & Chen, W. (2024). Increasing faculty's competence in digital accessibility for inclusive education: A systematic literature review. International Journal of Inclusive Education, 28(2), 197-213. https://doi.org/10.1080/13603116.2021.1937344

Cheng, C. H., & Lin, Y. (2002). Evaluating the best main battle tank using fuzzy decision theory. *European Journal of Operational Research*, *142*(1), 174–186. https://doi.org/10.1016/S0377-2217(01)00280-6

Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five approaches (4th ed.)*. Sage.

Dang, T. D., Phan, T. T., Vu, T. N. Q., La, T. D., & Pham, V. K. (2024). Digital competence of lecturers and its impact on student learning value in higher education. *Heliyon*, *10*(17), 1-12. https://doi.org/10.1016/j.heliyon.2024.e37318

Dewi, U., & Kristanto, A. (2025). The effectiveness of the doing knowledge model in international educational technology classrooms. *Journal of Education Technology*, *9*(1), 155–162. https://doi.org/10.23887/jet.v9i1.878

Febriana, R., Hanafi, I., Kandriasari, A., Nuryanto, A., Soeprijanto, S., Muksin, M., Ching, S. J., & Mamat, A. B. (2023). Employability skills and self-perception of diploma 3 graduates in the world of work. *Jurnal Pendidikan Vokasi*, *13*(2), 121–131. https://doi.org/10.21831/jpv.v13i2.54039

Flick, U. (2018). *An introduction to qualitative research (6th ed.)*. Sage.

Florian, L., & Hawkins, K. B. (2011). Exploring inclusive pedagogy. *British Educational Research Journal*, *37*(5), 813-828. https://doi.org/10.1080/01411926.2010.501096

Garad, A., Al-Ansi, A. M., & Qamari, I. N. (2021). The role of e-learning infrastructure and cognitive competence in distance learning effectiveness during the COVID-19 pandemic. *Cakrawala Pendidikan*, *40*(1), 81–91. https://doi.org/10.21831/cp.v40i1.33474

Gottschalk, F., & Weise, C. (2023). Digital equity and inclusion in education: An overview of practice and policy in OECD countries OECD. *Education Working Paper* (pp. 299). http://www.oecd.org/termsandconditions.

Gunawan, R. D., Sutisna, A., & Ana, E. F. (2024). Literature review: The role of learning management system (LMS) in improving the digital literacy of educators. *Jurnal Inovasi Teknologi Pendidikan*, *11*(2), 116–123. https://doi.org/10.21831/jitp.v11i2.56326

Habibi, A., Sarafrazi, A., & Izadyar, S. (2014). Delphi technique: Theoretical framework in qualitative research. *The International Journal of Engineering and Applied Sciences*, *3*(4), 8-13. https://www.theijes.com/papers/v3-i4/Version-4/B03404008013.pdf

Hamdan, N. H., Yunos, J. M., & Sern, L. C. (2020). Sustainable system for TVET teacher education program in Malaysia: Fuzzy delphi method. *Online Journal for TVET Practitioners*, 5(1), 7–14. https://penerbit.uthm.edu.my/ojs/index.php/oj-tp/article/view/6048

Hani, M. H. M., Ismail, A., Razali, S. S., Bakar, M. N. A, Rosman, N. L., Nasir, N., & Mohamad, Z. (2024). The development of digital competence model among TVET educators towards digitization: A concept paper. *Journal of TVET and Technology Review*, *2*(1), 1-18. https://publisher.uthm.edu.my/ojs/index.php/jttr/article/view/18112

Hashim, R. A., Kaur, A., & Valdez, N. P. (2019). Strategizing inclusivity in teaching diverse learners in higher education. Malaysian Journal of Learning and Instruction, 16(1), 105–128. https://doi.org/10.32890/mjli2019.16.1.5

Hsu, C. C., & Sandford, B. A. (2007). The delphi technique: Making sense of consensus. *Practical Assessment, Research, and Evaluation*, *12*(1), 1–8. https://doi.org/10.7275/pdz9-th90

Jamil, M. R. M., Idris, N., Zalli, M. M., Rakami, N. M. H. N., & Putra, Z. H. (2024). Transforming inclusive digital pedagogy in Malaysian tertiary TVET: Adapting to a new educational landscape. *Journal of Technical Education and Training*, *16*(2), 165–174. https://penerbit.uthm.edu.my/ojs/index.php/JTET/article/view/18320

Jaya, S., & Zaharudin, R. (2022). Emerging trends in STEM education: Envisioning future learning spaces and interaction technology tools framework using the fuzzy delphi method (FDM). *Malaysian International Journal of Research in Teacher Education (MIJORiTE)*, *3*, 45-56. https://myjurnal.mohe.gov.my/public/issue-view.php?id=16848&journal_id=847

Johari, M., Ali, A. O., Musa, J., Zakir, N., & Shahrill, M. (2024). Teacher educators' and students' perspectives on transitioning from conventional to online teaching and learning. *Cakrawala Pendidikan*, *43*(1), 232–241. https://doi.org/10.21831/cp.v43i1.52171

Kuntadi, I., Ana, Rohendi, D., Suryadi, D., Halim, F. A., Sari, A. R., Muktiarni, & Dwiyanti, V. (2022). Towards digital TVET: A comparative study on students' readiness in the industry digital demands in Indonesia and Malaysia. *Journal of Technical Education and Training*, *14*(3), 79–93. https://publisher.uthm.edu.my/ojs/index.php/JTET/article/view/12898

Li, Q. (2013). A novel likert scale based on fuzzy sets theory. *Expert Systems With Applications*, *40*(5), 1609–1618. https://doi.org/10.1016/j.eswa.2012.09.015

Lubis, S. (2010). Concept and implementation of vocational pedagogy in TVET teacher education. *Proceedings of the 1st International UPI conference on TVET*, (pp. 10-11).

OECD. (2021). *Bridging the digital divide: Challenges and opportunities in education*. OECD Publishing. https://doi.org/10.1787/4d4c3c45-en

Rane, N. L., Choudhary, S., & Rane, A. (2025). Education 4.0 and 5.0: Integrating Artifcial Intelligence (AI) for personalized and adaptive learning. *Journal of Artificial Intelligence and Robotics*, *1*(1), 29-43. https://doi.org/10.61577/jaiar.2024.100006

Saedah, S., Abdullah, M. R. T. L., & Rozkee, R. M. (2020). *Pendekatan penyelidikan rekabentuk dan pembangunan (PRP): Aplikasi kepada penyelidikan pendidikan*. Universiti Pendidikan Sultan Idris (UPSI).

Salmon, G. (2019). *E-tivities: The key to active online learning (2nd ed.)*. Routledge.

Subroto, D. E., Supriandi, S., Wirawan, R., & Rukmana, A. Y. (2023). Implementasi teknologi dalam pembelajaran di era digital: Tantangan dan peluang bagi dunia pendidikan di Indonesia. *Jurnal Pendidikan West Science*, *1*(7), 473-480. https://doi.org/10.58812/jpdws.v1i07.542

Thomas, K. F. C. (2022). Applying the self-determination theory (SDT) to explain student engagement in online learning during the COVID-19 pandemic. *Journal of Research on Technology in Education*, *54*(S1), S14–S30. https://doi.org/10.1080/15391523.2021.1891998

UNESCO. (2020). *Education in the digital age: Opportunities and challenges*. UNESCO Publishing. https://unesdoc.unesco.org/ark:/48223/pf0000373715