

Digitalization of TVET management in Malaysia: A shift towards electronic certificates

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ABSTRACT

In an era marked by rapid technological advancements and increasing demands for efficient and secure document management, transforming paper-based certificates into electronic certificates has emerged as a critical undertaking for the TVET sector. The conversion of physical certificates to digital formats involves digitising their content, implementing verification mechanisms, and securely storing them in electronic repositories. This paradigm shift reduces the environmental footprint associated with paper documentation and enhances accessibility, security, and efficiency in certificate management. Moreover, digital certificates enable the integration of advanced technologies, such as blockchain, to ensure the document's security and authenticity. The study reveals that electronic certification systems implemented by various institutions commonly incorporate features such as QR-code verification, blockchain technology, Public Key Infrastructure (PKI), cloud-based storage, and online validation mechanisms to enhance authenticity, security, and accessibility. Furthermore, key stakeholders across various agencies strongly support the implementation of electronic certificates due to their enhanced security features, reduced administrative burden, and improved operational efficiency. A qualitative approach was performed through semi-structured interviews with key stakeholders. The study reveals that key stakeholders across various agencies strongly support the idea of electronic certificates. Institutions and organizations are embracing this transformation due to the enhanced security features, reduced administrative burdens, and increased efficiency of electronic certificates. Furthermore, the environmental benefits of reduced paper usage align with the National Green Technology Policy and are gaining traction among stakeholders. The findings improve understanding regarding the digitization of TVET certification towards electronic certificates in line with technological advancement.

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INTRODUCTION

The transition from physical certificates to electronic certificates has gained increasing attention in recent years because digital certification systems can improve the efficiency, security, and accessibility of document management and verification processes (Hsu et al., 2022; Rustemi et al., 2023; Syarief, 2021). In Malaysia, the adoption of electronic certificates has the potential to provide benefits across various sectors by streamlining certification procedures and strengthening the reliability of document authentication systems. By digitizing certificates, verification and authentication can be conducted more quickly, accurately, and securely, thereby reducing the risk of document forgery, accelerating administrative processes, and minimizing verification-related burdens (Al Hemaury et al., 2024; Noorhizama et al., 2023; Said et al., 2023).

In Malaysia, electronic certification is particularly relevant to the halal industry, where certification serves as an important mechanism for ensuring compliance with Islamic dietary laws

and strengthening consumer confidence (Aziz & Chok, 2013). Recent developments in digital halal certification have demonstrated the potential to simplify verification processes, improve transparency, and enhance trust among consumers, regulatory authorities, and businesses (Syarofi & Syam, 2025). Similar developments can be observed in the healthcare sector, where electronic vaccination certificates facilitate the management, authentication, and verification of immunization records, thereby supporting more efficient public health administration (Petersen et al., 2021). These initiatives are consistent with the objectives of Malaysia's National Fourth Industrial Revolution (4IR) Policy, which seeks to strengthen the country's readiness for a digitally integrated ecosystem through the adoption of advanced digital technologies across economic and public-service sectors (Government of Malaysia, 2021). Consequently, the adoption of e-certificates represents an important component of broader digital transformation efforts that are increasingly evident in online banking, e-government services, digital public administration, and digital accreditation systems (Kasim et al., 2025).

The adoption of electronic certificates also supports Malaysia's sustainability and green technology initiatives by promoting paperless administrative systems that reduce paper consumption, physical storage requirements, and operational costs (Alharbi, 2023). Because electronic documents do not require printing, filing cabinets, or manual document handling, organizations can improve administrative efficiency while operating in a more environmentally sustainable manner (Rustemi et al., 2023). Within the Technical and Vocational Education and Training (TVET) sector, the Department of Skills Development (DSD) under the Ministry of Human Resources plays a central role in managing and awarding Malaysian Skills Certificates (SKM), which serve as important credentials for employment and career advancement in technical occupations (Nandiyanto et al., 2022). Given the significance of these certifications, the transition from conventional physical certificates to secure, reliable, and accessible electronic certificates has the potential to enhance the effectiveness of credential management and verification processes. This initiative is consistent with Malaysia's broader digital transformation agenda and ongoing efforts to modernize public services through digital technologies (Hsu et al., 2022).

Electronic certificates in the education and training sector refer to digitally issued credentials awarded to learners who successfully demonstrate the required competencies and learning outcomes (European Commission, 2022). Although electronic certificates offer numerous advantages in terms of accessibility, efficiency, and portability, their implementation must address important issues related to security, authenticity, and vulnerability to fraud (Hsu et al., 2022). Fake academic certificates have long been a concern in educational institutions and labor markets, creating a need for reliable verification mechanisms (Kumavat, 2019; Said et al., 2023). In response to these challenges, blockchain technology has emerged as a promising solution for issuing, storing, and verifying educational credentials because of its decentralized, transparent, tamper-resistant, and secure architecture (Alammary et al., 2019; Rustemi et al., 2023; Zheng et al., 2018). Blockchain stores information in immutable blocks that can be securely accessed and verified without the risk of unauthorized alteration, thereby enhancing trust, accessibility, authenticity, and long-term credential preservation (Al Hemaury et al., 2024; Chen et al., 2018).

In addition to enhancing security, electronic certificates offer significant advantages in terms of cost efficiency, sustainability, and administrative convenience. Digital certification systems support paperless operations by reducing the need for printing, physical storage, and document handling, thereby lowering operational costs and promoting environmentally sustainable practices (Alharbi, 2023; European Commission, 2022). Errors found in physical certificates often require costly reprinting, redistribution, and manual correction procedures, whereas digital certificates can be updated and reissued more quickly and efficiently (Hsu et al., 2022). Furthermore, electronic certificates can be transmitted instantly and securely regardless of geographical location, making them considerably more practical than traditional paper-based certificates (Cavallet et al., 2018; European Commission, 2022). Electronic certificates are also easier to store, manage, and retrieve, while being less vulnerable to physical loss, damage, or deterioration over time (Al Hemaury et al., 2024; Rustemi et al., 2023). These advantages make digital certification systems an increasingly attractive solution for educational institutions, training providers, and credentialing agencies.

Despite these advantages, several challenges remain in the implementation of electronic certificates, including dependence on internet connectivity, digital infrastructure, cloud-based storage systems, and users' digital literacy levels (van Laar et al., 2020; Vial, 2021). These factors may affect the accessibility and effective use of digital certification platforms, particularly among users with limited technological experience. Nevertheless, ongoing improvements in internet accessibility and the widespread adoption of smartphones are gradually reducing these barriers and facilitating broader acceptance of digital services (International Telecommunication Union, 2024). In situations where physical documents are unavailable, misplaced, or inaccessible, electronic certificates provide a reliable and convenient alternative because they can be stored, retrieved, shared, and verified quickly through mobile devices and digital applications (European Commission, 2022; Hsu et al., 2022). Consequently, electronic certification systems offer greater flexibility, portability, and accessibility than traditional paper-based credentials (Rustemi et al., 2023).

Blockchain technology further strengthens electronic certification systems by providing high levels of encryption, immutability, traceability, and data integrity (Zheng et al., 2018). Through cryptographic hash functions, each block is linked to the previous one, creating an immutable chain of records that makes unauthorized modification or tampering extremely difficult (Chen et al., 2018). These characteristics enable blockchain-based certification systems to enhance security, protect personal data, and facilitate secure credential verification and sharing among authorized stakeholders (Al Hemaury et al., 2024; Hsu et al., 2022). Recent studies have identified blockchain as one of the most promising technologies for issuing, storing, and verifying educational credentials because it improves transparency, trust, and verification efficiency while reducing the risk of fraud (Rustemi et al., 2023). Given the growing relevance of digital credentials and the ongoing digital transformation of TVET, this study aims to assess the current electronic certification criteria and capabilities implemented by different agencies and organizations in Malaysia. Furthermore, it explores stakeholders' perspectives within the Malaysian TVET sector regarding the transition from traditional paper-based certificates to electronic certificates, with particular emphasis on security, accessibility, system efficiency, and digital readiness (Vial, 2021).

Beyond technological advantages, the transition toward electronic certification should also be understood through a socio-organizational perspective, as digital transformation involves not only technological change but also shifts in organizational structures, processes, culture, and human capabilities (Gong & Ribiere, 2021; Vial, 2021). The successful adoption of e-certificates requires adequate organizational readiness, stakeholder commitment, and sufficient levels of digital literacy among users and administrators (Kane, 2019; van Laar et al., 2020). Within Malaysia's TVET ecosystem, which includes government agencies, accredited training centers, private providers, and industry partners, the effectiveness of digital certification initiatives depends heavily on coordinated capacity-building efforts and active stakeholder engagement (Otero, 2019). Without adequate digital preparedness and institutional support, even technologically advanced certification systems may fail to achieve their intended benefits and organizational objectives (Verhoef et al., 2021). Therefore, successful implementation of electronic certification requires a balanced approach that integrates technological innovation with organizational development and human capacity enhancement.

Moreover, the widespread adoption of electronic certificates aligns with global trends in digital credentialing, including the growing use of micro-credentials, open badges, and digital portfolios to recognize learning achievements and professional competencies (Brown et al., 2021; European Commission, 2022). As economies increasingly emphasize lifelong learning, reskilling, and upskilling in response to rapid technological and labour-market changes, the ability to issue, share, and verify digital credentials efficiently has become a significant competitive advantage for both institutions and individuals (UNESCO, 2022). Digital credentialing systems facilitate faster recognition of competencies, support flexible learning pathways, and enhance employability through more efficient qualification verification processes (Cedefop, 2023). For Malaysia, integrating electronic certification into broader TVET reform initiatives could strengthen the effectiveness, transparency, and international recognition of workforce qualifications (Otero, 2019). Such efforts are particularly important within the ASEAN region, where increasing labour mobility and cross-border skills recognition require more reliable, accessible, and interoperable credentialing systems (Keevy et al., 2026).

Furthermore, the digitalisation of certification creates opportunities to integrate advanced analytics and data-driven decision-making. With centralized digital records, agencies can analyse trends in certification issuance, track workforce competencies, and support evidence-based policymaking. This value-added dimension goes beyond merely replacing paper certificates, positioning e-certification as a strategic tool for human capital development. Another notable dimension is user experience and accessibility. Electronic certificates can be accessed at any time via secure digital platforms, reducing the administrative burden on both issuing bodies and certificate holders. This convenience is especially beneficial for TVET graduates who often need to present credentials during job applications, accreditation processes, or professional licensing. The ability to instantly retrieve verified digital certificates enhances their employability and reduces bureaucracy.

Overall, this study contributes to the growing body of knowledge on digital transformation in the TVET sector by providing an in-depth assessment of current electronic certification practices and stakeholders' readiness in Malaysia. The findings offer practical insights for policymakers, institutions, and technology providers in designing secure, efficient, and user-centred e-certification systems that support national digitalisation goals. More importantly, this research highlights key considerations necessary for ensuring that the transition from physical to electronic certificates strengthens TVET governance, enhances employability, and accelerates Malaysia's progress toward a fully digital credentialing ecosystem.

METHOD

Analysis of the implementation of the electronic system concept has revealed that it has already been extended to several countries, including the United Kingdom, China, Australia, Singapore, Morocco, and Malaysia. The institutions implementing the e-certification system in Malaysia include public higher education institutions such as the University Sultan Zainal Abidin (UniSZA) and the International Islamic University of Malaysia (UIAM), private higher education institutions such as University Tunku Abdul Rahman (UTAR), and companies from the industry offering technology-based services and products, including electronic certification systems. There are various methods by which institutions implement the electronic certification system. Table 1 presents examples and explanations from educational institutions in the United States and abroad that have begun issuing electronic certificates to their students.

Table 1. Institutions Implementing Electronic Certificates

Country	University	Portal	Characteristics	Technology	Users
Malaysia	UTAR	ismartcert	View e-cert Save & view graduate information Employers verify student status & cert	QR code Blockchain	Student Employer University
	UIAM	e-skrol	View e-cert Employers verify student status & cert		Student Employer
United Kingdom	Kent University	University portal	View e-cert	QR code	Student
	Strathclyde University		Save & view graduate information Employers verify student status & cert	Validation on the portal	Employer
	Birmingham University	GradIntelligence	View e-cert Save & view graduate information	Integration with Higher Education Achievement Record (HEAR) UK	Student Employer HEAR
	Essex University Warwick University Cardiff University		Employers verify student status & cert, find candidates Graduate assessment module (assessment; psychometric)		University Internship companies
Singapore	Polytechnic Ngee Ann	OpenCerts	View e-cert	Blockchain Cryptography	Student Employer

National University of Singapore (NUS) Institute Technical Education (ITE)	Save & view graduate information Employers verify student status & cert, find candidates Issue digital certificates on behalf of the university	University Internship companies
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Similarly, [Table 2](#) presents a comparative overview of the security features embedded in electronic certification systems implemented across countries, highlighting components such as authentication, verification processes, fraud-prevention mechanisms, uniformity, legal validation, and resilience against hacking attempts.

Table 2. Comparison of security features for an electronic certification system

Country	Authenticity Verification	Fraud and Forgery	Uniformity & Information Changes	Validation in terms of the law	Invasion & Hacking	Notes
Malaysia	√	√	√			Blockchain validation, Encryption
United Kingdom	√	√	√			Verification by the employer
Australia	√	√	√	√		Certificate control designed for the law
New Zealand	√	√	√	√		Certificate control designed for the law
Singapore	√	√	√		√	Blockchain validation, Encryption
Morocco	√		√			Digital authentication

The following analysis focuses on qualitative data obtained through interviews. Interviews were conducted online or in person to gather information on the dual issuance of certificates, specifically physical and electronic certificates. The study involved 48 informants representing 12 different departments, institutions, and companies. All data collected during the interview sessions were recorded through field notes and audio recordings for further analysis.

Table 3. List of informants representing TVET stakeholders

Organization	Category	Characteristics	No of informants
Government agency	Certification body	Certificate issuance & management	7
Government agency	I.T	Certification system management	
Government agency	Coordinator for accredited centers		13
Training institution (x 2)	Accredited training center (public)	Certificate management & handover	
Training institution (x 3)	Accredited training center (private)		10
Private company	Certification system developer for an electronic solution	PKI technology expert	10
Private company		PKI technology expert	
Private university	Certification body	e-Skrol & Blockchain	3
Public university	Certification body	e-Skrol & Blockchain	5

This study employed a qualitative research design, using semi-structured interviews, to explore the readiness, perspectives, and implementation practices regarding electronic certification

among Malaysian TVET stakeholders. A qualitative approach was selected to allow in-depth insights into processes, organizational readiness, and perceived challenges that cannot be fully captured through quantitative measures. Purposive sampling was used to select stakeholders directly involved in certificate issuance, management, technological development, and institutional governance. A total of 48 informants participated, representing government agencies, IT divisions, accredited training centres (public and private), universities, and private technology companies. This sampling strategy ensured that perspectives from multiple layers of the TVET ecosystem were captured comprehensively.

The main instrument used in this study was a semi-structured interview protocol developed to guide discussions on: (1) current certificate issuance processes, (2) challenges encountered with physical certificates, (3) expectations toward e-certification, (4) technological and organizational readiness, and (5) perceived advantages and risks of digital certification. The protocol allowed flexibility for probing and follow-up questions to obtain deeper insights. Data were collected over several weeks through online and face-to-face interviews. Each interview ranged from 30 to 60 minutes. With participants' consent, interviews were audio-recorded and supplemented with detailed field notes. For institutions unable to attend synchronous interviews, written responses were accepted to maintain inclusivity. All data were anonymized to ensure confidentiality.

The collected data were analysed using thematic analysis. Audio recordings were transcribed verbatim before coding. Thematic analysis followed [Braun and Clarke \(2006\)](#) six-phase framework: familiarization, initial coding, theme generation, theme review, theme definition, and final reporting. This approach facilitated the identification of key patterns across stakeholder groups related to implementation challenges, security considerations, usability, technological requirements, and policy alignment. To enhance reliability, two researchers independently coded the transcripts and reconciled discrepancies through discussion.

To ensure credibility and trustworthiness, triangulation was conducted by comparing data across stakeholder categories (government, industry, public institutions, private institutions). Member checking was performed by sharing summaries with several informants to confirm accuracy. Thick descriptions were employed to provide detailed context, thereby enhancing transferability to other TVET settings.

RESULTS AND DISCUSSION

The findings are organized into two main analytical layers: first, a comparative overview of existing electronic certification practices across selected countries and institutions; and second, thematic findings derived from stakeholder interviews in the Malaysian TVET context. This structure enables the study to connect global implementation patterns with local stakeholder readiness and perceived institutional needs.

The literature indicates that electronic certification systems, adopted by various domestic and international organizations, are regarded as secure and feasible for deployment. This can be achieved by incorporating various technologies into the implementation process, including blockchain, cloud storage, PKI (Public Key Infrastructure), and QR codes. Based on the study, Malaysia and Singapore were identified as examples of countries implementing blockchain-based electronic certification systems. Despite differences in the technologies used, the organizations share a common goal of implementing an electronic certification system, which further enhances the security of issued certificates while providing users with greater control over certificate security.

This variation indicates that e-certification systems do not follow a single technological pathway. Instead, countries appear to adopt technologies based on institutional maturity, legal readiness, cybersecurity priorities, and the expected level of interoperability. For Malaysia, the use of blockchain suggests an emerging orientation toward tamper-resistant and trust-based credentialing systems, which is particularly relevant for TVET qualifications that must be verified by employers and industry partners.

The system's security and user safety are also essential during implementation. The COVID-19 pandemic demonstrated the vulnerability of physical certificate management when institutions were unable to conduct on-site processes, and many certificate-related issues have been affected by

the COVID-19 outbreak. One notable consequence was the closure of educational institutions, which prevented graduates from attending graduation ceremonies and from collecting their certificates.

In Malaysia, institutions adopting electronic certificate systems include public institutions such as UIAM and UniSZA, private higher education institutions such as UTAR, and technology-focused companies that provide related services and products. The implementation of e-certificates has been well received in Malaysia and continues to support the country's development direction under the National Malaysia Plan (RMK-12), promoting technological and innovation development. In contrast, the traditional physical certification system remains manual and relies on human resources and machinery such as printing presses and computers. This conventional approach does not align with the country's ambitions for technological innovation, as it maintains the management system that has been used for decades.

Forty-eight interviews were conducted to assess stakeholders' acceptance of the implementation of electronic certificates. These interviews were analyzed thematically, yielding five key themes. Most informants supported the transition from physical certificates to electronic certificates.

Certificate Issuance Duration

When examining the current certificate issuance process, informants highlighted two significant concerns. Firstly, there is a considerable delay in trainees receiving their certificates upon completion of their training. Secondly, when certificate errors require correction, the waiting period is extended. Additionally, processing individual cases further increases overall processing time. Therefore, the informants agreed that introducing electronic certificates could reduce trainees' waiting time for certificate issuance.

In the TVET context, certificate issuance duration is not merely an administrative issue but directly affects graduates' transition into the labour market. Since TVET qualifications function as evidence of occupational competence, delays in certificate issuance may reduce graduates' ability to demonstrate their skills to employers in a timely manner. Therefore, electronic certification can be interpreted as a mechanism for improving both administrative responsiveness and graduate employability.

Furthermore, the analysis shows that long issuance durations negatively affect graduate employability, particularly for TVET students who depend on skills certificates for job placement. Faster issuance via e-certificates enables graduates to apply for jobs immediately after completing assessments, reducing the risk of missing job opportunities due to administrative delays. Employers also expressed a preference for systems that allow real-time verification, highlighting the practical value of instant digital credentials.

Storage Space

Informants agree that transitioning from physical to electronic certificates can save storage space at the certification body and accredited training centres. Electronic certificates eliminate the need to print and store physical copies, reduce paper consumption, save storage space, and contribute to environmental sustainability. These findings show that storage inefficiency is closely related to broader records-management problems within certification bodies and accredited centres. The accumulation of unclaimed certificates reflects not only physical storage limitations but also weaknesses in document retrieval, monitoring, and long-term credential management. By shifting to electronic certificates, institutions can transform certificate storage from a passive archiving activity into an active, searchable, and traceable digital record system.

Informants have highlighted the issue of certificates not claimed by trainees, which are retained for extended periods. Additionally, the organization has had to rent more space due to insufficient capacity to store these certificates. Accredited training centres also require additional administrative personnel and responsibilities, as their administrative staff will be responsible for managing, monitoring, and handling the bulk of certificates. The findings further reveal that some institutions store unclaimed certificates for more than five years, resulting in significant operational inefficiencies. Shift to e-certificates not only reduces reliance on physical filing systems but also

aligns with national sustainability goals. This echoes findings from earlier studies that digital archives substantially reduce overhead costs associated with physical document storage and retrieval.

Cost Saving

Electronic certificates can reduce costs by eliminating printing, re-printing, and paper procurement. It reduces the costs of paper, ink, printing equipment, and maintenance. Another factor that increases cost is discrepancies or inaccuracies in the certificates. DSD primarily covers the costs associated with errors on issued certificates. These costs include expenses incurred by accredited centres that must request revised certificates from DSD and bear the cost of their redistribution to affected trainees. Additionally, when trainees make errors in providing personal information for certificate production, this can incur additional costs. Such errors, originating from the trainees themselves, may result in fines, penalties, and the need for re-shipment, placing a potential financial burden on the trainees.

The cost-saving dimension should be understood in terms of both direct and indirect costs. Direct savings include reduced expenditure on paper, ink, printing equipment, storage facilities, and certificate redistribution. Indirect savings include reduced staff workload, fewer administrative corrections, shorter processing time, and lower opportunity costs for graduates waiting for corrected or reissued certificates. This indicates that e-certification has the potential to improve institutional efficiency beyond material cost reduction.

The stakeholders also highlighted indirect cost savings, including reduced labour hours, fewer administrative bottlenecks, and the elimination of third-party courier fees. At the national level, transitioning to digital certificates could save millions of ringgit annually, particularly given the high volume of TVET graduates. Moreover, digital certificates provide traceability that reduces fraud-related losses, a cost rarely accounted for in traditional systems.

Flexible Procedures

The certificate issuance procedure must be well coordinated and managed, as procedural issues sometimes make it difficult for accredited centres. For instance, procedures are often lengthy and time-consuming when addressing certificate errors. During the peak processing and issuance period, the current procedure should be reconsidered, or flexibility introduced to accommodate certificate printing. Thus, an electronic certificate may enhance procedural flexibility in situations beyond JPK's or AC's control. The introduction of e-certificates also enables automated workflows, reducing dependence on manual approval chains. The flexibility offered by electronic certificates also strengthens organizational resilience. During disruptions such as pandemics, system failures, staff shortages, or geographical constraints, digital certification enables institutions to maintain service continuity without relying entirely on physical presence or manual document handling. This finding suggests that e-certification can support a more adaptive certification governance model in the TVET sector. Stakeholders noted that digital systems could integrate automated checks, validation prompts, and real-time updates. This reduces human error and increases transparency in application tracking. Flexibility is particularly critical during crises such as pandemics, when physical processes cannot be conducted efficiently.

Security

Enhanced security measures are necessary to safeguard certificates against misuse and potential threats effectively. The skills certificate holds significant value due to its national and global recognition. Employers trust graduates with skills certificates, as these demonstrate skills aligned with industry requirements in Malaysia. The certificate must retain its fundamental worth, reputation, and ongoing recognition. Stakeholders expressed high confidence in blockchain-enabled e-certificates, citing benefits such as tamper-proof records, real-time verification, and resistance to forgery. This aligns with global trends in which blockchain is increasingly used in educational credentialing to mitigate fraud. Informants also emphasized that the transparency and audit-trail

features of blockchain enhance trustworthiness, particularly in industries that require strict compliance, such as aviation, healthcare, and manufacturing.

Across all themes, findings strongly indicate that shifting to electronic certificates is not merely a technological upgrade but a strategic transformation in governance and service delivery. The convergence of efficiency gains, cost reduction, enhanced user experience, and strengthened security demonstrates that e-certification aligns closely with Malaysia's broader digitalization and IR4.0 initiatives. Furthermore, international comparisons highlight that Malaysia is moving in the same direction as leading global education systems, particularly through its early adoption of blockchain for credential verification. This positions Malaysia's TVET ecosystem as a regional leader in secure, innovative certification management.

Taken together, the five themes indicate that the value of electronic certification lies in the integration of efficiency, accessibility, cost-effectiveness, flexibility, and security. These dimensions are mutually reinforcing: faster issuance improves graduate access to employment opportunities; reduced storage and cost burdens improve institutional efficiency; flexible procedures enhance service continuity; and stronger security mechanisms increase stakeholder trust. Thus, e-certification should be positioned not merely as a digital replacement for paper certificates but as a strategic instrument for modernizing TVET governance.

Security in e-certification should not be viewed solely as a technical feature, but also as a trust-building mechanism among certificate holders, employers, training institutions, and regulatory bodies. The use of blockchain, PKI, QR codes, and verification portals can strengthen confidence because stakeholders are able to validate certificate authenticity quickly and independently. This is particularly important in TVET, where the credibility of certification is closely linked to occupational competence and industry recognition.

However, the findings should be interpreted within the qualitative scope of this study. Although the interviews provide rich insights into stakeholder perceptions, the study does not quantitatively measure system performance, cost reduction, user satisfaction, or long-term adoption outcomes. Future implementation should therefore be accompanied by systematic monitoring and evaluation to assess technical reliability, legal acceptance, data protection, user experience, and integration with existing national certification systems.

CONCLUSION

In conclusion, this study demonstrates that the transition from physical to electronic certificates offers substantial advantages across the Malaysian TVET ecosystem. The findings highlight five key areas in which e-certificates provide clear improvements: issuance duration, storage efficiency, cost reduction, procedural flexibility, and enhanced security. These outcomes indicate that digital certification not only addresses operational challenges within existing manual systems but also aligns with national digitalisation agendas and global credentialing trends. Moreover, the adoption of e-certificates strengthens Malaysia's readiness for IR4.0 by enabling real-time verification, reducing administrative burdens, and providing a secure, tamper-proof credentialing framework supported by blockchain and PKI technologies. Despite these benefits, challenges remain, particularly in legal validation, technological infrastructure, and data protection, underscoring the need for coordinated policy development and cross-agency collaboration. Overall, this study contributes valuable insights into stakeholder readiness and implementation characteristics, offering practical implications for policymakers, training institutions, and technology providers in designing robust e-certification systems. Future research may expand by examining user acceptance, long-term system performance, and integration with emerging digital credential ecosystems. By addressing existing gaps and leveraging the identified advantages, electronic certificates have the potential to significantly transform Malaysia's TVET certification landscape and support a more agile, secure, and future-ready workforce.

REFERENCES

- Al Hemairy, M., Abu Talib, M., Khalil, A., Zulfiqar, A., & Mohamed, T. (2024). Blockchain-based framework and platform for validation, authentication & equivalency of academic certification and institution's accreditation: UAE case study and system performance (2022). *Education and Information Technologies*, 29(14), 18203–18232. <https://doi.org/10.1007/s10639-024-12493-6>
- Alammary, A., Alhazmi, S., Almasri, M., & Gillani, S. (2019). Blockchain-based applications in education: A systematic review. *Applied Sciences*, 9(12), 2400. <https://doi.org/10.3390/app9122400>
- Alharbi, W. (2023). Assessment of distribution system margins considering battery swapping stations. *Sustainability*, 15(8), 6782. <https://doi.org/10.3390/su15086782>
- Aziz, Y. A., & Chok, N. V. (2013). The role of halal awareness, halal certification, and marketing components in determining halal purchase intention among non-muslims in Malaysia: A structural equation modeling approach. *Journal of International Food & Agribusiness Marketing*, 25(1), 1–23. <https://doi.org/10.1080/08974438.2013.723997>
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp063oa>
- Brown, M., Mhichil, M. N. G., Beirne, E., & Lochlainn, C. Mac. (2021). The global micro-credential landscape: Charting a new credential ecology for lifelong learning. *Journal of Learning for Development*, 8(2), 228–254. <https://doi.org/10.56059/jl4d.v8i2.525>
- Cavallet, L. E., Canavari, M., & Neto, P. F. (2018). Participatory guarantee system, equivalence and quality control in a comparative study on organic certifications systems in Europe and Brazil. *Ambiente e Agua - An Interdisciplinary Journal of Applied Science*, 13(4), 1. <https://doi.org/10.4136/ambi-agua.2213>
- Cedefop. (2023). *Microcredentials for labour market education and training: Microcredentials and evolving qualifications systems*. Publications Office of the European Union. https://www.cedefop.europa.eu/files/5589_en.pdf
- Chen, G., Xu, B., Lu, M., & Chen, N.-S. (2018). Exploring blockchain technology and its potential applications for education. *Smart Learning Environments*, 5(1), 1. <https://doi.org/10.1186/s40561-017-0050-x>
- European Commission. (2022). *European digital credentials for learning*. European Commission. <https://europass.europa.eu/en/european-digital-credentials-learning>
- Gong, C., & Ribiere, V. (2021). Developing a unified definition of digital transformation. *Technovation*, 102, 102217. <https://doi.org/10.1016/j.technovation.2020.102217>
- Government of Malaysia. (2021). *National Fourth Industrial Revolution (4IR) Policy*. Economic Planning Unit, Prime Minister's Department. <https://ekonomi.gov.my/sites/default/files/2021-07/National-4IR-Policy.pdf>
- Hsu, C.-S., Tu, S.-F., & Chiu, P.-C. (2022). Design of an e-diploma system based on consortium blockchain and facial recognition. *Education and Information Technologies*, 27(4), 5495–5519. <https://doi.org/10.1007/s10639-021-10840-5>
- International Telecommunication Union. (2024). *Measuring digital development: Facts and figures 2024*. ITU. <https://www.itu.int/itu-d/reports/statistics/facts-figures-2024/>
- Kane, G. (2019). The technology fallacy: people are the real key to digital transformation. *Research-Technology Management*, 62(6), 44–49. <https://doi.org/10.1080/08956308.2019.1661079>
- Kasim, B., Ferriswara, D., & Haryati, E. (2025). Digital transformation in public services: A literature review on bureaucratic innovation and adaptation in the era of digital government.

- International Journal of Social Science and Humanity*, 2(4), 105–110. <https://doi.org/10.62951/ijss.v2i4.523>
- Keevy, J., Bateman, A., Manoharan, H. E., Molokwane, P., Lastra, R., Mlotshwa, H., Paterson, A., Ramchurun, R., Ravaioli, S., Shiohira, K., von Doetinchem, S., & Warren, K. (2026). Beyond qualifications frameworks: Large language models and the future of global skills recognition. *European Journal of Open, Distance and E-Learning*, 28(1), 3. <https://doi.org/10.65043/eurodl.162>
- Kumavat, N. (2019). Certificate verification system using blockchain. *International Journal for Research in Applied Science and Engineering Technology*, 7(4), 53–57. <https://doi.org/10.22214/ijraset.2019.4010>
- Nandiyanto, A. B. D., Fiandini, M., Hofifah, S. N., Ragadhita, R., Al Husaeni, D. F., Al Husaeni, D. N., Maryanti, R., & Masek, A. (2022). Collaborative practicum with experimental demonstration for teaching the concept of production of bioplastic to vocational students to support the sustainability development goals. *Journal of Technical Education and Training*, 14(2), 1–13. <https://doi.org/10.30880/jtet.2022.14.02.001>
- Noorhizama, N. K., Abdullah, Z., Kasim, S., A Hamid, I. R., & Mat Isa, M. A. (2023). Verification of Ph.D. certificate using QR code on blockchain ethereum. *JOIV: International Journal on Informatics Visualization*, 7(3), 716. <https://doi.org/10.30630/joiv.7.3.1584>
- Otero, J. P. G. de. (2019). *UNESCO-UNEVOC trends mapping: Innovation in TVET*. UNESCO-UNEVOC. https://unevoc.unesco.org/pub/tm_innovation.pdf
- Petersen, E., Lucey, D., Blumberg, L., Kramer, L. D., Al-Abri, S., Lee, S. S., Pinto, T. de C. A., Obiero, C. W., Rodriguez-Morales, A. J., Yapi, R., Abubakar, A., Tambyah, P. A., Holmes, A., & Chen, L. H. (2021). COVID-19 vaccines under the International Health Regulations – We must use the WHO International Certificate of Vaccination or Prophylaxis. *International Journal of Infectious Diseases*, 104, 175–177. <https://doi.org/10.1016/j.ijid.2021.01.039>
- Rustemi, A., Dalipi, F., Atanasovski, V., & Risteski, A. (2023). A systematic literature review on blockchain-based systems for academic certificate verification. *IEEE Access*, 11, 64679–64696. <https://doi.org/10.1109/ACCESS.2023.3289598>
- Said, S. H., Dida, M. A., Kosia, E. M., & Sinde, R. S. (2023). A blockchain-based conceptual model to address educational certificate verification challenges in Tanzania. *Engineering, Technology & Applied Science Research*, 13(5), 11691–11704. <https://doi.org/10.48084/etasr.6170>
- Syarief, E. (2021). Electronic land certificates: Its goals and challenges. *Research Horizon*, 1(4), 120–125. <https://doi.org/10.54518/rh.1.4.2021.120-125>
- Syarofi, M., & Syam, N. (2025). Digital transformation in halal certification: Opportunities for smes in Indonesia. *Klabat Journal of Management*, 6(1), 28. https://www.researchgate.net/publication/388664943_Digital_Transformation_in_Halal_Certification_Opportunities_for_SMEs_in_Indonesia
- UNESCO. (2022). *Transforming technical and vocational education and training for successful and just transitions: UNESCO strategy 2022-2029*. UNESCO. <https://doi.org/10.54675/EUDU5854>
- van Laar, E., van Deursen, A. J. A. M., van Dijk, J. A. G. M., & de Haan, J. (2020). Determinants of 21st-century skills and 21st-century digital skills for workers: A systematic literature review. *Sage Open*, 10(1), 100191. <https://doi.org/10.1177/2158244019900176>
- Verhoef, P. C., Broekhuizen, T., Bart, Y., Bhattacharya, A., Qi Dong, J., Fabian, N., & Haenlein, M. (2021). Digital transformation: A multidisciplinary reflection and research agenda. *Journal of Business Research*, 122, 889–901. <https://doi.org/10.1016/j.jbusres.2019.09.022>

- Vial, G. (2021). Understanding digital transformation: A review and a research agenda. *Managing Digital Transformation*, 13–66. <https://api.taylorfrancis.com/content/chapters/edit/download?identifierName=doi&identifierValue=10.4324/9781003008637-4&type=chapterpdf>
- Zheng, Z., Xie, S., Dai, H. N., Chen, X., & Wang, H. (2018). Blockchain challenges and opportunities: A survey. *International Journal of Web and Grid Services*, 14(4), 352. <https://doi.org/10.1504/IJWGS.2018.095647>