# Advancing Technical and Vocational Education Through Digital Innovation: A Pathway to Future-Ready Skills

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## ABSTRACT

The Fourth Industrial Revolution (4IR) necessitates a paradigm shift in Technical and Vocational Education and Training (TVET) to cultivate a digitally proficient, future-ready workforce. This study investigates the impact of digital tools on TVET pedagogy, identifies the core digital competencies for educators and learners, and examines the institutional factors influencing successful digital integration. Employing a sequential explanatory mixed-methods design, the research involved surveys and semi-structured interviews with instructors, students, and administrators from public TVET institutions in Malaysia. The findings reveal a strong positive correlation between the use of digital tools, such as Learning Management Systems (LMS), and perceived teaching and learning effectiveness. However, significant challenges persist, including a notable competency gap between instructors and students, varied digital readiness across different academic programs, and critical institutional barriers like inadequate infrastructure and inconsistent investment. The study concludes that successful and sustainable digital transformation in TVET is not merely about technology adoption but requires a holistic strategy that integrates policy alignment, continuous professional development, structured digital literacy training, and long-term infrastructural investment. Such a multifaceted approach is crucial to bridging existing gaps and fully realizing the potential of digital innovation in vocational education.

**Keywords:** TVET, Digital Transformation, Digital Competency, Educational Technology, Industry 4.0

## INTRODUCTION

Amidst the upswing of lightning-speed technological innovations, global economic reshuffle, and changed workforce requirements, Technical and Vocational Education and Training (TVET) has come forward to a position that is not only of high significance but also of complexity. TVET institutions have always been the mainstay of forming specialists in sectors that need dexterous and detailed skills, mainly where manual instruments are in use. Nevertheless, the classical TVET scheme that was reliant on hand work, worn-out courses, and rigid methods of teaching is now facing the challenges that the Fourth Industrial Revolution (4IR) hold. This revolution calls for a workforce that is not just knowledgeable in the technical aspects but also has digital literacy, is adaptable, and has lifelong learning skills [4].

The introduction of the IR 4.0 technologies, such as Artificial Intelligence (AI), the Internet of Things (IoT), Augmented Reality (AR), Virtual Reality (VR), robotics, and cloud computing is having a fundamental effect on the nature of work across several industry sectors. These modifications demand that how TVET programs are planned, executed, and evaluated be also changed. One need not even think about digital transformation anymore as it has already become a matter of the utmost importance. Digital tools and platforms are thus very much capable of refreshing one's instructional strategies, engaging students, and at the same time, getting quality training for students of various learning needs and from remote or underserved places. For example, immersive AR/VR simulations can copy the surrounding that exists in real industrial sectors, whereby the learners can therefore perform multiple tasks without any fear in the event of errors. Similarly, Learning Management Systems (LMS) alongside mobile learning apps will act as stepping stones that will enable students to study on their own and at their speed and will allow them to pick their learning styles and time schedules for the same [2].

At an international level, TVET education is experiencing a terrific act of digital change that has however turned out to be not so easily reachable due to many problems. Such problems are the lack of proper infrastructure as well as digital competencies among lecturers, ambiguous and incomplete policy frameworks, and the absence of institutional level acceptance to change. In addition to this, new technologies introduced do not match the industry's actual requirements and that is where the employability outcomes are restrained. To mitigate these drawbacks, a renewed approach that connects digital tools not as individual improvements rather as facilitators incorporated within a wide spectrum of pedagogical transformation, curriculum reconstruction, teacher training, and industry cooperation is required [3]. This should address the presence of all coexisting subsystems within the dynamics of the TVET ecosystem.

In Malaysia as well as in a majority of the developing countries, the government's intention to digitalize TVET keeps coming up as some of the major points in the national economic transformation agenda. The Malaysian Smart TVET Framework and the National Digital Economy Blueprint (My DIGITAL) are a few of the many initiatives that have been launched in the country and These initiatives have been taken to illustrate the place of technology in vocational education as a means to give it a better quality, to make it more inclusive and to be more responsive to the needs of society [5]. Nevertheless, research proofs of the actual impact and the best practices of digital integration in TVET are scarce, especially in real classroom settings and in the various vocational disciplines.

This paper is designed to investigate the potential that digital innovation holds for TVET practice and policy and thus create the right kind of skills for the future that will cater to the needs of both the local and the global industries. The study, to be more precise, searches for the digital tools being used in the TVET sector, the changes in the teaching approaches that are necessary for successful deployment, the competencies that educators and students must own, and, finally, the policies that will help to transfer and to keep running the digital transformation. Consequently, the document offers a multi-layered framework of TVET's redefinition in the digital era which highlights digital innovation not as just an accessory to educational practice but as a core of educational and economic advancement [1].

**The Role of Digital Tools in Modernizing TVET Pedagogy**

The use of digital tools in Technical and Vocational Education and Training (TVET) has resulted in a revolution that has taken the learning process from traditional face-to-face lecture to a dynamic learner-centered learning model. The digital tools are a great aid as today's traditional TVET methods, which are often more dependent on the use of physical workshops and the teaching of the instructor in the traditional way. Digital technologies are also known to be very adaptive, scalable, and interactive in the education sector, thus, the sudden transformation has been the order of the day [6].

Virtual labs and 3D simulation platforms allow learners to experience real-world industry tasks, thereby, exactly doing the same tasks that only a physical environment can allow like engine diagnostics, electric circuit testing using welding equipment—this without risking or straining of resources. Similarly, mobile learning apps and cloud-based Learning Management Systems (LMS) provide untiring access to learning content, leading to more independent study and knowledge retention. They also guarantee the opening of the doors to more flexible practices of teaching that can fit with any training style and rate of learning, in particular, students who have problems of different kinds, whether cognitive or psychomotor [7].

Teachers even get more support from AI-driven evaluative means and the advanced analytics systems since these technologies installed in these tools provide a basis for formative assessment and allow teachers to do grading and feedback in a very short time. Moreover, with the help of these means, teachers can also spot very quickly the gaps in learning and new learning strategies that are needed given the current level of learning. Simply put, the digital tools that have been adopted by TVET tutors today are designed to not only support and enhance the process of learning but also to change the way their students are tested, continually engaged, and equipped with knowledge [8].

Furthermore, digital technologies make it possible for the inclusion of transferable skills as the foundation of the TVET programs implementing strategies for the 21st-century workforce, who are required to the ever-changing

labour market. This segment is a clear testament to why the infusion of digital learning tools should be looked at as the most effective way of rejuvenating the digital TVET ecosystem that is the foundational pillar of any education system but not just complimentary items.

**Competency Requirements for Educators and Learners in a Digitally Enabled TVET Ecosystem**

As TVET evolves to a digitally-powered system, both the teachers and the students are required to learn new competencies in order to continue to be effective and relevant. The teachers' part includes not only the increase in digital skills but pedagogical agility, proficiency in educational technologies, and the creation of digital learning environments adjusted to the industrial standards and needs along the way are being of the utmost importance.

The TVET lecturers must also have skills in the following areas: developing digital content that is interactive, blending virtual and augmented reality into the practical sessions, conducting hybrid or blended learning, and using data analytics to track student performance. Teachers also have to possess the competence of making use of digital authoring tools, managing online assessments, and applying digital pedagogies like flipped classroom, project-based learning, or gamification that started to be increasingly prevalent with the virtual actions [8]. Another major responsibility of the educators is always to keep themselves well informed about the latest technologies in their area of alternative education so that the programs they create remain accurate and include the latest technology tools.

Similarly, students are required to have an equal amount of competence to fill the need. They, too, need to acquire skills of digital literacy, which not only includes the basic and obvious ones but also the ability to use them beyond using gadgets. They need to be able to search for sources of information and use them to interact with multimedia content critically, interact using digital communication tools, and display their independence in web-based training at any pace. Equally important are their competence in running the digital systems of the modern industry and the need to be familiar with the computer-aided design (CAD), the industrial automation software, the IoT systems to elaborate the digital fluency necessary for their future professional paths [7].

This particular part of the article presents a clear focus on the factor that the smooth transition to digital technology in TVET largely depends on the ability of the human race to skilfully make use of the technology. This requires such things as a digital skills training curriculum, continuous teacher professional development, and digital literacy programs for students [9].

**Strategic Challenges and Enablers for Digital Transformation in TVET Institutions**

Despite the acknowledged digital innovation in TVET, the adoption of it is often sidelined by various factors that present complex challenges. At the top of this list is institutional preparedness, as a significant number of TVET providers do not have the requisite infrastructure like upgraded hardware, reliable internet connectivity, and modern software solutions to offer on-demand employability skills. Further, limited allocations in that sector hinder the access to best-of-breed digital technologies and the capability to maintain them [10].

In addition to the above, the unpreparedness of the teaching staff for digital implementation is a significant barrier. A large number of the educators, particularly those coming from the rural and older generations, are faced with the steep learning curves as they attempt to blend into the new technology. Another contributing factor is the insufficient or lack of formal and continuous in-service training programs. This situation is such that with no clear plan for the digital TVET integration at the national level, the attempts of the local institutions often become isolated and disappear in the long run [11].

Issues in the regulatory area of policy may either prevent innovative actions or lead to obsolete practices. A good example is the inflexibility in the curriculum standards, which could be incapable of supporting e-learning. Alternatively, not having systems for accrediting digital competencies might be a reason for the institutions not to transform digitally.

Despite these barriers, the acceptance of digital tools in TVET can be fastened by embracing technology. One

among the many drivers is the digital-friendly policies put forward by the authorities such as national digital education blueprints, financing projects, and incentivising projects that channel towards the development of the digital curriculum. Besides, the complementarity of the business sector can as well cause a radical change by availing not only the digital tools but also the latest training content, and the interning opportunities that connect learning with the place of future employment [12].

Moreover, the leaders of the institutions that stick to digital revolution as the main priority and in partnership with the culture of experimentation and collaboration can lay the foundation for continuous change. This part underlines the fact that TVET digitalization is the process that is of institutional scale and is expected to last in the medium to long term, which are confirmed by such activities as policy synchronization, stakeholder engagement, and sustainable infrastructure planning as the components of the digital transformation strategy.

### Research Objectives

1. To investigate the impact of digital tools and technologies on teaching and learning practices in Technical and Vocational Education and Training (TVET).
2. To identify the core digital competencies required by TVET educators and learners for effective participation in a digitally enhanced training environment.
3. To examine the institutional and policy-level enablers and barriers that influence the successful integration of digital innovation in TVET systems.

## RESEARCH METHODOLOGY

### Research Design

The present research affords a mixed-methods research design, which pulls together both quantitative and qualitative points of view, to end up with a better understanding of the influence of digital tools in TVET pedagogy, competency development, and institutional transformation. The study uses a sequential explanatory design in which both broad-asked surveys and deeper-meaningful interviews were conducted.

This design was considered to be most suitable for exposing, through links, both the width (via surveys) and the depth (through interviews) essential to carry out a thorough inspection of the stepping-up of digital innovation in TVET institutions. The merging of different types of data is a tool for the appreciation of the precision of the final results, and the pattern of a two-phase study is equally important for setting up the research objectives.

### Population and Sampling

This research chose the TVET instructors, students and institutional administrators from certain public vocational colleges and polytechnics in Malaysia as respondents. The use of a multi-stakeholder approach makes the study unique and sound. This approach has been employed to take into account the views of every party involved in TVET innovation, i.e. the givers and receivers of the programs. A systematic purposive sampling method was used for this research. For the quantitative part, 120 instructors and 240 students from six schools were considered to be the sample size. For the qualitative part, 15 people (5 instructors, 5 administrators, 5 students) were considered for the study since they were the ones who had used digital tools in the area of teaching, learning, or managing.

### Research Instruments

To have a complete understanding of the research objectives, a combination of both quantitative and qualitative data-gathering tools was used. The quantitative tool was a structured questionnaire that was used to find out primary factors on TVET digitalization as well as to measure the integration of digital tools in TVET contexts. The tool was designed, revised, and validated via feedback from three experts in the TVET, digital pedagogy, and educational research fields for content validation. The final version of the questionnaire was then broken down into four parts that consisted of demographic information, the users' experience and personal view of digital tools, how they assessed their digital competencies, and their perceptions of the impact on the teaching

and learning effectiveness there. Each of the items from sections 2 to 4 was measured by the means of a Likert scale. The scale was from "1" being "Strongly Disagree", to "5" being "Strongly Agree". After a pilot test with 30 participants, the survey instrument was found to be reliable. The instrument reached a high level of the internal consistency as it acquired a Cronbach's alpha coefficient of 0.87.

As for the qualitative component, the investigator came up with a semi-structured interview protocol to make a deeper analysis of how participants were affected regarding the issue of digital innovation in TVET. The interview guide was constructed of questions that were open in nature and its main aim was to put forth the inquiry about the types and purposes of digital tools used by the interviewees, and also, they were asked to speak about the challenges they encountered during the establishment of these tools, to mention institutional and policy support mechanisms, the training they had or were in need, and about the outcomes in terms of teaching quality, learner performance, and employability. The interviews were performed in person for those who were reachable in that way as well as through video conferencing platforms, depending on the availability and preferences of the participants.

### Data Analysis

Utilising IBM SPSS Statistics version 27, the quantitative data that the questionnaire derived from were handled by computer. Summary statistics, e.g., means and standard deviations, were generated to depict the participants' views on the extent of their use of digital tools and their effectiveness. Hypotheses based on the characteristics of the groups like gender, type of program, and educational establishment went through examination by independent samples t-tests, and one-way ANOVA was conducted. Additionally, principal component analysis with varimax rotation was used to determine the underlying factors of the items that measure digital competency and thus EFA was used. Thus, the analysis with Pearson's r was used for the purpose of testing if there is a statistical relationship between the variables digital tool usage, digital competency, and the said teaching and learning effectiveness of the teacher and the student.

Striving to understand the experiences and thoughts that their participants had in their response to the semi-structured interview, the researchers resorted to thematic analysis that confirmed the six stages suggested by Braun and Clarke (2006). An inductive coding approach that allowed for themes to be generated as they became apparent through the data was utilized, beside that, rather than being forced through the already set categories. What's more, the software of NVivo was of great help during the coding process as it helped in making the entire procedure faster and easier. To avoid any ambiguity, all the extracted themes were aligned to the main objectives of the study, which were three. The credibility of the results was maintained through the use of such techniques as member checking and peer debriefing, where participants were involved in validating and/or challenging the results, and those that are outside of the study were asked for their input during the research process.

Quantitative data gathered via the questionnaire were then fed into IBM SPSS Statistics version 27 for analysis, while being scored descriptively. The principal values such as the means and standard deviations were calculated to represent how digital tools were utilized and what participants generally thought was the most effective practice. The second data set was focused on group identification with the help of independent samples t-test and one-way ANOVA, in which the variance questions on gender, program type, and institution were also manipulated. EFA or Exploratory Factor Analysis was thus used to conduct the following part of the survey, where the factors that were mentioned and that measure digital competency were listed out, this was conducted using principal component analysis with varimax rotation as the rotation method. In a last step, Pearson correlation analysis was run to see if there is a relationship between the three variables of digital tool usage, digital competency, and teacher-student effectiveness of the perceived teaching and learning.

## RESEARCH FINDINGS

### Quantitative Findings

This portion exposes the numerical data obtained from the questionnaires given to 120 TVET teachers and 240 students in six particular institutions. The research is centered around the utilization of digital tools, self-assessed digital skills, and the extent to which these are considered to affect teaching and learning. The findings are

presented in the order of descriptive statistics, inferential tests (t-tests and ANOVA), exploratory factor analysis, and correlation analysis for a complete understanding of the research aims.

**Digital Tool Usage**

Respondents reported high frequency of using several digital tools in their teaching and learning environments. The most frequently used tools were:

1. Learning Management Systems (LMS) : M = 4.21, SD = 0.74
2. Video conferencing platforms (e.g., Google Meet, Zoom) : M = 4.03, SD = 0.81
3. Simulation/VR-based software : M = 3.12, SD = 0.97
4. Mobile learning applications : M = 3.85, SD = 0.89

Respondents agreed that digital tools have enhanced interactivity (M = 4.05, SD = 0.69) and flexibility in learning (M = 4.22, SD = 0.63).

**Self-Reported Digital Competency**

Instructors rated their digital competence at a moderately high level (M = 3.92, SD = 0.68), particularly in areas such as content creation, online assessment design, and technology troubleshooting. Students reported slightly lower competency levels (M = 3.57, SD = 0.75), with weaker confidence in using tools like simulations and data analytics dashboards.

**Independent Samples T-Test**

An independent samples t-test was conducted to determine if there were significant differences in digital competency between instructors and students.

| Group | N | Mean | SD | t | p |
|---|---|---|---|---|---|
| **Instructors** | 120 | 3.92 | 0.68 | 4.83 | <.001* |
| **Students** | 240 | 3.57 | 0.75 | | |

***Significant at the 0.05 level.**

**Interpretation**: Instructors reported significantly higher digital competencies than students (**p < .001**), indicating the need for structured digital literacy support for learners.

**One-Way ANOVA**

A one-way ANOVA was used to assess whether perceived teaching/learning effectiveness differed based on **program type** (e.g., Engineering, ICT, Hospitality, Services).

| Program | N | Mean | SD |
|---|---|---|---|
| **Engineering** | 60 | 4.02 | 0.60 |
| **ICT** | 70 | 4.15 | 0.52 |
| **Hospitality** | 50 | 3.79 | 0.70 |
| **Services** | 60 | 3.92 | 0.66 |
| **F(3, 236)** | | **3.45** | **p = 0.018*** |

**Post-hoc Tukey** test revealed that ICT students perceived significantly higher teaching/learning effectiveness via digital tools compared to Hospitality students.

**Exploratory Factor Analysis (EFA)**

EFA was conducted on 18 items measuring digital competencies to identify underlying constructs. The Kaiser-Meyer-Olkin (KMO) value was 0.863, and Bartlett's Test of Sphericity was significant ($x^2 = 1324.56$, $df = 153$, $p < 0.001$), confirming suitability.

Three distinct factors were extracted (Eigenvalues > 1), explaining 62.4% of the total variance:

1. Digital Instructional Design - use of tools for lesson planning, content delivery, and assessment.
2. Technology Operation & Support - technical skill in managing platforms and troubleshooting.
3. Collaborative & Analytical Tools - use of discussion boards, analytics dashboards, and peer tools.

Each construct showed acceptable internal consistency (Cronbach's $\alpha > 0.8$).

**Correlation Analysis**

Pearson correlation was performed to assess the relationship between digital tool usage and perceived teaching/learning effectiveness.

| Variable | r | p |
|---|---|---|
| **Digital Tool Usage x Effectiveness** | 0.64** | <.001 |
| **Digital Competency x Effectiveness** | 0.58** | <.001 |

****Significant at the 0.01 level.**

**Interpretation**: There was a strong, positive correlation between frequency of digital tool usage and perceived effectiveness, suggesting that greater adoption of digital technologies is associated with improved learning outcomes.

Several vital insights from the quantitative part of the research pointed out the basic ways in which digital technologies are used in the educational process of TVET institutions. Both the instructors and the students made use of the Learning Management Systems (LMS) and video conferencing platforms the most, this fact pointed out their usage as the main tools of the content delivery and the virtual interaction. When it comes to digital competence, teachers' self-reported ability was higher than students'. They reported high levels of proficiency especially in simulation tools, where students indicated that they were the weakest group. When the data from the program boils down to the program type, information and communication technology programs (ICT) students have a very high digital learning perception significantly when hospitality students are compared to their peers. The semantic analysis has identified that digital competences are characterized by three pillars: digital instructional design, technical support, and collaborative skills and the use of analytical tools. The last and final part of the paper, by means of correlation analysis, the authors found out that there was a strong positive relation between the frequency of digital tool utilization on the one hand, and the sense of enhancement of educational quality on the other hand. This suggests that greater use of digital technologies can lead to better learning outcomes in TVET.

## QUALITATIVE FINDINGS

The data for this study was gathered through fifteen semi-structured interviews with TVET instructors, students, and administrators, and the researchers conducted the thematic analysis on it. Braun and Clarke's (2006) six-phase framework was the basis of the analysis, which followed an inductive approach to enable themes to be

naturally obtained from the data, finding underlying themes that were not predefined. NVivo software was applied to manage the process of identifying the themes, creating categories, and then on to the stage of theme consolidation and editing. The coding work was the vehicle that has driven the authors to compose three major themes and nine minor subthemes, which are in line with the aims of the study.

**Theme 1: Pedagogical Transformation through Digital Tools**

Respondents repeatedly mentioned that digital instrument inclusion had turned the teaching models, from being static to more engaging and interactive, and student centered.

- **Subtheme 1.1: Enhanced Engagement and Flexibility**

  Educators and students were both keen to point out that such tools as Google Classroom, Moodle, and Zoom not only provided flexibility in scheduling learning but also allowed students to reach the materials again. An instructor said: "My students can learn at their own pace now, especially when I upload tutorial videos. They can pause and repeat until they understand."

- **Subtheme 1.2: Blended and Simulation-Based Learning Adoption**

  There were a few professors experimenting with a mixture of blended learning and simulations to help students with their practical skills. Nevertheless, the availability of simulation software was not the same in all educational facilities. A student stated: "We used a 3D welding simulator once. It really helped to understand the hand movement before we went to the actual lab."

- **Subtheme 1.3: Challenges in Digital Content Delivery**

  The shortage of training and time to do the task was the main cause of teachers failing to develop digital content of good quality. This was particularly the problem with older teachers.

**Theme 2: Competency Gaps and Digital Readiness**

It was reported that digital readiness was not the same for all instructors and students, which had an impact on the success of digital integration.

- **Subtheme 2.1: Instructor Competency and Professional Development Needs**

  Among the teachers, some really felt as if they were proficient in the use of technology, while others were not ashamed to state that they would become confident of their skills when they receive more help. One of them said: “I can go about using PowerPoint and Google Meet, however, the use of video editing or interactive modules makes me confused.”

- **Subtheme 2.2: Student Digital Literacy Variability**

  The analysis said that students from the ICT sectors were well informed about online tools and were more comfortable with such technology, while others from different departments still needed training. A hospitality major commented: “Some of these platforms, we just go to class, and we don't know how to use them. I get forlorn at the beginning of an online class.”

- **Subtheme 2.3: Peer Support and Informal Learning**

- Both sets of students and instructors were aware of the part peer support plays in overcoming technology problems, with students frequently helping each other with tool navigation.

**Theme 3: Institutional Support and Strategic Constraints**

Various institutional influences played a crucial role in digital adoption and were shared with positive and

negative examples.

- **Subtheme 3.1: Infrastructure and Connectivity**

  Inadequate internet access and older equipment were found to be the most significant obstacles. One administrator brought out: "We have only one lab with working internet strong enough to support online teaching."

- **Subtheme 3.2: Policy and Leadership Support**

  Institutions led by active and visionary leaders who complemented this with sound digital plans of action achieved far better results. “Our principal encourages digital teaching. We even have weekly sessions to share tips,” said one instructor.

- **Subtheme 3.3: Lack of Sustained Investment**

  Most participants stressed the idea that digital transformation is a long-term process of investment and not merely a matter of training or devices on a single date.

| Theme | Subtheme | Code Example | Representative Quote |
|---|---|---|---|
| **Pedagogical Transformation** | Enhanced Engagement & Flexibility | Flexible access, self-paced learning | “Students can pause and learn again on their own time.” |
| | Blended & Simulation Learning | Simulation trial, blended instruction | “The VR simulator gave us a real feel of the job site.” |
| | Challenges in Content Delivery | Lack of skills, time constraints | “I’m not trained to create online learning modules.” |
| **Competency Gaps & Readiness** | Instructor Competency | Need training, tool confusion | “I struggle when I have to use advanced features.” |
| | Student Digital Literacy | Lack of exposure, unpreparedness | “Sometimes I don't know how to submit assignments online.” |
| | Peer Support | Help from classmates, informal tutoring | “I usually ask my friend to show me how to use the system.” |
| **Institutional Support & Strategic Issues** | Infrastructure Limitations | Weak internet, hardware limitations | “Our lab’s connection drops often—it’s frustrating.” |
| | Leadership and Policy | Support from admin, staff meetings | “We were encouraged to try digital tools during MCO.” |
| | Investment Challenges | Short-term funding, lack of upgrades | “After getting the tablets, we didn’t get any follow-up training.” |

**Table 1: Sample Coding Framework from Thematic Analysis**

From the qualitative data gathered, it was established that the nature of the new media has transformed the pedagogical clothing at TVET, making it flexible, interactive, and accessible. Nevertheless, the lack of digital competencies among educators and learners is the key transformative challenge. The success of the digital transition cannot be achieved without the support of colleges, the availability of the necessary infrastructural, and continuous professional development, It is these three conditions that are at the forefront of a more effective transformation. These results not only confirm the quantitative data and the strategic significance of a structured approach but also the need for such in order to unite these facts into a valid system of digital electoral

identification for TVET.

# DISCUSSIONS

### Examine the Role of Digital Tools in Enhancing TVET Pedagogy

It was noted in the research that digital tools, especially the Learning Management Systems (LMS) and interconnected with the video conference ones, contribute significantly to the change in the instruction scene of TVET. Among the quantifiable results were high average utilization indices gained by these tools indicating that they are broadly perceived. In addition to the numbers, the usefulness has been confirmed during the open-ended questions, where teachers perceived that technology was really enabling the flexibility, engagement, and accessibility of education in the classroom.

These findings are consistent with studies that show LMS and video tools support student-centered learning and improve knowledge retention through self-paced delivery [13], confirming the nourishing influence of digital tools on the learner-centered approach to teaching while showing that the combination of such tools with self-paced learning systems considerably strengthened knowledge retention. For instance, in the light of challenges in the workplace for TVET students, learners could learn those competencies best on the mobile or simulations, especially if they are complicated and even risky to perform the exercises on the training spot [14]. Although, the incoherent opportunity for employing sophisticated simulation tools along with observations in the interviews revealed to us some subtle digital inequities among schools and the possible danger of the diffusion of quality vocational education [15].

Thus, it can be said that the use of digital tools for TVET is a great way to modernize its pedagogy. At the same time, the effect of these tools depends on the availability of infrastructure, the choice of suitable tools, and the match with teaching of the course. These tools must not be just taken over by institutions; rather, they are required to design and implement tools in the context of the TVET tradition.

### Identify the Competency Requirements of Educators and Learners in a Digitally Enabled TVET Ecosystem

The second objective focused on understanding the digital readiness and competency levels of educators and learners. The quantitative results indicated a significant competency gap, with instructors perceiving themselves as more digitally competent than students ($M=3.92$ vs. $M=3.57$, $p < .001$). This statistical finding is powerfully illustrated by the qualitative data. For instance, while instructors expressed confidence with primary tools, students, particularly those outside ICT programs, reported feeling unprepared. One Hospitality major commented, “Some of these platforms... I get forlorn at the beginning of an online class,” highlighting the practical impact of this competency divide.. Exploratory Factor Analysis further classified digital competencies into instructional design, technical operations, and collaborative tool use, reinforcing the multidimensional nature of digital literacy in TVET.

This resonates with [8], who argued that digital competency is not merely about tool usage but involves pedagogical adaptation and the ability to integrate technology into meaningful learning experiences.

The study also uncovered informal peer support systems among both educators and students, suggesting the value of collaborative learning communities. Nonetheless, the gap in competency remains a concern and points to the urgent need for structured digital competency frameworks and inclusive training programs for both teaching staff and students.

### Explore the Strategic Challenges and Enablers of Digital Transformation in TVET Institutions

The last goal evaluated the wider policy and institutional aspects of the digital shift. The thematic analysis showed that infrastructure deficits, for example, poor internet access and outdated equipment, were top barriers, especially in rural or under-resourced institutions. The results from ANOVA indicated that the perception of the effectiveness of digital learning changed significantly across different program types. Moreover, the students of

ICT declared greater effectiveness than that of Hospitality ($p = 0.018$). The thematic analysis clarifies the difference in the division of the two factors, namely student digital literacy and resource availability. The triumph in the ICT sectors can be opposable with the difficulties faced in the rest; as one school official pointed out, poor infrastructures such as 'only one lab with the internet strong enough for online teaching' impact non-tech programs more severely than those that are tech-focused.

The respondents complied with the request for some of the strategic enhancers: visionary leadership, policy convergence, and well-targeted continuous professional development. Those institutions that had well-defined strategic digital policies and strong support from the administration showed positive results in terms of adoption. These observations align with findings that strong management involvement, a clear digital vision, and sustained leadership are critical to driving successful digital transformation in TVET [16] and are echoed in frameworks identifying institutional logic as central to digital progress [17].

Furthermore, the absence of continuous funding and further intervention after the initial release of technology was a repeatedly mentioned matter, indicating a function more of a responsive nature rather than a strategic one to digital adoption in certain fields. So, for the digital conversion to be not just effective but also sustainable, hospitals have to invest not only in the tools but also in the people, the new curriculum, and the monitoring framework [18].

**Recommendations for Policy and Practice**

On the basis of the results, this research puts forward the following practical recommendations to the stakeholders:

1. For the Policymakers: Initiate a National TVET Digital Competency Framework that defines the basic skills needed by the educators as well as the students. This has to be accompanied by renewable, long-term financing models for the upgrading of the infrastructure, instead of the usual one-off grants.
2. For Institutional Leaders: Put in place a structured, tiered professional development program for educators, where the main focus is on the pedagogical integration rather than just the technical skills. Make it possible for the teachers to have access to peer support and collaborative learning through the establishment of formal platforms for sharing best practices.
3. For Curriculum Developers: Require the adoption of primary digital literacy modules in all TVET programs as a measure of closing the identified competency gap between different student cohorts.

**Limitation And Future Research**

Moreover, several limitations are noted in this research, and these limitations offer perspectives for the future scholarly work. Firstly, the research depends on the self-reported data on the digital competence and the perceived efficiency of the digital tools. Such a method might be open to various types of biases in the responses of the subjects, e.g., social desirability bias, thus the participants could present the competency of their skills or the positive impact that the digital tools give to them. The upcoming works of scholars might involve objective methods, for instance, direct skill assessments and system usage data analysis for the purpose of confirming these self-reported results.

In addition, the sample was selected solely from the public TVET institutions located in urban and semi-urban areas of Malaysia. Therefore, the results may lack generalizability to private institutions, rural colleges, or different national contexts with significant infrastructural and policy changes. It is required to carry out further investigations to understand the effect of digital transformation in these diverse places so as to have a deeper understanding of the issue.

Thirdly, the research ignored the possible influence of confounding factors such as the student's financial status, their prior exposure to personal technology, or the level of support in a particular institution. These aspects could have a significant impact on both the ability to use digital technologies and the availability of resources, thus leading to different results. A more accurate study should consider these factors when investigating the use of digital technologies in TVET.

Lastly, the research design of a single moment and a correlation can only show the associations between the variables but not the directions of these associations. Despite the strong positive correlation we observed between digital tool usage and effectiveness, we are unable to state that the tools directly lead to better outcomes. It will require experimental or longitudinal research to be certain of the cause-effect relationship.

## CONCLUSION

The study reveals that the use of digital tools in Technical and Vocational Education and Training (TVET) has a lot to offer teachers who want to innovate their teaching methods and to make learning more efficient and prepare students for a labour market highly reliant on technology. The quantitative and qualitative data suggest that, although tools like LMS and video conferencing are used by many, there are no clear plans for the adoption of simulations and mobile learning for broader and more consistent uses, as there are obstacles in infrastructure and digital capabilities. Educators and students, particularly those not from ICT backgrounds, are struggling to make the switch to digital teaching and so the importance of clearly designed training and skill development is stressed. The role of the leadership of and the backup received from the institution, as well as the long-run digital roadmaps, are the factors from which the transformation a success emanates. Besides, in order to be able to bring a new digital change in TVET that is effective and sustainable, it refers to a deliberate delineation among policy-making, skill development, and infrastructural investment.

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