Addressing the Skills Gap in Technical and Vocational Training for Sustainable Socio-Economic Growth and Development

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ABSTRACT

Technical Vocational Education and Training (TVET) plays an important role in socio-economic development of society by equipping individuals with the practical skills and knowledge needed to thrive in the modern workforce. This paper explores several transformative innovations in TVET, such as digitals and online learning platforms, the use of Virtual Reality (VR) / Augmented Reality (AR) technologies for knowledge transfer, competency-based education (CBE), green skills development, Public-Private Partnerships (PPPs) and industry-based training internship in Malaysia & globally. The advancements in these areas should enhance skill acquisition, improve employability of fresh graduate and ensure training programs are aligned with current and future market demands, thereby reducing the skills gap and fostering sustainable economic growth. By making education more accessible and tailored towards the needs of various industries, these innovations support the UN Sustainable Development Goals (SDGs) for inclusive development and empower under-served populations. The paper aims to provide a comprehensive analysis of these transformative TVET initiatives, their socio-economic impacts and best practices for implementation. It also offers policy recommendations and strategies for stakeholders to invest in and support these initiatives, ensuring the continuous improvement and relevance of TVET in driving global economy.

Keywords: TVET, Digital Learning, Virtual Reality, Augmented Reality, Competency-Based Education, Green Skills, Public-Private Partnerships.

INTRODUCTION

In today's rapidly evolving economy, Technical and Vocational Education and Training (TVET) plays an important role in equipping individuals with the practical skills and knowledge required for the workforce to fulfil the high-skill shortage in the industries (Freud, 2021). TVET is essential for fostering economic growth, enhancing productivity and ensuring that industries have access to a skilled manpower capable of meeting the demands of modern technologies and practices. By focusing on skill-based education, TVET helps bridge the gap between theoretical knowledge and practical application, spearheading economic development. It also provides pathways for lifelong learning and career advancement, enabling individuals to adapt to changing job markets and technological advancements.

Despite its importance, the TVET sector faces significant challenges that hinder its effectiveness. One of the most pressing issues is the skills gap, where there is a disconnect between the skills provided by TVET institutions and the new needs of employers due to new technological advances such as AI, Data Analytics and Internet of Things (IoT). This gap is widened by the rapid technological changes, which require continuous updates to curricula and training methods (Kana & Letaba, 2024). In addition, there are disparities in access to quality TVET programs, particularly in rural and underserved areas, limiting opportunities for many individuals. Other challenges include inadequate funding, outdated infrastructure and a lack of qualified instructors, all of which contribute to the difficulty in delivering high-quality vocational education.

Theoretical Framework

The theoretical framework of this study can be grounded in the 'Skill-Biased Technological Change' (SBTC) theory, which posits that technological advancements disproportionately increase the demand for skilled labour

while reducing the need for routine, low-skill tasks (Wang, J et al., 2021). This theory aligns with the author's emphasis on the transformative role of Technical and Vocational Education and Training (TVET) in addressing the skills gap and fostering sustainable socio-economic development. SBTC suggests that as industries adopt advanced technologies such as automation, artificial intelligence (AI), and the Internet of Things (IoT), the demand for workers with specialized technical skills rises, creating a pressing need for education systems to adapt (Barzaeva, M., & Ilyasov, R., 2022). TVET, as highlighted in this paper, serves as a critical mechanism for equipping individuals with the competencies required to thrive in this evolving labour market. By integrating innovations such as digital and online learning platforms, virtual and augmented reality (VR/AR), and competency-based education (CBE), TVET institutions can align their curricula with the demands of skill-intensive industries, ensuring that graduates are prepared to meet the challenges of a technology-driven economy. These innovations not only enhance the accessibility and quality of vocational training but also address the structural shifts in labour demand caused by technological change, as theorized by SBTC.

Furthermore, the SBTC framework underscores the importance of continuous skill upgrading and lifelong learning, which are central to this paper's discussion of TVET's role in fostering economic resilience. As technological advancements accelerate, the half-life of skills shortens, necessitating ongoing education and training to maintain workforce relevance (Burns, R., 2020). The paper's focus on green skills development, public-private partnerships (PPPs), and industry-based training internships reflects this dynamic, as these initiatives are designed to provide workers with the specialized knowledge and practical experience needed to adapt to emerging sectors such as renewable energy, sustainable manufacturing, and advanced engineering. SBTC also highlights the potential for technology to exacerbate inequalities if access to skill-building opportunities is unevenly distributed (Holzer, H. J., 2019). The paper addresses this concern by advocating for inclusive TVET programs that reach underserved populations, particularly in rural and remote areas, through digital platforms and innovative delivery methods. By leveraging the principles of SBTC, the paper provides a robust theoretical foundation for understanding how TVET can bridge the skills gap, reduce socio-economic disparities, and drive sustainable development in a rapidly changing global economy.

Therefore, the primary aim of the paper is to explore the transformative innovations in TVET that address these challenges and their socio-economic impacts. Various innovations have been conducted, including digital and online learning platforms, virtual and augmented reality (VR/AR), competency-based education (CBE), green skills development, public-private partnerships (PPPs) and industry-based training internship. The paper will describe how these advancements could bridge the skills gap and promote sustainable socio-economic growth (**Figure 1**). The structure of the paper is designed to provide a comprehensive analysis of each innovation, followed by a brief discussion on their socio-economic implications. The paper concludes with policy recommendations and future directions to ensure the continuous improvement and relevance of TVET in the modern economy.

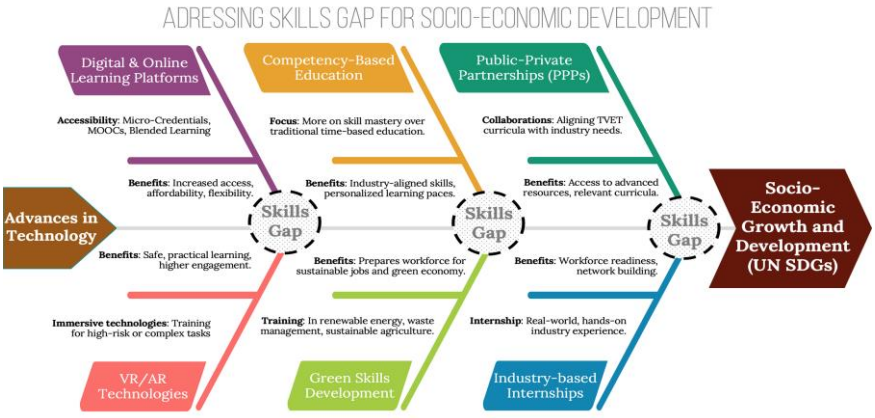

Figure 1. 'Fish Bone' Diagram illustrating skills gap in the workforce that could be reduced with various TVET innovations in order to promote sustainable socio-economic growth and development (and achieve UN SDGs). The diagram reflects the study's conceptual framework ('Skill-biased Technological Change' theory) with the primary objective to address the current skills gap in the workforce with various TVET innovations.

DIGITAL AND ONLINE LEARNING PLATFORMS

Overview of Digital and Online Learning in TVET

Digital and online learning in TVET refers to the use of internet-based platforms and digital technologies to deliver educational content and, facilitate skill development and provide audio-visual practical training. This mode of learning encompasses a variety of formats, including fully online courses (such as Coursera and EdX), blended learning environments that combine online and face-to-face instruction and interactive e-learning modules (such as Open Learning). The significance of digital and online learning in TVET lies in its ability to make education more accessible and flexible, allowing learners to engage with training materials at their own pace and from any location with internet access. This flexibility is particularly beneficial for individuals who may have work or family commitments, as well as for those living in remote areas with limited access to traditional educational institutions.

The adoption of digital and online learning in TVET has seen a significant increase in recent years (Hashim et al., 2023), driven by advancements in technology and the growing recognition of the need for flexible learning solutions. One prominent trend is the rise of Massive Open Online Courses (MOOCs), which offer a wide range of vocational subjects to a global audience. Blended learning models are also becoming increasingly popular, combining the best aspects of online and in-person instruction to enhance the learning experience. The recent COVID-19 pandemic has accelerated the transition towards digital learning, with many TVET institutions rapidly shifted to online platforms to continue providing education during lockdowns and social distancing measures.

Innovations in Digital Learning

Innovations in digital learning have modernized the landscape of TVET by introducing a variety of platforms and technologies designed to enhance the accessibility and quality of vocational education (Razak et al., 2022). Micro Credentials (MCs), for instance, (depending on course provider) allow learners to gain specific skills and knowledge through short, focused courses that lead to industry-recognized certifications. This approach enables continuous skill development and caters to the rapidly changing needs of the job market. MOOCs offer another significant innovation, providing free or low-cost access to high-quality educational content from prominent institutions such as Harvard University, MIT and Stanford University through platform such as edX, Coursera, Stanford Online. These platforms often include interactive elements such as forums, quizzes and peer assessments, which enhance the learning experience. University of Oxford is known for offering a mix of online and in-person courses through Oxford's Continuing Education and various professional development programs (Zakaria et al., 2024).

Leading learning platforms such as Coursera and edX have significantly impacted TVET education. For example, partnerships between these platforms and community colleges have enabled the integration of MOOCs into vocational curricula, providing students with access to specialized courses and expert instruction that would otherwise be unavailable. The City University of New York (CUNY) has successfully incorporated Micro Credential programs into its TVET offerings, allowing students to earn digital badges that are recognized by employers in industries such as healthcare and information technology. More information can be obtained from their website. (https://www.cuny.edu/about/administration/offices/ocip/students/jobs-ceo-council).

Similarly, Malaysia Ministry of Higher Education (MOHE) has launched MOOCs initiative hosted by Open Learning (Zakaria et al., 2024), which includes vocational courses tailored to the needs of local industries. This initiative has enabled students to engage in flexible, competency-based education, leading to improved employment outcomes and increased alignment between vocational training and industry requirements. These case studies highlight the transformative potential of digital learning innovations in enhancing the reach and effectiveness of TVET programs globally.

Socio-Economic Impacts

The adoption of digital and online learning platforms in TVET has significantly increased the accessibility and

flexibility of vocational education (Ismail et al., 2022). With the availability of internet, these platforms allow individuals from remote and under-served areas to access high-quality training programs that were previously out of reach. This democratization of education ensures that a broader segment of the population can acquire essential skills, contributing to a more inclusive and equitable workforce. The flexibility offered by online learning enables individuals to balance their education with other commitments, such as work or family responsibilities, making it possible for more people to engage in lifelong learning and continuous skill development (Kahu, E. R., & Nelson, K. (2018). This increased accessibility and flexibility ultimately lead to a more skilled and adaptable workforce, capable of meeting the evolving demands of the economy.

Digital learning innovations in TVET also enhance employability and workforce readiness by providing learners with up-to-date skills and knowledge that align with current industry needs which nowadays often involve automation and smart (AI-based) technology (Fakhar et al., 2024). Online platforms often feature courses developed in collaboration with industry experts, ensuring that the training content is relevant and applicable. Additionally, the incorporation of interactive elements, such as simulations and practical exercises, allows learners to gain hands-on experience and build competencies that are directly transferable to the workplace. Micro Credentials and digital badges further boost employability by offering verifiable proof of specific skills, making it easier for employers to identify qualified candidates. As a result, graduates of digital TVET programs are better prepared to enter the workforce and contribute to their respective industries.

The economic benefits of digital learning innovations in TVET can be seen through various successful programs. For instance, the collaboration between Coursera and community colleges in the USA has led to significant improvements in employment rates among graduates. According to a study by the Brookings Institution, participants in these programs experienced a 10% increase in job placements compared to traditional TVET graduates (Siddique et al., 2020). In Malaysia, the Malaysia MOOC initiative has also contributed to economic growth by aligning vocational training with the needs of key industries such as manufacturing and information technology (Mustapha & Hussain, 2021). The increased alignment has resulted in higher productivity and competitiveness for Malaysian businesses, driving economic development. These examples demonstrate that by embracing digital learning innovations, TVET programs can generate substantial economic benefits, including higher employment rates, improved productivity and enhanced economic growth.

Virtual and Augmented Reality (VR/AR)

Introduction to VR/AR in TVET

Virtual Reality (VR) and Augmented Reality (AR) are immersive technologies that are increasingly being integrated into TVET (Lukhele & Laseinde, 2024). VR refers to a fully immersive, computer-generated environment that simulates real-world or fantastical experiences, allowing users to interact with these environments in a seemingly real way. AR, on the other hand, overlays digital information onto the real world, enhancing the user's perception and interaction with their actual surroundings. In TVET, these technologies have a wide range of potential applications, including simulations of complex machinery and equipment, virtual laboratories and interactive tutorials for skills such as welding, automotive repair and healthcare procedures.

The use of VR and AR in TVET offers numerous benefits, particularly through the creation of immersive learning environments. One of the primary advantages is the ability to provide hands-on training without the risks and costs associated with real-world practice. For instance, trainees can practice high-risk tasks such as operating heavy machinery or performing medical procedures in a safe and controlled virtual environment. This not only enhances safety but also allows for repeated practice until proficiency is achieved. Immersive learning environments can improve engagement and retention by providing a more interactive and stimulating educational experience. Learners are able to visualize and manipulate objects in a three-dimensional space, leading to a deeper understanding of complex concepts and procedures (Sahabuddin, E. S., & Makkasau, A., 2024).

Innovations and Applications

Virtual Reality (VR) and Augmented Reality (AR) have found specific and impactful applications in various

fields of vocational training (Ab Halim et al., 2020). For example, in welding, VR simulators such as the Lincoln Electric's VRTEX provide a safe and controlled environment for trainees to practice their skills, replicating real-world welding conditions without the associated risks and costs. In healthcare, VR is used to train medical professionals in complex surgical procedures and patient care scenarios. Platforms like Osso VR offer realistic, immersive simulations that enhance the proficiency of surgeons and medical staff. Similarly, in electronics, AR applications like the Microsoft HoloLens enable trainees to visualize and interact with intricate circuitry and components, providing a hands-on learning experience that traditional methods cannot match.

Several pilot programs and initiatives have demonstrated the effectiveness of VR/AR in vocational training. In the United States, the Los Angeles Trade-Technical College has successfully integrated VR welding simulators into its curriculum, resulting in higher student engagement and improved skill proficiency. In the United Kingdom, the National Health Service (NHS) has implemented VR training modules for surgical trainees, leading to enhanced surgical outcomes and reduced training costs (Howard et al., 2023).

In Malaysia, the Ministry of Education has launched pilot programs incorporating VR/AR in TVET institutions. For example, the Penang Skills Development Centre (PSDC) has adopted VR training. They offer a range of programs in areas such as engineering, advanced semiconductor technology and artificial intelligence (Lee et al., 2020). PSDC enhances the practical skills of their students, by integrating VR and AR into their curriculum, making them more job-ready and aligned with industry needs. In addition, academics (teachers and lecturers) at TVET institutions can also utilize Google VR cardboard which is commercially available at affordable price for a more immersive classroom teaching, viewing YouTube 360-degree science and engineering video collections.

Economic Impacts

The integration of VR and AR technologies into TVET significantly enhances skill acquisition and knowledge retention among learners (Chandrasekar, 2022). Immersive environments created by these technologies offer virtual hands-on, practical experiences that mirror real-world scenarios, enabling trainees to practice and perfect their skills without the constraints of physical resources. The study has shown that learners in VR/AR environments retain information better and perform tasks more accurately compared to traditional training methods.

One of the most significant economic benefits of utilizing VR and AR in vocational training is the reduction in training costs and associated risks (Kaplan et al., 2021). Traditional training methods often involve expensive materials, equipment and facilities, as well as the potential for accidents and errors. VR and AR technologies reduce these problems by providing a virtual platform where students can practice safely and repeatedly without consuming physical resources or risking injury. For example, in medical training, VR simulations eliminate the need for costly cadavers or live patients, reducing expenses and ethical concerns. The ability to simulate high-risk scenarios in a controlled environment minimizes the chances of accidents during real-life applications, leading to safer workplaces and lower insurance costs for employers.

The implementation of VR and AR as part of TVET has also positively impacted on overall productivity and job performance within industries (Davila Delgado et al., 2020). Workers trained through immersive technologies tend to be more proficient and capable of performing complex tasks with greater accuracy and efficiency. This translates into higher-quality output and fewer errors on the job, enhancing overall productivity. The use of these technologies fosters continuous learning and skill upgrading, enabling employees to keep pace with technological advancements and industry demands. For instance, automotive technicians trained with AR tools can quickly adapt to new diagnostic techniques and repair methods, maintaining high performance standards.

Competency-Based Education (CBE)

Concept of Competency-Based Education

Competency-Based Education (CBE) is an educational approach that focuses on equipping learners with

specific, measurable skills and competencies required to perform effectively in their professional roles. Unlike traditional education models that often emphasize the accumulation of credit hours and the completion of a predefined curriculum, CBE is designed around the demonstration of mastery in particular areas. The principles of CBE include personalized learning pathways, where students progress at their own pace; assessments based on the demonstration of competencies rather than time spent in class; and a strong alignment with industry standards to ensure that the skills acquired are directly relevant to the job market (Janssens et al., 2023).

The fundamental difference between Competency-Based Education and traditional education models lies in the focus on outcomes rather than processes. Traditional education systems typically follow a rigid structure with set schedules, courses and assessments, often prioritizing theoretical knowledge over practical application. Students advance based on the time spent in class and the completion of courses, which may not always correlate with the acquisition of practical skills. In contrast, CBE allows for greater flexibility and personalization, as learners move forward by demonstrating their mastery of specific skills and knowledge areas. This model is particularly beneficial in vocational and technical education, where the emphasis is on acquiring tangible skills that can be immediately applied in the workforce.

Innovations in CBE

Implementing Competency-Based Education (CBE) effectively requires a strategic approach and the utilization of various tools to facilitate personalized and mastery-based learning. Key strategies include the development of clear competency frameworks that outline the specific skills and knowledge students must acquire (Dodge et al., 2023). These frameworks are often created in collaboration with industry stakeholders to ensure alignment with job market demands. Digital platforms and online learning management systems (LMS) such as Open Learning are essential tools in CBE, providing adaptive learning pathways, real-time progress tracking and competency-based assessments. These platforms enable educators to offer personalized instruction and feedback, helping students master each competency before moving on to the next. Competency-based assessment tools, such as e-portfolios and performance tasks, allow for practical demonstration of skills, ensuring that students can apply what they have learned in real-world contexts.

Several institutions worldwide have successfully implemented CBE, showcasing best practices and the impact of this educational model. For example, Western Governors University (WGU) in the United States has pioneered the use of CBE, offering a variety of degree programs that allow students to progress at their own pace based on demonstrated competencies. This model has led to higher completion rates and improved student satisfaction. Another notable example is the Southern New Hampshire University's (SNHU) College for America program, which provides competency-based, online associate and bachelor's degrees designed to meet the needs of working adults.

In Malaysia, Tun Hussein Onn University of Malaysia (UTHM) has integrated CBE into its engineering programs activity (Abdullah et al., 2021), focusing on industry-relevant skills and practical training. These case studies highlight the effectiveness of CBE in enhancing student outcomes, providing flexible learning opportunities and ensuring that graduates possess the competencies required by employers. Best practices from these institutions include continuous collaboration with industry partners, the use of technology to support personalized learning and a commitment to ongoing assessment and improvement of competency frameworks.

Socio-Economic Impacts

The adoption of Competency-Based Education (CBE) has significant economic impacts through the facilitation of personalized learning and faster skill acquisition. By allowing learners to progress at their own pace, CBE ensures that students can focus on mastering specific competencies without being held back by a traditional semester-based schedule. This personalized approach means that students can complete their training more quickly, entering the workforce sooner and reducing the time and financial resources spent on education (Rhoney, D. H., & Meyer, S. M., 2024).

CBE's strong emphasis on aligning educational outcomes with industry needs enhances job matching and employability, thereby having a positive economic impact. Often, CBE programs are designed in close collaboration with employers and industry experts to ensure that the competencies taught are directly relevant to current job market demands. This alignment helps to bridge the skills gap, as graduates possess the specific skills and knowledge that employers are seeking. The competency-based approach allows for more precise assessment of a candidate's abilities, making it easier for employers to identify suitable candidates. This improved job matching reduces the time and costs associated with hiring and training new employees, leading to increased productivity and efficiency within organizations.

In the long term, the economic benefits of CBE extend beyond immediate job placement and productivity gains to broader workforce development and economic resilience. By continuously aligning educational outcomes with evolving industry requirements, CBE helps create a dynamic and adaptable workforce capable of meeting future challenges. This adaptability is crucial in a rapidly changing global economy, where technological advancements and market shifts require ongoing skills development. The focus on competencies fosters a culture of lifelong learning, encouraging individuals to continually upgrade their skills throughout their careers (McMullen et al., 2023).

Green Skills Development

Importance of Green Skills in TVET

Green skills refer to the knowledge, abilities, values and attitudes needed to live in, develop and support a sustainable and resource-efficient society (Devaki, 2021). These skills encompass a wide range of competencies, including the ability to manage natural resources sustainably, reduce waste and emissions and promote environmental stewardship. In the context of TVET, green skills are integrated into curricula to prepare learners for careers that contribute to environmental sustainability and the green economy. The relevance of green skills to sustainable development is profound, as they enable individuals and industries to adopt practices that minimize environmental impact and support the long-term health of the planet. TVET institutions also contribute to advancing the UN Sustainable Development Goals (SDGs), particularly those related to responsible consumption and production, climate action and sustainable cities and communities.

The demand for green skills is rapidly growing across various emerging sectors, creating new opportunities for employment and economic growth (Varma & Malik, 2023). Sectors such as renewable energy, energy efficiency, sustainable agriculture and waste management are at the forefront of the green economy. For instance, the renewable energy sector, including solar, wind and hydroelectric power, requires skilled technicians for installation, maintenance and operation of green technologies. Energy efficiency initiatives in construction and manufacturing also demand workers proficient in green building practices and energy-saving technologies. Sustainable agriculture practices, such as organic farming and precision agriculture, require expertise in environmentally friendly techniques. Waste management and recycling industries are expanding, necessitating skills in waste reduction, materials recovery and circular economy practices.

Innovations in Green Skills Training

Innovations in green skills training within TVET have led to the development of specialized academic programs and curricula that address the needs of the emerging green economy. One notable area is renewable energy, where academic programs train students in the installation, maintenance and operation of solar panels, wind turbines and other sustainable energy systems. Courses in energy-efficient construction teach learners how to design and build structures that minimize energy consumption and negative environmental impact, incorporating techniques such as passive solar design, advanced insulation and energy-efficient HVAC systems. Academic programs that focused on sustainable agriculture equip students with skills and knowledge in soil health management, organic farming system such as hydroponic / aquaponic with its water conservation (recirculating) technique (Dabakarov, S et al., 2020).

Effective green skills training programs often result from strong collaboration between TVET institutions, industry and government. These partnerships ensure that the training provided is relevant to current and future

market demands and adheres to industry standards. For example, partnerships with renewable energy companies can facilitate the development of hands-on training modules that reflect real-world applications and technologies. Government agencies play a crucial role in setting regulatory frameworks and providing funding and resources for program development. Collaborative efforts can also include the creation of apprenticeship programs and internships that give students practical experience in green industries (Pavlova, M., 2019).

In Malaysia, initiatives like the Green Technology Master Plan involve joint efforts from educational institutions, government bodies and private companies to develop a skilled workforce for the green economy (Mustaffa et al., 2021).

Socio-Economic Impacts

Green skills training through TVET significantly contributes to the development of the green economy and the creation of new jobs. TVET programs facilitate the transition to a more sustainable economic model by equipping individuals with the competencies needed to work in emerging green sectors such as renewable energy, sustainable agriculture and energy-efficient construction. This shift generates numerous job opportunities. For example, the renewable energy sector alone is projected to create millions of jobs worldwide, ranging from solar panel installers to wind turbine technicians (Maka & Alabid, 2022).

The integration of green skills into TVET curricula promotes long-term environmental and economic sustainability. As industries increasingly adopt sustainable practices, the demand for workers skilled in green technologies and methods continues to rise. This alignment fosters a more resilient economy that can adapt to global environmental challenges and resource constraints. By training a workforce that adept in sustainable practices, TVET programs contribute to reducing the ecological footprint of industries and communities, promoting conservation and efficient use of resources. In the long run, the program helps mitigate climate change and environmental degradation but also reduces operational costs for businesses through energy savings and waste reduction (Maiurova, A., 2022).

Globally, several successful green TVET initiatives illustrate the positive impact of integrating green skills into vocational education. In Germany, the dual education system includes comprehensive training in renewable energy technologies and energy efficiency, producing a highly skilled workforce that supports the country’s leading position in the green economy. Similarly in Malaysia, the Penang Skills Development Centre (PSDC) has developed green technology training programs in collaboration with industry and government, focusing on areas such as sustainable manufacturing and energy-efficient construction.

Public-Private Partnerships (PPPs)

Role of PPPs in TVET

Public-Private Partnerships (PPPs) in the context of TVET refer to collaborative agreements between government entities (such as public universities) and private sector organizations aimed at enhancing the quality, relevance and accessibility of vocational education. These partnerships are designed to leverage the strengths of both sectors: the public sector's regulatory and policy-making capabilities and the private sector's expertise, resources and understanding of industry needs. The significance of PPPs in TVET lies in their potential to bridge the gap between education and employment, ensuring that training programs are aligned with current market demands and technological advancements (Remington & Yang, 2020).

The collaboration between public and private sectors in TVET brings numerous benefits that enhance the overall effectiveness and impact of vocational training programs. One of the primary advantages is the alignment of TVET curricula with industry requirements, which ensures that graduates possess the skills and knowledge needed by employers. This alignment not only improves employability but also reduces the skills gap in the labour market. Private sector involvement often brings innovative training methodologies, advanced technologies and practical insights into the training process, enriching the learning experience. Public sector support, on the other hand, provides the necessary regulatory framework, funding and infrastructure to implement and sustain TVET programs.

Innovative PPP Models

Several innovative Public-Private Partnership (PPP) models have demonstrated the effectiveness of collaborative efforts in enhancing TVET. One notable example is the partnership between Siemens and the German government, which has developed comprehensive apprenticeship programs that blend classroom instruction with hands-on training in Siemens' facilities. This model has been highly successful in producing skilled workers ready to meet the demands of the manufacturing and engineering sectors. In Australia, the partnership between the government and private companies through the "Skills for Victoria" initiative has modernized TVET by integrating cutting-edge technologies and industry-relevant curricula, thereby improving student outcomes and employability (Guthrie, H et al., 2014).

Effective collaboration in PPPs for TVET requires strategic planning and a clear understanding of the roles and contributions of each partner. One key strategy is establishing a shared vision and common goals that align with both national educational objectives and industry needs. Regular communication and joint planning sessions can ensure that the partnership remains focused and adaptive to changing circumstances. Another important strategy is the integration of industry expertise into the curriculum development process, ensuring that training programs are relevant and up-to-date. Providing incentives such as tax benefits or co-funding opportunities can also encourage private sector participation. Establishing robust monitoring and evaluation mechanisms helps track the progress and impact of the partnership, allowing for continuous improvement.

Socio-Economic Impacts

One of the most significant economic impacts of Public-Private Partnerships (PPPs) in TVET is the alignment of academic training programs (and teaching syllabi) with market demands (Siddiky & Uh, 2020). TVET institutions ensure that the skills taught are directly relevant to the needs of employers. This alignment reduces the skills gap, making graduates more employable and capable of contributing effectively from the outset. Industries can provide insights into emerging technologies and sector-specific requirements, which can be incorporated into training modules.

PPPs in TVET also lead to enhanced resource allocation and funding, which are crucial for the development and sustainability of high-quality training programs. Private sector participation often brings additional financial investments, advanced technologies and industry-specific expertise, which complement the resources provided by the public sector. This collaborative funding model allows for the establishment of advance training facilities, the development of innovative instructional materials and the recruitment of skilled instructors. In Malaysia, partnerships between TVET institutions and multinational corporations have resulted in significant investments in training infrastructure and resources.

The economic benefits of PPPs in TVET extend beyond individual graduates to industries and communities at large. For industries, the availability of a well-trained and competent workforce leads to increased productivity, innovation and competitiveness. Companies can reduce their training costs and shorten the onboarding period, as employees enter the job market with job-ready skills.

This efficiency translates into higher profitability and growth for businesses. On a community level, successful PPPs in TVET contribute to socio-economic development by creating job opportunities, reducing unemployment rates and fostering economic stability. Communities benefit from the economic activity generated by thriving local industries, which can lead to improved infrastructure, services and overall quality of life. In Malaysia, TVET programs supported by PPPs have been instrumental in uplifting local economies and providing pathways for sustainable development, showcasing the far-reaching positive impacts of these collaborations.

Industry-Based Training Internships

Concept and Importance of Industry-Based Training Internships

Industry-based training internships are increasingly recognized as essential components of TVET programs

(Vinayan et al., 2022). The rapid pace of technological advancement and the evolving nature of the global job market necessitate a workforce that is not only theoretically knowledgeable but also practically skilled. Traditional classroom-based education often falls short in providing the hands-on experience and real-world application required in many industries. As a result, there is a growing need for training solutions that bridge the gap between academic learning and practical skill acquisition. Industry-based internships address this need by immersing students in actual work environments where they can apply their theoretical knowledge, engage with professional tools and technologies and understand industry standards and practices.

Spending 1-2 years in industry as part of a TVET program offers numerous benefits to the students. It provides an invaluable practical experience that enhances their technical skills and proficiency. Working alongside experienced professionals allows students to learn best practices, develop problem-solving skills and gain insights into the daily operations of their chosen field. The students are exposed to the business aspects of their industry, such as project management, customer relations and financial planning, which are crucial for career advancement and entrepreneurship. The experience working at the industry builds their professional networks improve employability of the students and demonstrate their capabilities to potential employers. Many companies use these internships as a pipeline for future hiring, offering job placements to interns who have proven their competence and fit within the organization.

Innovations and Applications

Innovations in industry-based training internships have led to the development of dynamic and effective training programs across various sectors. In the manufacturing sector, companies like Siemens have pioneered dual education systems that combine in-class learning with practical work experience. This model has been replicated in fields such as information technology, where companies partner with educational institutions to offer internships that focus on the latest technological advancements and real-world applications. In the healthcare sector, internships have evolved to include simulation-based training followed by hands-on clinical experience, ensuring that students are well-prepared for the complexities of patient care. The agricultural sector has also embraced innovative internships, incorporating precision farming techniques and sustainable practices to equip students with modern, environmentally-friendly skills.

In Malaysia, the Ministry of Education's collaboration with industries through the National Dual Training System (NDTS) has improved the employability of TVET graduates (Abd Hamid et al., 2023). Companies like Intel Malaysia have partnered with local TVET institutions to offer internships that provide students with practical experience in advanced manufacturing and electronics. These programs have not only enhanced students' technical skills but also fostered strong industry-education linkages, contributing to economic growth and workforce development in Malaysia. These success stories highlight the transformative impact of well-structured industry-based internships on students' careers and the broader economy.

Socio-Economic Impacts

Industry-based training internships significantly increase access to education and training by providing practical learning opportunities that complement classroom instruction (Nyemba et al., 2021). These internships make vocational education more attractive and accessible to a wider range of students, including those who may not thrive in traditional academic settings. By bridging the gap between theoretical knowledge and real-world application, internships enable students to gain valuable skills and experience that are directly relevant to their chosen careers. This hands-on approach to learning also helps to democratize education, ensuring that students from diverse backgrounds and regions can participate in high-quality training programs.

The economic impacts of industry-based training internships extend beyond the individual benefits to students, contributing significantly to local economies and job creation. Internships help create a skilled workforce that meets the needs of local industries, attracting businesses and fostering economic development. By providing companies with a steady stream of trained and job-ready individuals, internships reduce recruitment and training costs, thereby increasing productivity and competitiveness. Furthermore, internships often lead to full-time employment opportunities, reducing unemployment rates and boosting household incomes. In regions like Malaysia, successful internship programs have led to the establishment of numerous small and medium-

sized enterprises (SMEs), which are crucial drivers of economic growth. These SMEs not only create jobs but also stimulate local economies by fostering innovation and entrepreneurship.

Socio-Economic Analysis

Methodology for Assessing Economic Impacts

The methodology for assessing the economic impacts of TVET innovations, such as digital online learning platforms, the use of VR/AR technologies and competency-based education (CBE) involves a comprehensive framework that integrates both qualitative and quantitative analysis. This framework begins with a baseline study to establish current conditions and identify key areas of impact. It includes stakeholder consultations to gather insights from employers, trainees, educators and community members about the perceived benefits and challenges of the training programs. The framework also involves longitudinal studies to track changes over time, ensuring that both immediate and long-term impacts are captured for analysis.

To effectively assess the economic impacts of TVET innovations, it is essential to identify and monitor key metrics and indicators that reflect changes in both the labour market and broader economic conditions. Primary metrics include employment rates, job placement rates and income levels of graduates from TVET programs, which directly indicate the effectiveness of training in enhancing employability and economic stability. Other indicators are productivity gains within industries that have benefited from skilled labour, the number of new businesses or SMEs established by program graduates and the level of investment attracted to regions with improved vocational training facilities. Metrics related to educational outcomes, such as completion rates, skill proficiency levels and trainee satisfaction also provide valuable insights into the quality and relevance of the training programs.

Comparative Analysis of Innovations

A comparative analysis of TVET innovations, such as digital and online learning platforms, VR/AR technologies, competency-based education (CBE), green skills development and public-private partnerships (PPPs) reveals distinct and complementary impacts of each on economic outcomes. Digital and online learning platforms have democratized access to education, enabling a broader demographic to acquire skills, thereby increasing overall employability and reducing regional skill disparities. VR/AR technologies have enhanced the quality of training by providing immersive and hands-on experiences that improve skill retention and job readiness. CBE has streamlined the education-to-employment pipeline by ensuring that learners acquire competencies directly aligned with industry needs, resulting in higher job placement rates and improved workforce efficiency. Green skills development has supported the growth of the green economy by preparing a workforce capable of implementing sustainable practices. PPPs have fostered innovation and resource-sharing, enhancing the relevance and quality of TVET programs, industry-based training internship exposed students to the business aspects of their chosen industry, such as project management, customer relations and financial planning.

The combined effects of these innovations create powerful synergies that amplify their individual economic impacts. For instance, the integration of digital learning platforms with CBE frameworks can provide personalized and flexible learning pathways, catering to diverse learner needs while ensuring alignment with industry standards. VR/AR technologies can be incorporated into digital learning modules, offering high-quality and practical training experiences regardless of location.

Long-term Socio-Economic Benefits

Innovations in TVET play a crucial role in advancing the United Nations Sustainable Development Goals (SDGs), particularly those related to quality education, decent work and economic growth, industry innovation and reduced inequalities. Enhancing the accessibility, relevance and quality of vocational training contribute to SDG 4, which aims to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. Competency-based education (CBE) and digital learning platforms, for example, provide flexible learning paths that cater to diverse needs, fostering greater educational inclusivity. The emphasis on

green skills development supports SDG 8 (decent work and economic growth) and SDG 9 (industry, innovation and infrastructure) by preparing a workforce capable of driving sustainable economic activities and fostering innovation. Public-Private Partnerships (PPPs) also help reduce inequalities (SDG 10) by extending training opportunities to remote and underserved communities, thereby promoting more equitable economic development.

The innovative approaches in TVET, particularly those that leverage technology (Vasilev I., 2024) and collaborative models, hold significant potential for scalability and replication across different regions and contexts. The success of digital learning platforms, VR/AR technologies in providing accessible and high-quality vocational training can be replicated in other countries, especially in regions with similar educational and economic challenges. The adaptability of competency-based education frameworks makes them suitable for various industries and educational systems, enabling widespread adoption. The collaborative nature of Public-Private Partnerships (PPPs) provides a replicable model for resource-sharing and industry engagement, which can enhance the effectiveness and sustainability of TVET programs globally.

Policy Recommendations and Future Directions

Policy Frameworks for Supporting TVET Innovations

In order to effectively support TVET innovations, policymakers must establish comprehensive and forward-thinking policy frameworks that address the evolving needs of the labor market and technological advancements such as Artificial Intelligence (Shiohira, 2021). One key recommendation is the integration of competency-based education (CBE) standards into national education policies, ensuring that curricula are aligned with industry requirements and that skills acquisition is prioritized over traditional time-based learning. Policymakers should also incentivize the adoption of digital and online learning platforms by providing funding for the development and maintenance of these technologies, as well as training for educators to effectively utilize them. Government subsidies to access satellite-based internet could also be considered to individuals living in remote areas for quality online training resources and education.

Effective implementation of TVET innovations requires strategic planning and coordination among various stakeholders, including government agencies, educational institutions, industry partners and community organizations. One strategy is to establish dedicated bodies or task forces that oversee the development and implementation of TVET policies, ensuring alignment with national economic goals and labor market demands. Policymakers should promote continuous professional development for TVET educators, equipping them with the skills and knowledge to leverage new technologies and pedagogical approaches. To support the scalability and sustainability of innovations such as VR/AR technologies, governments can provide financial incentives and grants, as well as facilitate access to infrastructure and resources. Monitoring and evaluation frameworks are essential for assessing the impact of TVET initiatives, allowing for data-driven decision-making and continuous improvement.

Future Research and Development

Future research and development in TVET should focus on several key areas to continue enhancing the effectiveness and reach of vocational education. One critical area is the ongoing integration of advanced technologies, such as artificial intelligence (AI) and machine learning, into TVET curricula and delivery methods. Research should explore how these technologies can personalize learning experiences, predict labor market trends and align training programs with emerging job opportunities. Another area for further study is the development of comprehensive frameworks for competency-based education (CBE) that can be adapted across different industries and educational contexts. Additionally, the impact of green skills training on economic and environmental sustainability requires deeper investigation, particularly in terms of quantifying long-term benefits and identifying best practices for implementation.

International collaboration and knowledge exchange are essential for driving innovation and best practices in TVET. By participating in global networks and partnerships, countries can share experiences, research findings and successful models, fostering a collaborative approach to vocational education reform. Organizations such

as UNESCO-UNEVOC (for Vocational Education) play a major role in facilitating these exchanges, offering platforms for policymakers, educators and industry leaders to discuss challenges and solutions. Collaborative research projects and joint initiatives can lead to the development of standardized frameworks and tools that enhance the quality and relevance of TVET programs worldwide. International collaboration can support capacity-building efforts, enabling developing countries to access the expertise and resources needed to implement advanced TVET systems.

CONCLUSION

The key findings from this analysis highlight the impact of innovative TVET initiatives on addressing the skills gap and promoting socio-economic development. Innovations such as digital and online learning platforms, VR/AR technologies, competency-based education (CBE), green skills training and Public-Private Partnerships (PPPs) have proven to enhance skill acquisition, improve employability and align training with market demands. These advancements not only provide practical, job-ready skills but also ensure that education is accessible to all, including those in remote and underserved areas.

To realize the full potential of these transformative TVET initiatives, it is crucial for stakeholders to invest in and support their implementation and expansion. Governments, educational institutions, industry partners and international organizations must collaborate to create robust policy frameworks, provide adequate funding and facilitate the adoption of cutting-edge technologies and methodologies. Policymakers should incentivize partnerships and foster environments conducive to continuous professional development for educators. Industry leaders need to actively participate in curriculum development and provide real-world insights to ensure relevance of training programs.

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Declaration of interest

The author reports that there are no competing interests to declare.

REFERENCES

1. Ab Halim, F., Muda, W. H. N. W., Zakaria, N., & Samad, N. H. B. A. (2020). The potential of using augmented reality (AR) technology as learning material in TVET. Journal of Technical Education and Training, 12(1).
2. Abd Hamid, H. B., Piahat, T. Bin, Haris, N. A. L. A., & Hassan, M. F. (2023). Shades of Gray TVET in Malaysia: Issues and Challenges. International Journal of Academic Research in Business and Social Sciences, 13(6), 2152–2167.
3. Abdullah, S. A., Saud, M. S., & Hisham, M. H. M. (2021). Establishing mobile learning elements using competency-based education framework. Journal of Technical Education and Training, 13(1), 102–111.
4. Barzaeva, M., & Ilyasov, R. (2022). Sustainable development of the global labor market in the context of the transformation of the industrial complex of the digital economy. Reliability: Theory & Applications, 17(SI 4 (70)), 476-484.
5. Burns, R. (2020). Adult Learner at Work: The challenges of lifelong education in the new millenium. Routledge.
6. Chandrasekar, B. (2022). Application of Augmented Reality in TVET, A Modern Teaching-Learning Technology. In Augmented Reality and Its Application. IntechOpen.
7. Dabakarov, S., Borowka, W., & Ricci, A. (2020). Greenhouse Hydroponics: An Opportunity for Enhanced Academic Learning & Food Sustainability at Skidmore. Capstone submitted to the Department of Environmental Studies & Sciences, Skidmore College ("Greenhouse Hydroponics: An Opportunity for Enhanced Academic...-Skidmore").

8. Davila Delgado, J. M., Oyedele, L., Beach, T., & Demian, P. (2020). Augmented and virtual reality in construction: drivers and limitations for industry adoption. Journal of Construction Engineering and Management, 146(7), 04020079.
9. Devaki, N. (2021). Green Skills For Green Transformation and Sustainable Future. The Opportunities of Uncertainties: Flexibility And Adaptation Needed In Current Climate. Volume I (Social Science and ICT), 114.
10. Dodge, L., Bushway, D. J., & Long, C. S. (2023). A leader's guide to competency-based education: From inception to implementation. Taylor & Francis.
11. Fakhar, H., Lamrabet, M., Echantoufi, N., & Ajana, L. (2024). Towards a New Artificial Intelligence-based Framework for Teachers' Online Continuous Professional Development Programs: Systematic Review. International Journal of Advanced Computer Science & Applications, 15(4).
12. Freud, S. (2021). Skill Shortages, Skill Gaps, and Labor Demand. Caught in the Cultural Preference Net: Three Generations of Employment Choices in Six Capitalist Democracies, 71.
13. Guthrie, H., Smith, E., Burt, S., & Every, P. (2014). Review of the effects of funding approaches on Service Skills qualifications and delivery in Victoria. Melbourne: Service Skills Victoria.
14. Hashim, S., Masek, A., Amran, N. I., Zulkifli, N. N., Lip, R., & Utami, P. (2023). Observation on technical and vocational education and training (TVET) students' knowledge, motivation and self learning level in online learning application. AIP Conference Proceedings, 2582(1).
15. Holzer, H. J. (2019). The US labor market in 2050: Supply, demand and policies to improve outcomes (No. 148). IZA Policy Paper.
16. Howard, T., Iyengar, K. P., Vaishya, R., & Ahluwalia, R. (2023). High-fidelity virtual reality simulation training in enhancing competency assessment in orthopaedic training. British Journal of Hospital Medicine, 84(9), 1-8.
17. Ismail, A., Syakir, A. H. A., Bahrudin, I. A., Samsudin, N. A., & Shafieek, M. S. M. (2022). Implementation of Distance and Digital Learning During Pandemic Covid-19 in Malaysia. Online Journal for TVET Practitioners, 7(1), 8–19.
18. Janssens, O., Embo, M., Valcke, M., & Haerens, L. (2023). When theory beats practice: the implementation of competency-based education at healthcare workplaces: focus group interviews with students, mentors, and educators of six healthcare disciplines. BMC Medical Education, 23(1), 484.
19. Kahu, E. R., & Nelson, K. (2018). Student engagement in the educational interface: Understanding the mechanisms of student success. Higher education research & development, 37(1), 58-71.
20. Kana, N., & Letaba, P. (2024). The reshaping of curriculum transformation to address the 21st-century skill sets and employment prospects during the Fourth Industrial Revolution era: a case of the South Africa TVET colleges. South African Journal of Higher Education, 38(2), 157–175.
21. Kaplan, A. D., Cruit, J., Endsley, M., Beers, S. M., Sawyer, B. D., & Hancock, P. A. (2021). The effects of virtual reality, augmented reality, and mixed reality as training enhancement methods: A meta-analysis. Human Factors, 63(4), 706–726.
22. Lee, K., Wong, C. Y., Intarakumnerd, P., & Limapornvanich, C. (2020). Is the Fourth Industrial Revolution a window of opportunity for upgrading or reinforcing the middle-income trap? Asian model of development in Southeast Asia. Journal of Economic Policy Reform, 23(4), 408-425.
23. Lukhele, B. N., & Laseinde, O. T. (2024). Exploring Mechanical Engineering Equipment at TVET Colleges in South Africa, Towards Integrating Virtual and Cyber-Physical Learning. Procedia Computer Science, 232, 2690–2700.
24. Maiurova, A., Kurniawan, T. A., Kustikova, M., Bykovskaia, E., Othman, M. H. D., Singh, D., & Goh, H. H. (2022). Promoting digital transformation in waste collection service and waste recycling in Moscow (Russia): Applying a circular economy paradigm to mitigate climate change impacts on the environment. Journal of Cleaner Production, 354, 131604.
25. Maka, A. O. M., & Alabid, J. M. (2022). Solar energy technology and its roles in sustainable development. Clean Energy, 6(3), 476–483.
26. McMullen, J., Arakawa, N., Anderson, C., Pattison, L., & McGrath, S. (2023). A systematic review of contemporary competency-based education and training for pharmacy practitioners and students. Research in Social and Administrative Pharmacy, 19(2), 192-217.
27. Mustaffa, N. K., Isa, C. M. M., & Ibrahim, C. K. I. C. (2021). Top-down bottom-up strategic green building development framework: Case studies in Malaysia. Building and Environment, 203, 108052.

28. Mustapha, R., & Hussain, M. A. M. (2021). Vocational Education and Training in Malaysia. In L. P. Symaco & M. Hayden (Eds.), International Handbook on Education in South East Asia (pp. 1–28). Springer Nature Singapore.
29. Nyemba, W. R., Mbohwa, C., & Carter, K. F. (2021). Problem-and Industry-Based Learning: Research, Theory and Practice. In Bridging the Academia Industry Divide: Innovation and Industrialisation Perspective using Systems Thinking Research in Sub-Saharan Africa (pp. 81–105). Springer.
30. Pavlova, M. (2019). Emerging environmental industries: impact on required skills and TVET systems. International Journal of Training Research, 17(sup1), 144-158.
31. Razak, A. N. A., Noordin, M. K., & Khanan, M. F. A. (2022). Digital learning in technical and vocational education and training (TVET) in public university, malaysia. Journal of Technical Education and Training, 14(3), 49–59.
32. Remington, T. F., & Yang, P. (2020). Public-private partnerships for skill development in the United States, Russia, and China. Post-Soviet Affairs, 36(5–6), 495–514.
33. Rhoney, D. H., & Meyer, S. M. (2024). Competency-based education: the need to debunk misconceptions and develop a common language. American Journal of Pharmaceutical Education, 88(2), 100637.
34. Sahabuddin, E. S., & Makkasau, A. (2024). Utilization of virtual reality as a learning tool to increase students' pro-environmental behavior at universities: A maximum likelihood estimation approach. Eurasia Journal of Mathematics, Science and Technology Education, 20(12), em2540.
35. Shiohira, K. (2021). Understanding the Impact of Artificial Intelligence on Skills Development. Education 2030. UNESCO-UNEVOC International Centre for Technical and Vocational Education and Training.
36. Siddiky, M. R., & Uh, S.-B. (2020). Linking TVET with industries in Bangladesh: Need for supportive policies and an approach to TVET. Journal of Technical Education and Training, 12(3), 1–21.
37. Siddique, G. K., Lodhi, H., Anwer, M., & Zubair, M. K. (2020). Effectiveness of Traditional and Competency Based Curricula: Perspective of Graduates, Trainers and Employers. Review of Education, Administration & Law, 3(2), 307–314.
38. Varma, C., & Malik, S. (2023). TVET in the 21st Century: A Focus on Innovative Teaching and Competency Indicators.
39. Vasilev, I. (2024). Smart City and the Model of Vocational Education and Training: New Trends, Advantages and Challenges. Knowledge-International Journal, 65(5), 529-535.
40. Vinayan, G., Ling, S. M., & Harikirishanan, D. (2022). Harmonizing The TVET Landscape In Malaysia Via Industry-Driven Collaborations: An Industrial Perspective. Economic and Social Development: Book of Proceedings, 262–270.
41. Wang, J., Hu, Y., & Zhang, Z. (2021). Skill-biased technological change and labor market polarization in China. Economic Modelling, 100, 105507.
42. Zakaria, I., Anual, N., Abdul Karim, Z. H., Kozako, M. F., Nurul'ain, I., & Zamri, M. N. (2024). The evolution, challenges and prospects of implementing Massive Open Online Courses (MOOCs) in Malaysian public universities. International Journal of E-Learning and Higher Education (IJELHE), 19(1), 59–8