

# Integration of 5G Technology in TVET Education: Opportunities, Challenges, and Implementation Strategies

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**Abstract**— The development of 5G technology, which is distinguished by its fast speeds, low latency, and reliable, effective internet access, has created new opportunities to improve the educational system, especially in the area of Technical and Vocational Education and Training (TVET). The purpose of this study is to investigate how 5G technology might enhance the standard of instruction at Malaysian TVET institutions, with an emphasis on real-time simulations, augmented reality (AR), virtual reality (VR), and remote industrial training. This study's methodology compares the deployment of 5G technology in TVET systems across a number of developed nations as a baseline and source of documentation. The results show that incorporating 5G technology into TVET curriculum creation could increase educational access across geographic borders, speed up students' acquisition of technical knowledge, and improve learning experience interaction. Additionally, this report suggests that the TVET system's use of 5G technology be reinforced by means of industrial partnerships, rigorous teacher training, and the availability of appropriate auxiliary equipment. To sum up, one of the most important ways to create a workforce that is highly qualified and competitive in the Fourth Industrial Revolution is to fully integrate 5G technology into the TVET education ecosystem.

**Keywords**— TVET, 5G, IR 4.0, Challenges, AR, VR, IoT, AI

## I. INTRODUCTION

5G is a next-generation wireless technology that has emerged as a result of the rapid advancement of mobile communication technology with ultra-low latency, much faster data transmission speeds, and the ability to connect more devices at once than its predecessors [1]. In addition to transforming the telecommunications industry, this technology has a significant impact on a number of other domains, such as business, healthcare, agriculture, and education. Globally, industrialised countries like China, Germany, South Korea, and the United Kingdom have stepped up their attempts to incorporate 5G technology into their social and industrial ecosystems, hastening the process of complete digital transformation. This development emphasises how urgently educational institutions must embrace this technology strategically, especially those in the Technical and Vocational Education and Training (TVET) sector [2].

In order to maintain economic growth in the Fourth Industrial Revolution (IR 4.0) period, TVET is vital in developing a competent and semi-skilled workforce. TVET is emphasised in the 12th Malaysian Plan (2021–2025) as a key factor in both economic expansion and human capital development [3]. There is a growing need in the industry for workers who are knowledgeable about new technologies like automation, artificial intelligence (AI), the Internet of Things (IoT), and now 5G. To ensure that its graduates are competitive and able to fulfil the needs of an increasingly complicated labour market, TVET institutions must therefore not only connect their curricula with current technology developments but also speed the integration of digital aspects [4].

Given this, it is becoming increasingly clear how urgent it is for TVET to embrace cutting-edge technology like 5G. Opportunities for more dynamic, student-centered, and industry-oriented learning methodologies are presented by the incorporation of 5G in TVET education [5]. Real-time simulation for hands-on training, virtual reality remote learning, and performance tracking via real-time data analytics are some possible uses of 5G in TVET. For technological integration in higher education to be successful, lecturers must be well-versed in digital literacy [5, 6, 26].

The purpose of this study is to comprehend and describe how 5G technology might improve technical and vocational education and training (TVET) in Malaysia. The main goal is to determine how 5G applications might improve technical teaching and learning methods, especially with regard to increase the effectiveness of hands-on training, broadening educational opportunities, and boosting the calibre of students' educational experiences. The study also aims to identify potential obstacles that can occur during the adoption of 5G technology and to evaluate the opportunities that come with its integration into TVET institutions. The study further intends to provide practical and efficient implementation techniques to guarantee the successful adoption of 5G technology.

This study is guided by the following research questions:

1. How can 5G technology be integrated into Malaysia's TVET education to enhance technical teaching and learning?
2. What opportunities and challenges arise from implementing 5G in TVET institutions?
3. What practical strategies can be adopted to ensure effective 5G integration in the Malaysian TVET context?

## II. LITERATURE REVIEW

Since its worldwide rollout in 2019–2020, 5G technology has become a major force behind innovation in digital education. With latency as low as 1 millisecond and data transfer rates exceeding 1 Gbps, 5G creates new possibilities for real-time video-based learning, 5G speeds up virtual reality and interactive learning at technical colleges, claims [7]. Advanced technologies like IoT, virtual reality (VR), augmented reality (AR), and AI are starting to be used in TVET to improve the educational experience for students [8]. More than 70% of educational institutions in developed nations intend to incorporate 5G into their operations by 2025, especially in the technical and vocational education sector, according to a report produced by GSMA Intelligence in 2022 [9].

## III. METHODOLOGY

A qualitative methodology based on document analysis techniques was used to carry out this investigation. In order to gather data, a literature review was conducted, which involved examining journal articles, research papers, policy documents, and case studies about the use of 5G technology in technical education and training both internationally and in Malaysia. Additionally, industry studies and worldwide trends on the incorporation of new technologies in the TVET sector were cited in this study.

The evaluation method involved a comparative analysis of case studies from five countries (South Korea, Germany, China, United Kingdom, and Malaysia) to identify best practices and challenges in integrating 5G into TVET. Each case study was assessed based on technological implementation, educational outcomes, stakeholder involvement, and scalability potential. This systematic approach ensured that the findings and discussions were grounded in both global trends and the specific Malaysian context.

## IV. CASE STUDY

### A. Case Study 1: South Korea in TVET Education

South Korea is a global leader in the use of cutting-edge technology in vocational training and also one of the earliest nations to set up "Smart TVET Centres" with 5G connectivity. Advanced VR tools created especially for educating technicians in the automotive and renewable energy industries are integrated into these centres. By using immersive simulations, training efficacy is maintained while reliance on physical resources is decreased and learners are able to acquire practical skills in a secure setting [10].

Additionally, the incorporation of 5G technology facilitates smooth, instantaneous interactions in workshops that use AR

and VR. In addition to increasing engagement, this promotes more adaptable and responsive learning environments. Students can work together digitally, get immediate feedback, and keep doing things until they understand them. Therefore, the education model in South Korea shows how immersive technology and high-speed networks may transform vocational training by making it more efficient, accessible, and in line with the demands of the future industry [11].

Improved skill learning and greater student engagement are clear indicators of these projects efficacy. Strong industry-academia cooperation, sophisticated technology infrastructure, and strong government support are all essential for success. Problems still exist, though, like the expensive price of VR gear and the requirement for specific technical assistance [12].

### B. Case study 2: Germany in TVET Education

Germany has adopted 5G technology in vocational education as part of its larger "Industries 4.0" plan, which seeks to use digital innovation to revolutionize technical training and production. 5G has been incorporated into training environments by top TVET institutions like the Fraunhofer Institute, especially in fields like robotics and factory automation. These institutions employ cutting-edge virtual reality (VR) and augmented reality (AR) simulations, to educate students how to handle CNC machines and industrial systems with confidence and accuracy, [13].

High-speed 5G-enabled smart labs allow for interactive, real-time training sessions that closely resemble real-world industrial environments. By eliminating the requirement for costly physical equipment, this arrangement improves the calibre of experiential learning. Simulations that are repetitive, risk-free, and flexible enough to accommodate varying learning speeds are beneficial to trainees [14].

A major focus on digital transformation and significant government investment are important success factors. However, obstacles like high upfront expenditures, cybersecurity threats, and stakeholder opposition to change have been noted. Germany's commitment to creating a highly skilled, future-ready workforce that can meet the demands of the IR 4.0 is shown in its overall acceptance of 5G in TVET [13].

### C. Case Study 3: China in TVET Education

China is leading the way in the digital transformation of Technical and Vocational Education and Training (TVET) with its impressive advancements in integrating 5G technology into its system. In 2021, the nation opened more than 100 "5G+ Smart Education Labs" in different areas. Students can participate in realistic, hands-on VR simulations in these labs, which function as sophisticated training environments. Students are exposed to real-world situations in disciplines like electrical engineering, construction, and even surgery, skills that are essential in today's workforce [15, 25].

Furthermore, by incorporating 5G connectivity into its national TVET e-learning platform, China has made a significant advancement. This development guarantees greater access to high-quality education regardless of location by greatly enhancing the distribution of interactive, real-time

training information. Students can engage in immersive learning experiences more successfully with lower latency and faster data delivery [16, 17].

Strong government funding and well-thought-out laws supporting innovation and education are key success factors. There are still issues, though, like the requirement to create instructional materials that make the most of these technologies and to successfully modify curricula [18, 19]. China's extensive 5G rollout in TVET demonstrates its dedication to developing a workforce with the necessary skills for emerging industries.

#### *D. Case Study 4: United Kingdom in TVET Education*

The UK has started a progressive project called the "5G Testbed for TVET (University of Surrey, King's College London and the University of Bristol)" pilot program to investigate how 5G might change vocational education [20]. In the fields of engineering and information technology, which depend on fast, low-latency connectivity for remote collaboration, simulations, and real-time feedback, this project aims to improve training. Through the integration of 5G into training environments, the UK hopes to assess how enhanced connectivity might enhance technical content delivery and facilitate more responsive, interactive learning environments [20].

With the help of this testbed, vocational schools are experimenting with novel approaches to provide practical instruction utilising cutting-edge technology including cloud-based platforms, AR, and VR. In addition to evaluating 5G's viability in the classroom, the project collects important data on how it affects student performance and skill development. Because of its proactive strategy, the UK is positioned as a leader in the transformation of next-generation TVET [20].

The program has shown promise in terms of enhanced connection and assistance for distance learning. Collaboration with industry partners and government support are key success factors. However, there are still obstacles to overcome, such as guaranteeing fair access to 5G technology and resolving data security issues [20].

#### *E. Case Study 5: Malaysia in TVET Education*

Malaysia is aggressively incorporating cutting-edge technology, such as 5G, into its Technical and Vocational Education and Training (TVET) system to improve the quality of technical education [1]. To give professionals the skills, they need to use 5G in smart manufacturing settings. Organizations like the Penang Skills Development Centre (PSDC) have launched specialized courses like the "Certified 5G for Manufacturing" course. These programs are in line with the national goal of developing a workforce that is prepared for the future and skilled in IR 4.0 capabilities [21].

Graduates' increased employability is proof of the efficacy of these technology applications. PSDC reports a high employment rate among its trainees because of its collaborations with top firms and industry-aligned curriculum. In a similar vein, Malaysia's Ministry of Human Resources' PROTON Institute (ADTEC Melaka), a TVET institution, has been outfitted with classrooms and labs that support 5G. The modernization program for the 5G telecommunications

workshop is a component of the institution's endeavor to improve training facilities and guarantee that TVET graduates stay relevant in the face of Malaysia's rapid advancements in 5G technology [22]. Additionally, Malaysian polytechnics have embraced Work-Based Learning (WBL) frameworks, combining academic knowledge with real-world skills via partnerships with regional IT companies. By using these strategies, students are guaranteed to be adequately equipped to meet the changing needs of the job market [1].

Even with these developments, problems still exist. Disparities in infrastructure between urban and rural areas, insufficient funding, fragmented governance structures, and a lack of industry engagement are some of the main problems. Educators also require ongoing professional development, to effectively offer technology-integrated courses [23, 24]. Government organizations, academic institutions, and industry players must work together to address these issues to promote the fair and efficient adoption of technology advancements in TVET throughout Malaysia [23].

## V. FINDING

### *A. Opportunities*

There are numerous new potential to improve the calibre of instruction and learning when 5G technology is included into Technical and Vocational Education and Training, or TVET. Students can experience real-world industrial simulations in a secure and engaging virtual environment thanks to 5G's ultra-fast internet rates and low latency, which make it possible to use VR and AR applications in hands-on teaching. Furthermore, 5G facilitates excellent real-time distant learning, giving students in remote locations access to a wider variety of technical education materials. Through intelligent machinery and equipment, 5G-powered Internet of Things (IoT) apps may also be able to track and evaluate student performance in real time. Additionally, this technology enables the creation of virtual labs that cut costs and minimize safety hazards for students doing technical instruction and experiments. All of these chances immediately improve student involvement, support experiential learning, and result in TVET graduates who are more equipped to handle demands from the industry in the future.

### *B. Challenges*

Even though 5G technology has a lot of potential, there are obstacles to overcome before it can be used in TVET education. The high cost of infrastructure investment, which includes building 5G networks, buying new compatible equipment, and setting up facilities for technical support is one of the primary challenges. In order for teachers to become proficient and incorporate with this new technology into their lessons, they must also undergo retraining. Since the deployment of 5G entails the extensive transmission and storage of data, data security and privacy issues also surface. The success of implementation may also be impacted by the scarcity of 5G-capable devices and the digital divide between urban and rural areas. In order to overcome these obstacles and guarantee that the advantages of 5G technology may be fully realized in TVET education, a well-thought-out implementation strategy is necessary.

## VI. DISCUSSION

Significant adjustments must be made to the way technical and vocational education and training (TVET) is approached in light of the development of 5G technology. The advent of 5G in the TVET environment calls for a thorough overhaul of infrastructure, pedagogy, and teacher competency in addition to the introduction of new technologies. Big data learning, AR, and virtual simulation-based teaching strategies are becoming more and more popular and need to be integrated into the current curriculum. This conversation emphasizes how TVET universities must move away from old methodologies and towards interactive, student-centered teaching strategies backed by real-time technologies made possible by 5G.

Furthermore, educational institutions cannot be the only ones implementing 5G in TVET education. It calls for strategic cooperation between a number of stakeholders, including the government, business sectors, tech firms, and the academic community. Particularly, the industry sector needs to actively assist TVET institutions in comprehending the actual demands of the labour market and in offering assistance in the form of technology, knowledge, and possibilities for industrial training. Another crucial factor is the proficiency of teachers; training for ongoing professional development and empowerment are necessary to guarantee that they can use technology in the classroom.

Additionally, while talking about integrating 5G, equity and inclusivity must be given top priority. The advantages of modern technology shouldn't be denied to students from low-income or rural homes. In order to guarantee that all children, regardless of background, receive high-quality education, implementation methods must incorporate efforts to close the digital divide and provide complete infrastructure. Overall, this conversation highlights the need for comprehensive, inclusive, and forward-looking planning when implementing 5G in TVET to guarantee that it actually creates a workforce that is sustainable and competitive worldwide.

## VII. RECOMMENDATIONS

A number of strategic recommendations should be taken into consideration in order to guarantee the successful integration of 5G technology in TVET education and training. First and foremost, the government is urged to offer specific financial assistance for the construction of 5G infrastructure in TVET institutions, which includes the supply of appropriate instructional materials and fast internet access. Second, in order for teachers to comprehend and become proficient with this new technology for use in the classroom, training programs and upskilling must be intensified. Third, in order to support technology transfer, industrial training, and cooperative projects centred on digital innovation, TVET institutions ought to form solid alliances with the technology sector and 5G service providers.

Additionally, before new strategies are widely adopted, pilot projects pertaining to the usage of 5G in technical education should be put into place to evaluate their efficacy. Community-based strategies should also be taken into account, especially to guarantee equal access to high-quality education for pupils in underprivileged and rural areas. Finally, to

guarantee that it stays relevant in light of both present and upcoming technology advancements, a comprehensive, flexible, and future-proof TVET education policy should be created.

## VIII. CONCLUSION

In conclusion, there is a great deal of promise for 5G technology to change TVET education in Malaysia. The teaching and learning process can be made more dynamic, effective, and impactful with the use of technologies like smart simulations, real-time learning, and Internet of Things-based monitoring. However, thorough preparation in terms of infrastructure, teacher skills, and cross-sector cooperation is necessary for successful implementation. In order to create a workforce that is competitive, ethical, and relevant in the digital age, this paper highlights the need for TVET to be ready to adapt and change in tandem with the IR 4.0. 5G can be a major driver in enabling the national TVET education system to become more intelligent, adaptable, and sustainable if it is implemented in a comprehensive and inclusive manner.

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## REFERENCES

- [1] M. Baharuddin, Z. A. N. Rahim, M. S. Iqbal, and N. Ibrahim, "TVET Education for Community Education 5.0 in Malaysia," *ResearchGate*, 2024.
- [2] L. Wei, J. L. H. Nga, and I. A. Shahzad, "Investigating the determinants of vocational education and economic development in digital age: A review from 2018–2023," *Int. J. Religion*, vol. 5, no. 9, pp. 495–502, 2024.
- [3] N. Nahar, "Penguasaan kemahiran membaca dan menulis bahasa Melayu dalam kalangan murid bukan penutur natif di sekolah jenis kebangsaan (SJK) [Mastery of Malay reading and writing skills among non-native speaker students in national type schools (SJK)]," *Issues in Language Studies*, vol. 9, no. 1, pp. 107–123, 2020. [Online]. Available: <https://doi.org/10.33736/ils.2223.2020>
- [4] M. Sounoglou, "Greek, Finnish and Danish curricula and their relation to the labor market: a critical approach," *J. Crit. Educ. Policy Stud.*, vol. 21, no. 3, pp. 125–152, 2023.
- [5] H. Mardiana, "Perceived impact of lecturers' digital literacy skills in higher education institutions," *SAGE Open*, vol. 14, no. 3, 2024. [Online]. Available: <https://doi.org/10.1177/21582440241256937>
- [6] H. Miço and J. Cungu, "The need for digital education in the teaching profession: A path toward using the European Digital Competence Framework in Albania," *IAFOR J. Educ.*, vol. 10, no. 2, pp. 29–50, 2022.
- [7] M. R. Ridzwan and N. A. S. Binti Abd Rahman, "The analysis of the government policy on technical and vocational education and training (TVET) and the

- predicaments of TVET in Malaysia,” *Int. J. Humanities Technol. Civiliz.*, vol. 7, no. 1, pp. 53–58, 2022. [Online]. Available: <https://doi.org/10.15282/ijhtc.v7i1.7611>
- [8] I. Kuntadi *et al.*, “Towards digital TVET: A comparative study on students’ readiness and the industry digital demands in Indonesia and Malaysia,” *J. Tech. Educ. Train.*, vol. 14, no. 3, pp. 79–93, 2022. [Online]. Available: <https://doi.org/10.30880/jtet.2022.14.03.008>
- [9] GSMA Intelligence, *The Mobile Economy 2022*, GSMA, 2022. [Online]. Available: <https://www.gsma.com/mobileeconomy/>
- [10] M. An, K. Ko, and E. Kang, “Problems and directions of development through analysis of virtual reality-based education in Korea,” *Int. J. Inf. Educ. Technol.*, vol. 10, no. 8, pp. 552–556, 2020. [Online]. Available: <https://doi.org/10.18178/ijiet.2020.10.8.1423>
- [11] Faster Capital, 2025, “Technical and Vocational Education and Training: TVET: Fueling Innovation in the Business World,” 2025. [Online]. Available: <https://fastercapital.com/content/Technical-and-Vocational-Education-and-Training--TVET---TVET--Fueling-Innovation-in-the-Business-World.html>
- [12] British Chamber of Commerce in Korea, *Global Technology Report: Immersive Technologies in Korea*, Innovate UK, 2022. [Online]. Available: <http://www.bceck.or.kr>
- [13] Fraunhofer Institute, “Smart TVET Labs: Training the workforce for Industry 4.0,” *Fraunhofer Research Reports*, 2021.
- [14] Fraunhofer Institute, “Industry 4.0 5G Positioning and Communication Testbed,” *Fraunhofer Research Reports*, 2021.
- [15] W. Zhu and S. Wang, “5G + VR technology enables the construction of smart classrooms in universities,” in *Proc. 3rd Int. Conf. Mod. Educ. Inf. Manag. (ICMEIM)*, 2022, pp. 47–54.
- [16] Y. Fan, H. Zheng, R. S. Ebonite, W. R. De Asis, and R. A. Juanatas, “Overview and developmental analysis of China’s technical and vocational education and training,” *Int. J. Innov. Res. Sci. Stud.*, vol. 7, no. 1, pp. 251–260, 2024.
- [17] *Smart Education of China platform surpasses 164 million users*, The State Council of the People's Republic of China, May 17, 2025.
- [18] M. Munkholm, “China’s competitive edge in education technology and agility,” LinkedIn, 2025. [Online]. Available: <https://linkedin.com/pulse/chinas-competitive-edge-education-technology-agility-munkholm>
- [19] X. X. Zhang, “Digital transformation and smart education in China: Current status and challenges,” *Open Access Library Journal*, vol. 12, pp. 1–11, 2025. [Online]. Available: <https://doi.org/10.4236/oalib.1112952>
- [20] United Kingdom Department for Education, “5G Testbed Programmes for TVET Institutions,” *UK DfE Reports*, 2022. [Online]. Available: <https://www.gov.uk/guidance/5g-testbeds-and-trials-programme>
- [21] Penang Skills Development Centre (PSDC), “Certified 5G for Manufacturing,” [Online]. Available: <https://psdc.org.my/training/programs/certified-5g-for-manufacturing>
- [22] Majlis Penyerahan Bangunan oleh Pihak JKR kepada ADTEC Melaka, 2025. [Online]. Available: <https://www.facebook.com/share/p/19UuwtRzof/>
- [23] M. K. F. Ahmad and H. Rosnan, “Overcoming challenges in Malaysia’s technical and vocational education: A path forward for TVET,” *Int. J. Res. Innov. Soc. Sci. (IJIRSS)*, vol. 8, no. 3, 2024.
- [24] R. Abdul Hamid, I. M. Ismail, and W. A. J. Waan Yahaya, “Augmented reality for skill training from TVET instructor perspective,” *Interactive Learn. Environ.*, vol. 32, no. 4, pp. 1291–1299, 2024.
- [25] *Smart Education of China platform surpasses 164 million users*, The State Council of the People's Republic of China, May 17, 2025.
- [26] A. N. Zulkifli, F. N. Rusli, M. N. Saad, and Y. M. Yussop, “A study of students’ motivation in using the mobile arc welding learning app,” *Int. J. Interact. Mobile Technol. (iJIM)*, vol. 13, no. 10, pp. 89–105, 2019. [Online]. Available: <https://online-journals.org/i-jim/article/view/11305>