INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN BUSINESS & SOCIAL SCIENCES

Vol 15, Issue 01, (2025) E-ISSN: 2222-6990

Relationship between Teacher's Knowledge and Digital Technology Integration in Design and Technology Teaching Practices

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To Link this Article: http://dx.doi.org/10.6007/IJARBSS/v15-i1/24527 DOI:10.6007/IJARBSS/v15-i1/24527

Published Date: 15 January 2025

Abstract

Quality Technical and Vocational Education and Training (TVET) requires skilled teachers who keep up with global changes in technology. In line with the intention of the Malaysian Ministry of Education, the subject of Design and Technology (RBT) was introduced to expose students to the use of technology in TVET at the lower secondary level. This study was conducted to identify the relationship between technological, pedagogical and content knowledge with the practice of digital technology integration among RBT teachers in Petaling Perdana district. This study uses a quantitative approach in the form of correlation through a survey method involving 229 RBT secondary school teachers. The selection of respondents was made using a simple random sampling method. In summary, the results derived from the descriptive examination of technological, pedagogical and content knowledge indicate a significant level with a score value (M=3.91, SD=0.38). Next, the practice of digital technology integration recorded a score value (M=3.85, SD=0.61) which is at a high level. Pearson's correlation analysis shows that there is a moderate significant relationship between technological, pedagogical and content knowledge with the practice of digital technology integration among RBT teachers ($r=0.572$, $p<0.01$). Therefore, the teacher's knowledge must always be consistent at a high level so that the integration of digital technology in RBT subjects can be used as a continuous practice.

Keywords: Teacher's Knowledge, Technological, Pedagogical and Content Knowledge, Digital Technology, Design and Technology

Introduction

Technical and Vocational Education and Training (TVET) is an important component in providing a highly skilled workforce to meet the needs of Industry 4.0. With the rapid change in technological development, integrating digital tools in the teaching and learning process is an important factor in the current Malaysian educational landscape (Abdullah et al., 2019). As a result, lower secondary subjects such as Design and Technology (RBT) are designed to

provide students with new skills in technology usage and reasoning in the design process. The combination of the two elements equips students to be Industry 4.0 ready with relevant technology skills and experience to adapt with digital literacy.

Teacher skill is an integral component of successful use of digital technology in RBT. Led by those who form curriculum implementers, RBT teachers are essential components in the starting phase of the transference process from traditional to digital teaching methods that is essential in synchronizing the development of the Industry 4.0 job market (Gilkes, 2020). Digital technologies such as Internet of Things (IoT), Artificial Intelligence (AI) and robotics have been incorporated into education with the School Standard Curriculum introduced in 2017. Both these efforts fall under the Malaysian Education Development Plan 2013-2025 which supports digital learning to enhance students' technological skills. Ministry of Education also continues to strengthen this trend by implementing policies that lead to the acceptance of integration of digital technology as part of the education system with the latest development of the world education system while ensuring the RBT subject is more technology-based and emphasis on reasoning.

However, even for those teachers who were able to use digital integration effectively in RBT also required technological, pedagogical and content knowledge (Gilkes, 2020). Research evidence showed that skills of digital teachers helped to overcome the problems during the digital teaching that was indicated in the applications using Magnetcode and Arduino Uno for robotic automation components in the usages of classrooms (Ministry of Education Malaysia 2016; 2017). Insufficient knowledge in the domains of technology, pedagogy and content (TPACK) can impede the successful integration of digital innovation into teaching practices (Hamzah et al., 2019). Consequently, ongoing professional development is essential to effectively bridge this gap. This study attempts to investigate the relationship of each knowledge dimensions of TPACK on effective digital teaching practices of RBT teachers that integrated with lifelong learning and Industry 4.0 learning (Richard et al., 2023; Masrifah et al., 2022).

Problem Statement

The implementation of the Design and Technology (RBT) subject is in line with Malaysia's Digital Education Policy (2023) and Seventh Shift in the Malaysian Education Blueprint (2013-2025), which aspires to produce skilled teachers and global quality education. This congruence facilitates the integration of digital technology in TVET ecosystem, driving the achievement of the Sustainable Development Goals (SDG) especially the right for everyone to have access to lifelong learning opportunities. In doing so, the RBT curriculum focuses on equipping students with digital skills and a mindset for technology as they will be engaged with a technology-rich world. Even so, a recent discovery of teachers' digital competency found that only 2.2% of teachers are advanced, while 39.9% are intermediate and 57.9% are basic level (Ministry of Education Malaysia, 2023). Especially, teaching subject outside their specialisation teacher reporting it challenging to adopt digital technology into their pedagogy due to insufficient of their digital skills (Ministry of Education Malaysia, 2023). Such a scenario is more alarming for RBT teachers, when findings on digital pedagogical knowledge have shown to inhibit the development of active and innovative learning spaces (Masingan & Sabari, 2021). These gaps in digital competency are considerable barriers RBT teaching given the need to cultivate activeness.

The newly introduced RBT at lower secondary TVET Malaysia is still facing unprecedented challenges in terms of its curriculum mastery and instructional effectiveness. Ongoing professional training that encourages the use of technology to improve teaching is rarely experienced by teachers (Engeness, 2021). In contrast with the traditional, technical subjects such as RBT also requires to provide students with experiences for Industry 4.0. Based on the Theory of Planned Behavior (Azjen, 1991), the practice of individual behavior is closely related to the teacher's knowledge. This is supported by several past studies that have found that the practice of integrating digital technology is influenced by technological, pedagogical and content knowledge (Mat et al., 2023; Endot, 2020; Zolkefli et al., 2018). In addition, many studies related to the practice of integrating digital technology in teaching have been conducted, but the studies conducted focus on Mathematics (Osman & Maat, 2022), Malay Language (Hishamudin, 2023), English as a Second Language (Rauf & Suwanto, 2020) and Preschool Education (Masnan & Mohamed, 2023), studies specifically on the context of RBT teachers have been limited. Therefore, there is a need to examine the practice of digital technology integration among RBT teachers and its relationship with knowledge of technology, pedagogy and content. This study aims to ensure effective integration of digital technology in the RBT curriculum and improve the quality of teacher's instructional practices.

Research Objective

The objectives of the study are as follows:

1) To identify the level of digital technology integration practices among RBT teachers in the Petaling Perdana district.
2) To identify the level of technological, pedagogical and content knowledge among RBT teachers in the Petaling Perdana district.
3) To determine the relationship between the level of technological, pedagogical and content knowledge with digital technology integration practices among RBT teachers in the Petaling Perdana district.

Literature Review

Digital Technology Integration Practices

The technological advancement brought by the Fourth Industrial Revolution creates the demand for a digitally literate work force and these demands have forced the Technical and Vocational Education and Training (TVET) to embrace digital technology for an effective TVET by creating a meaningful student learning experience. Digitally, this integration in TVET uses blended learning, virtual management systems, simulations, flipped classrooms, virtual and augmented reality to shift from traditional to interactive digital pedagogy (Brohus et al., 2022). Digital tools help not just in improving the students' skilfulness in practical TVET sessions but also enable flexible, self-directed learning through various mobile applications and learning available online (Taib et al., 2020).

Digital technology encourages collaboration among teachers and other stakeholders to share knowledge that is consistent with what is relevant in the discipline (Tan et al., 2021). At the same time, an appropriate technology choice can significantly improve learning achievements so that the effectiveness of digital use in education is directly influenced by the technology itself as well as the alignment with learning goals (Shafie et al., 2019), thus making digital pedagogy an indispensable part of teacher's digital knowledge (Myyry et al., 2022). Empowered teachers in digitalization lead to global calls on students to voluntarily reason the

need of learning to be meaningful and motivated (Hata & Mahmud, 2020). However, issues such as the lack of infrastructure, time and the changing educational systems need to be solved for the successful integration (International Labour Organization, 2020). In addition, students and teachers alike require sufficient time to adjust with these digital environments and unplanned use of technology can distract from learning. Upgrading technological infrastructure is a crucial requirement to have successful integration in Design and Technology curriculum, where digital skills ensure the students are prepared for Industry 4·0 (Haslin & Hamzah, 2023). This, therefore, promotes digital integration in TVET to enhance teaching and learning, which serves as a prerequisite for developing digital literacy and preparing TVET for educational advancement through strategic use of appropriate technology that aligns with teaching and learning goals.

More previous research on digital technology integration practice in education indicated different levels of technology use among teachers and lecturers based on subjects and schools. Similarly, Manoharan and Iksan, (2020) found a moderate level (M=2.98) of digital technology integration within 30 Science teachers in Pasir Gudang, Johor. Krishnan and Din (2023) found similar findings when studying 82 lecturers at Port Dickson Vocational College and they found the use of digital technology among lecturers at a moderate level (M=3.56). Finally, the case study conducted by Masingan and Sharif (2021) showed that non-specialist of Design and Technology teachers used technology at the level of substitution and augmentation based on the SAMR model which is at the enhancement level but did not proceed up to transformational level. Based on interviews performed in this specific study, various constraints were identified, such as limited content mastery and technology mastery, which limit the ability to integrate technology in teaching and learning. It can be concluded that digital technology integration practices in education are not the same by subject specialization, therefore further research are needed in relation to digital technology integration practices among Design and Technology teachers because this subject is fairly new, also research of TVET field is still limited.

Teacher's Knowledge

Literature on professional knowledge and the various theories and models that have been applied, have been explored by previous researchers. The Technological, Pedagogical and Content Knowledge (TPACK) Model (Mishra & Koehler, 2006) is an expansion of Shullman's knowledge theory (1986) that interact to influence how someone teaches. The TPACK model is a guiding framework for technology-related classroom teaching practices studies and covering the three main dimensions of knowledge of TPACK to provide better learning experiences for students. As a result, the TPACK model supports teachers in understanding and applying digital technologies within their instructional practices, specifically in the context of Design and Technology subject. Adequate technological knowledge among teachers is essential for the effective implementation of appropriate pedagogical approaches.

In order for Design and Technology teachers to incorporate digital technology into subject thus requiring a focus at the school administration level on technological knowledge (TK), pedagogical knowledge (PK) and content knowledge (CK). However, Design and technology is still fairly new and some teachers are not confident with the concepts and embedding digital technology in lessons. Studies indicate, on the other hand, that the level of technical knowledge of teachers is generally moderate or low (Masingan & Sharif, 2021;

2019). At the same time, teachers with enhanced pedagogical knowledge are generally more willing and optimistic about integrating digital technology, whereas insufficient content knowledge leads to poor confidence in digital technology in lessons (Margot & Kettler, 2019). As a result, they are not applying competent enough at the aspect of TK, PK and CK, thus, will not obtain effective teaching (Azam et al., 2023). Finally, the TPACK model is an effective model for improving teacher digital technology knowledge within the teaching practice. First, this intertwines the relationship between teacher knowledge and digital technology use in Design and Technology as teachers who have the capability of choosing an appropriate technology corresponding to the Design and Technology curriculum content enhance the ability to teach a lesson.

TPACK is a framework that focuses on the interplay of different types of knowledge suggesting that technological, pedagogical and content knowledge must be used together to maximize the impact of technology on teaching (Mishra & Koehler, 2006). TPACK can be thought of as teachers' skills to choose, adapt and implement specific technologies in specific contexts to specific instructional goals and to support students to use digital tools effectively to accomplish those goals. The findings also showed that moderate technological knowledge by TVET lecturers, which indicates that the technology skills of the lecturers are high but the challenge lies on the ability to use and adapted technology tools in the instructional activities (Razali et al., 2022). Thus, both experiences and instructional strategies are important to pre-service teacher TPACK development. A research conducted by Khaliq et al. (2023) has reported limited technology integration in the Pakistani teachers and similar to our result that the Science teachers were in initial stages of SAMR and TPACK implementation reveals the hurdles behind the progression to higher technology integration levels from the matrix in both educational settings.

Research Theory

The TPACK model, as described by Mishra and Koehler (2006), emphasize complex relations among three basic forms of knowledge, namely Technological Knowledge (TK), Pedagogical Knowledge (PK) and Content Knowledge (CK). The combination of these dimensions result in four distinct types of combined knowledge, Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK) and Technological Pedagogical Content Knowledge (TPACK), (Mishra & Koehler, 2006). In this study, the researcher has examined teachers' knowledge on the basis of three main domains of DTK (TK, PK, & CK) for resolving the challenges of integrating digital technology on teaching RBT subjects. Since TPACK is primarily concerned with areas of knowledge particularly relevant to technologies, pedagogy, and content and their interplay it is relevant to examining the role of teacher knowledge on Design and Technology teachers' digital technology integration practices. Teacher knowledge regarding technology use is a vital component in effective integration as access to and use of appropriate technological tools and resources must be available to students. In addition, knowledge of technology and the content enables teachers to take full advantage of the power of digital tools in a Design and Technology lesson. Teachers understanding Design and Technology curriculum content is also important, so they can choose appropriate technologies that provide greater instructional effectiveness. As a result, the TPACK Model links technological, pedagogical and content knowledge to inform the planning of professional development for teachers to integrating digital technology in their teaching practices.

Methodology

Research Design

This study used a quantitative approach with a descriptive survey design to explain the relationship between the study variables. Questionnaire instruments are used because they allow data collection to be done only once providing sufficient information to understand certain phenomena (Creswell, 2012; 2022). In this study, the dependent variable is digital technology integration practices while technological, pedagogical and content are the independent variables.

Population and Sample

The study population consists of 490 practicing teachers who teach the Design and Technology subject in secondary schools in the Petaling Perdana district, Selangor. The sample size was 238 Design and Technology teachers used in this study was determined through the formula of Cochran, 1977. Simple random sampling was used to select the sample from 29 daily secondary schools located at the Petaling Perdana district, Selangor.

Research Instrument

This research used a questionnaire instrument delivered via Google Form to collect the data from the respondents with the dependent variable is digital technology integration practices and independent variables are technological, pedagogical and content knowledge. The researcher adapted 62 items from prior studies to fit the purpose of in the present study and the questionnaire was designed in four sections to ease in data management as well as helping the respondents to understand (Creswell, 2022). The initial Section A consists the information of demographic data while the subsequent Section B concerns the Technological, Pedagogical and Content Knowledge (Mohammad Rusdi, 2017). Section C is Knowledge of construction subject in Design and Technology (Endot, 2020) and Section D is Digital Technology Integration Practices in Design and Technology teaching (Zaleha, 2020). The pilot study showed a Cronbach Alpha values of between 0.91 and 0.95. Thus, the items are kept in high reliability of the items and can be applied for real research. So, the closer the value of Cronbach Alpha to 1.0 the higher the reliability of the instrument (Cohen et al., 2018).

Data Analysis

This section reports the findings of the study based on descriptive and inferential statistical analysis. Researchers targeted a total of 238 study respondents based on a simple random sampling method. However, only 229 respondents provided feedback on the Google Form link within the specified time period. In social science studies, a return rate of 95.33% is considered high (Siqi & Chaetnalao, 2024). The descriptive analysis is used to analyze the demographic information of the respondents, including frequency and percentage. Knowledge of technology, pedagogy and content, as well as the practice of digital technology integration are analyzed using mean, standard deviation, frequency and percentage. Pearson's correlation analysis, r, is used to answer the hypothesis for research questions related to the relationship between the dependent variable and the independent variable.

Finding

Digital Technology Integration Practices among Design and Technology Teachers

Table 1 shows the mean score and standard deviation to identifying the level of digital technology integration practices among Design and Technology teachers. There are 10

positive items used to answer the questions in this section. Overall, the finding shows that digital technology integration practices among Design and Technology teachers are at the high level with an overall mean score of M=3.85 and SD=0.61.

Table 1
Digital Technology Integration Practices among Design and Technology Teachers

Item No.	M	SD	Interpretation
D1	4.25	0.65	High
D2	4.07	0.73	High
D3	4.06	0.78	High
D4	3.75	0.88	High
D5	3.93	0.89	High
D6	3.85	0.78	High
D7	3.64	0.92	Moderate
D8	3.61	0.83	Moderate
D9	3.56	0.83	Moderate
D10	3.77	0.90	High
Digital technology integration practices	**3.85**	**0.61**	**High**

Knowledge among Design and Technology Teachers

Table 2 shows the mean score and standard deviation to identify the level technological, pedagogical and content knowledge among Design and Technology teachers. The analysis of the research findings on the level of technological, pedagogical and content knowledge shows that the dimension of pedagogical knowledge recorded the highest score (M=4.12, SP=0.43), followed by the content knowledge dimension (M=3.89, SP=0.49) and finally the dimension of technological knowledge (M=3.71, SP=0.). Overall, the teacher's knowledge of technology, pedagogy and content is at a high level with a mean score value (M=3.91, SP=0.38).

Table 2
Knowledge among Design and Technology Teachers

Dimension	M	SD	Interpretation
Technological knowledge	3.71	0.49	High
Pedagogical knowledge	4.12	0.43	High
Content knowledge	3.89	0.49	High
Knowledge	**3.91**	**0.38**	**High**

Relationship between Teacher's Knowledge and Digital Technology Integration Practices among Design and Technology Teachers

Table 3 shows that Pearson's correlation analysis was conducted to test the hypothesis, Ho1, which is that there is no significant relationship between the level of technological, pedagogical and content knowledge with the practice of digital technology integration among Design and Technology teachers. The findings of the study show that there is a significant relationship between technological, pedagogical and content knowledge and the practice of integrating digital technology with a correlation value ($r=0.572$, $p<0.01$). The finding shows this relationship is moderate. The technological, pedagogical and content knowledge have a direct relationship with the practice of digital technology integration among RBT teachers, so

hypothesis Ho1 is rejected. Therefore, this study is significant to achieve the overall goal of the study.

Table 3
Correlation between Variables

Variable	Digital Technology Integration Practices (Pearson's correlation coefficient, r)	Interpretation Relationship
Technological, Pedagogical and Content Knowledge	0.572**	Moderate

** Correlation is significant at the 0.01 level (2-tailed)

Discussion

Digital Technology Integration Practices among Design and Technology Teachers

The findings of the study found that the digital technology integration practice of Design and Technology teachers in Petaling Perdana are at a high level. This result is different from the study conducted by Mahonaran and Iksan (2020) and Krisnan and Rosseni (2023) who found the integration level of digital technology among Science teachers in Pasir Gudang and lecturers in Vocational College Port Dickson only moderate level. Moreover, according to the findings obtained on a case study, teacher that not specialist on Design and Technology still at low level of integration which only have substitution and augmentation stage (Masingan & Sabariah, 2021). The results of the research were quite high because these teachers have experienced the phase of digital technology use during the Covid-19 pandemic that struck the whole world, including Malaysia, at the end of 2019. During that time, Design and Technology teachers were introducing digital technology to students, such as Google Classroom, Zoom, Google Meet, Magnetcode and Tinkercad simulation circuit as well as other digital applications related to the subject.

Consequently, the implementation of digital technology is still at a medium and low level. The results of this study found a high level teaching practice integration of digital technology in 2024 because of Covid-19 pandemic phase that exposure Design and Technology teachers to using digital technology in teaching. Besides, the result of the study indicates that the practice of integrating digital technology in Design and technology subjects allows teachers to gain information faster and to date, offering a higher quality of teaching and learning process in Design and Technology subjects using digital technology in Manufacturing Technology, Electrical Design, Electronic Design, Mechatronics Design and Product Production topics while also limiting the workload of teachers. This study also shows that teachers are always upgrading the knowledge they have in accordance with the objective of the Digital Education Policy (2023) and Design and Technology curriculum that aims to encourage teachers to integrate digital technology in the teaching and learning process from the lower secondary level in order to follow the wave of Industry 4.0.

Knowledge among Design and Technology Teachers

This study's finding reveals that the technological, pedagogical and content knowledge for Design and Technology teachers in Petaling Perdana are fairly high compared to a past study on technological, pedagogical and content knowledge among TVET lecturers at Sarawak Community College which only revealed a moderate level of knowledge (Razali et al., 2022). Denoting a different finding from global studies that have claimed low awareness over

technological, pedagogical and content knowledge (Leendert et al., 2021; Kaplon-Schilis, 2019). The study finds that Design and Technology teachers possess a high technological, pedagogical and content knowledge, which can be interpreted in the highest level. The high level of pedagogical knowledge is probably related to teacher's experience with most having 7 or 8 years of teaching experience. As stated by Leendert et al., (2021), effective pedagogy is developed by experienced teachers who use various strategies to address the different needs of students. This flexibility is key to making sure that teaching methods are both relevant and effective in supporting student learning and success.

Technological, pedagogical and content knowledge high-level consistent knowledge is very important to enable that the integration of digital technology will become an ongoing practice in the teaching and learning subjects. This is furthermore adapted to the clime of curriculum that stress on reasoning skill and digital innovation and the Digital Education Policy (2023) as well as the Malaysian Education Development Plan 2013-2025 and the core for Civil Education to have skilful teacher and teaching globally in quality. The support for the employment of digital technologies in education also aligns with the first and fourth goals of the Sustainable Development Goals on quality education and lifelong learning opportunities (UNESCO, 2020). The high level of proficiency level of technological, pedagogical and content knowledge possessed by Design and Technology teachers needs to be sustained to foster the integration of digital technology in improve teaching quality relevant to the advancement of national education (Abdullah et al., 2019; Gilkes, 2020)

Relationship between Teacher's Knowledge and Digital Technology Integration Practices among Design and Technology Teachers

There is a positive relationship between technological, pedagogical and content knowledge and the practice of digital technology integration among the Design and Technology teachers, as revealed in the Pearson correlation analysis, but it is of moderate strength. Related to this finding is the prior studies which indicate that there is a strong relationship between the technological, pedagogical and content knowledge and the digital technology implementation in teaching (Gilkes, 2020; Zolkefli et al., 2018). While modest, this relationship indicates that if technological, pedagogical and content knowledge were ameliorated, it could provide a foundation for better practice of digital technology integration. On the other hand, the moderate strength of the correlation may be affected by factors external to the model, specifically support from administrative and educational authorities, which is in line with the TPACK model by Mishra and Koehler (2006). This social pressure can result from school administrators who expect teachers to integrate technology in their classrooms.

More frequent and targeted professional development would suggest a relationship with more moderate significance. The demographics indicate that most teachers are only attending classes on digital technology once or twice every year and this may not be enough to succeed with the quickly advancing technology. Therefore, the recommendation for more opportunities for practicing technological, pedagogical and content knowledge is evidenced by findings of Mishra and Koehler (2013), which reflects that professional development improves teacher's effectiveness in their teaching. Furthermore, the majority of Design and Technology teachers are specialist and have gone through digital technology training, which indicates that higher technological, pedagogical and content knowledge is associated with

greater use of technology in instruction. Consequently, incorporating professional development programs and providing all technological resources will ensure that technology is incorporated in ways that support the intent of effective use, talking about the Digital Education Policy (2023) and Malaysian Education Blueprint 2013-2025 to ensure that teachers are competent and that nationally, education is globally competitive.

Conclusions and Recommendations

This study aimed to examine the relationship between technological, pedagogical, and content knowledge and the practices of digital technology integration among Design and Technology teachers in the Petaling Perdana district. Findings indicate that both the integration practices and the levels of technological, pedagogical and content knowledge among Design and Technology teachers are high. Pearson correlation analysis reveals a significant relationship between these knowledge domains and digital technology integration practices, though the correlation strength remains moderate.

Consequently, Design and Technology teachers are encouraged to sustain and enhance their digital integration knowledge and practices through continuous professional development initiatives such as workshops, Peer Learning Coaching (PLC) and In-Service Training. Support from administrators is also crucial to fostering consistent technology integration in Design and technology teaching and learning. The study's implications and recommendations for further research aim to provide insights for strengthening technological, pedagogical and content knowledge alongside digital integration practices in Design and Technology education.

Acknowledgement

Special thanks to the instruments' owners who permitted the use of their instruments for this study and to all Design and Technology teachers who agreed to answer the questionnaire.

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