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RESEARCH ARTICLE

Teachers' Competency in Utilizing Google Classroom as an LMS in Vocational Education

Asma Nur Fatihah Mohd Noor[1], Wan Omar Ali Saifuddin Wan Ismail*[2], Wan Marfazila Wan Mahmud[3], Norliza Ab Halim[4], Sharizal Ahmad Sobri[5]

[1, 2, 3] Faculty of Islamic Contemporary Studies, Universiti Sultan Zainal Abidin, Terengganu, Malaysia
[4]Kuala Kangsar Community College, Perak, Malaysia
[5]Department of Engineering, Nottingham Trent University, United Kingdom

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***Corresponding Authors:**
woasaifuddin@unisza.edu.my

ABSTRACT

The Fourth Industrial Revolution and the 2020 global COVID-19 pandemic have accelerated the integration of educational technology, thus, necessitating the support of digital education. The Ministry of Education Malaysia had introduced Google Classroom (GC) to teachers to overcome some of the challenges posed by these two global events, marking a significant step towards digitalization. However, this advancement highlighted several issues, such as insufficient technological knowledge, practice, and understanding of GC, leading to limited integration of teaching, and learning. This study aimed to measure vocational teachers' knowledge and proficiency in using GC as a Learning Management System (LMS) within the TPACK model framework. A descriptive quantitative approach was employed using an online survey, in which the survey instruments were distributed to 66 secondary school vocational subject teachers in Terengganu. Findings revealed that components such as technological knowledge (TK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and technological pedagogical content knowledge (TPACK) were at a moderate level, suggesting vocational teachers have a fair understanding of GC but require further support for effective integration. This study recommends several intervention measures, including workshops and continuous training on GC, as well as enhancing content knowledge and innovative pedagogy specifically tailored for vocational education. Implementing the TPACK framework will empower vocational teachers to effectively use technology in their teaching practices, in line with the country's emphasis on developing the TVET sector. Therefore, it will help to prepare students to be digitally fluent and well-suited for the demands of today's job market

INTRODUCTION

The integration of technology with education has been a prominent and evolving feature of the educational landscape in this century. This trend is further exemplified by various educational initiatives and technological advancements that have emerged to facilitate digital education in line with the Fourth Industrial Revolution (IR4.0). These developments have also played a significant role in curbing the impact of the COVID-19 epidemic that began in 2020. This situation has encouraged teachers to change their pedagogy towards a digital pedagogy (Maphalala et al., 2022). Likewise,

Malaysia has endeavoured to keep up with digital education (Alakrash & Razak, 2021). The Ministry of Education Malaysia (MoE) has taken the initiative to ensure that education in Malaysia is abreast with changes in global educational trends. In collaboration with Google, the GC platform was introduced in order to promote the use of digital pedagogy amongst teachers (Jiew et al., 2022). In early March 2020, Malaysia had recorded the highest search hits in the world for the phrase "Google Classroom", according to Google Trend (Osman et al., 2023), which clearly indicates that teachers in Malaysia were responding to MoE's suggestion to use the provided digital learning platform. However, to what extent does the use of GC by teachers combine aspects of pedagogy and subject content to achieve effective teaching and learning?

In the context of understanding these aspects, competence plays a vital role in ensuring various forms of innovation or discoveries in education (Purina-Bieza, 2021). The scope of a teacher's competence extends well beyond the mere ability to utilize innovative tools. It significantly influences the mastery in subject matter and diversity of pedagogical techniques, especially in the integration of new educational technologies (Mishra & Koehler, 2006). Thus, a comprehensive assessment of a teacher's competence involves a threefold framework of knowledge, namely involving technology, content, and pedagogy. This multifaceted approach underscores the complex interaction between these knowledge domains in fostering an education system that is both innovative and adaptable to new learning paradigms (Erdogmus et al., 2021).

Teachers' knowledge of content and pedagogy plays an important role in ensuring that the utilisation of technology is integrated into the classroom (Mishra & Koehler, 2006). Teachers need to cultivate subject content with pedagogy through an in-depth knowledge of educational technology as a step towards digital pedagogy. The GC platform is familiar to educators worldwide because of the various advantages it provides (Fahriany et al., 2022). Although the benefits of this platform are popularly recognized, there are still several prevalent problems, including the lack of a teacher's mastery of educational technology (Nisa et al., 2019). This is because a teacher's lack of initiative, creativity, and technological skill are factors that hinder the optimal use of GC (Murtikusuma et al., 2019), all of which can be caused by several factors.

One of the factors is the teacher's knowledge and skills, which are vital in determining the effectiveness of GC in teaching. GC is a user-friendly LMS that helps integrate various educational applications (Lakshmi & Ahamed, 2023). However, a lack of training and understanding is a contributing factor in the failure to apply GC more extensively, and this turns the teaching and learning process into a single entity (Mutohhari et al., 2021). Moreover, a lack of training and understanding in integrating the platform into the curriculum is also an obstacle (Svensson et al., 2020). In this context, the emphasis on content knowledge, pedagogy, and technology is an essential element required for the continuous professional development of teachers. This will indirectly encourage teachers to design and implement more effective interactive lessons that meet the educational needs of the 21st century. In light of this, the research question posed by this study is, "What is the competence level among teachers in relation to utilizing GC as an LMS, based on TPACK dimensions?"

LITERATURE REVIEW

There are various definitions of teacher competence based on differing viewpoints and theoretical lenses. Madjid et al. (2020) described competence as a fusion of knowledge, skills, and abilities, which were deemed essential aspects of a teacher's proficiency. Similarly, Osman et al. (2019) defined

competence as the integration of knowledge, skills, and experience that enabled individuals to perform tasks efficiently and accurately. Awang Jafar et al. (2020) suggested a broader definition of competence that included a teacher's ability to complete specific tasks, adapted to changes in the profession, handled career transitions, and managed their own professional growth and behavior. Sulaiman and Ismail (2020) further expanded on this multifaceted concept by encompassing personal attributes and mindsets, highlighting the significance of these diverse aspects in the productive and successful completion of tasks.

Overall, these perspectives indicate that teachers' competence encompasses various aspects, including knowledge, skills and profesional attributes. Madjid et al. (2020) and Awang Jafar et al. (2020) greatly emphasised on skills, proficiency, and ability, whereas Osman et al. (2019) and Sulaiman and Ismail (2020) highlighted knowledge as a crucial component. This emphasises that an ideal teacher's competency includes a deep understanding of content, pedagogy and technology as well as the ability to integrate these elements for effective teaching and learning. Emphasizing this integrated knowledge is vital in an era of increasing technology-oriented education. Consequently, a teacher's digital competence is regarded as a fundamental aspect of education. Nevertheless, studies indicated that most teachers rated their own digital skills for understanding and using instructional technology as low to moderate (Basilotta-Gómez-Pablos et al., 2022).

Issues and Gaps in the Study

In the education digitalization era, teachers' digital competency becomes a priority. Mutohhari et al. (2021) investigated the competence of vocational teachers in Indonesia and found high levels of technology awareness but low levels of competence. Whereas Murtikusuma et al. (2019) highlighted the lack of teachers' initiative and skills in using GC in Banyuwangi (East Java), although 90.3% of practical learning was done through GC. This study used both qualitative and quantitative methods.

Further studies by Ugla and Abdullah (2022) and Ramadhani et al. (2019) showed the tendency of teachers to use technology as a learning medium without the full integration with pedagogy. Ugla and Abdullah (2022) found that GC facilitated access to materials and learner interaction in Iraq, while Ramadhani et al. (2019) found the need for training and orientation to maximize the use of GC. Nisa et al. (2019) and Svensson et al. (2020) also highlighted the effectiveness of training for improving GC use, with Svensson et al. (2020) stating the need for additional practice to fully realize the potential of GC.

Previous studies have contributed significantly to the understanding of technology use in educational contexts. Ndibalema and Mrosso (2024) found a positive trend in the use of technology in pedagogy but indicated a need for further research to investigate specific pedagogical content and teachers' digital skills in teaching. Therefore, there is a gap in the literature regarding the comprehensive integration of technology with pedagogy and subject content. These studies mainly focused on technology's knowledge dimension without giving sufficient consideration to the alignment between pedagogical and content knowledge. This alignment is important for the holistic implementation of educational technology. It highlights the importance of conducting further studies that cover all dimensions of the TPACK model to ensure that the use of technologies, such as GC, is not limited to being a learning medium, but rather, an integrated element in a comprehensive instructional strategy. Hence, this approach requires effective integration of content, pedagogy, and technology.

Significant differences in the sample selection and research methods used in the studies demonstrate the diverse approaches in research regarding teachers' pedagogical competencies. This current study

focused on vocational secondary school teachers in Terengganu and used GC, since LMS provides a unique perspective when analysing teachers' competency based on the dimensions of content, mainly technological, pedagogical and content knowledge (TPACK). Focusing on specific samples and technologies can provide a thorough understanding of the integration of educational technology in effective vocational teaching practices.

The Technological Pedagogical Content Knowledge (TPACK) Model

The Technological Pedagogical Content Knowledge (TPACK) model, which integrates technology, pedagogy, and content knowledge, is an important framework in contemporary education. This model was developed by Mishra and Koehler (2006), whereas the Pedagogical Content Knowledge (PCK) model was introduced by Shulman (1986), who added a technology dimension to the components. Mishra and Koehler (2006) developed PCK by applying elements of technological knowledge (TK) to better understand teachers' knowledge when effectively using technology. The use of technology in teaching and learning should be emphasized when it comes to digital education. This aims to encourage students to use the necessary learning skills, while teachers need to provide directions for students to learn the instructional content together with other contents in the form of content integration. Figure 1 provides an overview of the knowledge components that are combined to form the TPACK framework.

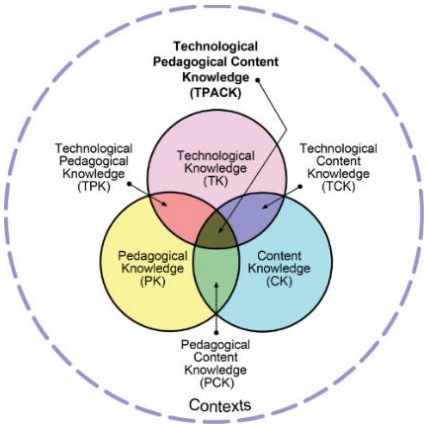

Figure 1. TPACK model by Mishra and Koehler (2006), as visualized by TPACK.org.

Based on Figure 1, Koehler et al. (2014) further elaborated on this model, describing it as built on three fundamental components: Content Knowledge (CK), which refers to a teacher's subject matter expertise; Pedagogical Knowledge (PK), encompassing understanding of various instructional methods and strategies; and Technology Knowledge (TK), involving familiarity with both traditional and modern educational technologies. The framework further explores the interactions among these primary elements through four additional components: technological content knowledge (TCK), which examines how technology and content influence each other; Pedagogical Content Knowledge (PCK), addressing how to organize and adapt topics for diverse learners; technological pedagogical knowledge (TPK), focusing on how technology can both constrain and enhance teaching practices; and TPACK itself, representing the complex interplay of all these elements. TPACK enables teachers to develop appropriate, context-specific strategies that effectively integrate technology into their teaching practices.

This current study focused on four crucial aspects, namely TK, TPK, TCK and TPACK, to explore how teachers integrate technology into their teaching practices, with a particular emphasis on the

implementation of GC. This approach provides an opportunity to understand how TPACK elements come together in a teacher's daily classroom practices to shape students' digital literacies and prepare them to meet the demands of today's job market (Kara, 2021; Hsu & Chen, 2019). It is also consistent with the understanding that mastering educational technology is necessary to improve the quality of digital learning (Nithitakkharanon & Nuangchalerm, 2022). With the rapid advancement of technology, teaching requires a deep understanding of the integration of content, pedagogy, and technology, which is facilitated by the TPACK model. This model plays a crucial role in guiding teachers when adapting to instructions related to the use of the latest technologies, such as GC, to create dynamic and holistic learning experiences (Ching & Roberts, 2020).

Google Classroom (GC)

GC is a Learning Management System (LMS) used in Malaysia. The platform has been growing since the launch of the Digital Educational Learning Initiative Malaysia 2.0 (DELIMA 2.0) in June 2020 (Mohd Fasiah, 2022). DELIMA 2.0 is a product of GC's rebranding by the MoE to support educational transformation, which is in line with the Malaysian Education Development Plan 2013–2025. GC, developed by Google in 2014, is a free LMS that is effective and can improve teaching and learning productivity (Abidin & Saputro, 2020). As a web-based system, GC dominates by providing various features associated to digital learning, including several other benefits such as storage of learning materials, circulating and editing assignments as well as facilitating the teaching process (Alqahtani, 2019). The integration of various external applications in GC, such as Quizizz, Tynker, and Padlet, makes GC a key platform for digital education that enriches the learning experience and promotes collaboration between teachers and students (Miller et al., 2022). The performing features in GC enhances teaching and learning productivity, facilitates convenient access to learning materials, and supports collaborative educational experiences through the integration of external applications.

In the context of GC's role in education, the platform has revolutionized teaching and learning through its flexibility and integration of various technologies. Whereas in the context of teaching, GC facilitates the management of coursework and assignments (Korobeinikova et al., 2020), while improving communication and supporting innovation in the teaching process (Ugla & Abdullah, 2022; Warman, 2021). GC provides access through mobile devices, together with additional functionalities, such as virtual classes and discussion forums, which makes the platform particularly relevant in the digital era (Oluyinka & Cusipag, 2021). Conversely, GC promotes performance, interaction, and collaboration, as well as the organized management of learning materials, in the context of learning (Kumar & Bervell, 2019). These features not only increase a student's motivation but also promote a more efficient and sustainable use of resources (Fahrurrozi et al., 2019). In this regard, GC can be used as a tool in contemporary education that effectively focuses on students' aspirations and needs in the digital age.

Research Objective

This study aimed to identify the competency levels of vocational education teachers in relation to using GC as a LMS based on the TK, TCK, TPK, TPACK dimensions. It then determined teachers' overall competency by analysing the combination of these four components.

METHODOLOGY

This quantitative study used the survey method to effectively collect numerical data for measuring specific constructs and facilitate the statistical analysis, focusing on the essential phases of the

research process. These critical phases are outlined in Figure 2, which captures the key components fundamental to the framework of this study. According to Cohen et al. (2018), this research design is necessary for ensuring meticulous and systematic implementation of the study.

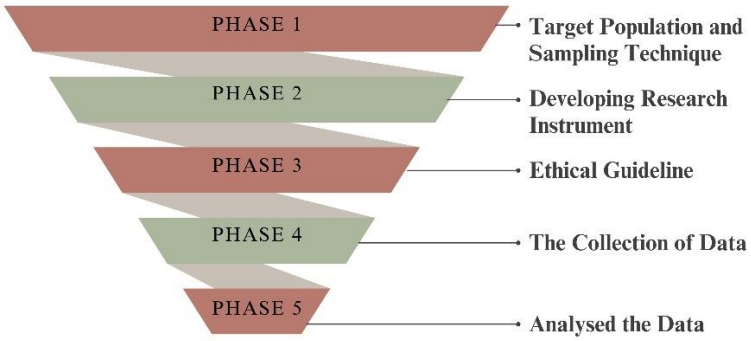

Figure 2. Research Design Phases

Based on Figure 2, the methodology employed in this study consists of five key phases. These phases encompass defining the target population and selecting an appropriate sampling technique, constructing the research instrument, adhering to ethical guidelines, gathering the necessary data, and analyzing the collected data. The subsequent section will provide an overview of each phase in the research process.

Target Population and Sampling Technique

The target population for this study was selected based on the MoE's initiative to strengthen Technical and Vocational Education and Training (TVET). This direction aligns with the national objective of producing graduates with robust technical and vocational skills to meet the demands of the IR 4.0. As the bridge between technical expertise and digital literacy, vocational teachers play a crucial role in this endeavor. Thus, the integration of technology and pedagogy is paramount, as it provides students with early exposure to these essential competencies, equipping them for future challenges.

The study population consisted of 66 teachers who taught vocational subjects across 55 daily secondary schools in Terengganu. The research employed the Krejcie and Morgan (1970) method for determining the sample size due to its scientific rigor and practical applicability. Based on this method, the initial sample size was calculated to be 56 participants. A simple random sampling technique was utilized to ensure that the selected participants (teachers) were representative of all eight districts in Terengganu. As recommended by Chua (2021), 10 additional respondents were designated as reserves to mitigate potential non-cooperation from the primary sample. Consequently, the final sample for this study encompassed all 66 teachers, representing the entire target population and enhancing the study's representativeness. This outcome aligns with recommendations that optimal research methods involve using the entire population as the study sample or selecting a sample closely approximating the population size (Ghazali & Sufean, 2021; Lay & Khoo, 2016; Krejcie & Morgan, 1970).

Developing Research Instrument

The instrument was divided into two parts, as in Part A and Part B. Part A, which consisted of three items using a nominal scale, specifically addressed the demographics of the respondents. Meanwhile,

Part B consisted of four sections, each aligned with different constructs, in which Section B-S1 consisted of five items and measured technological knowledge (TK), Section B-S2 consisted of four items and measured technological content knowledge (TCK), and Sections B-S3 and B-S4 consisted of seven items and measured technological pedagogical knowledge (TPK) and technological pedagogical content knowledge (TPACK), respectively. Sections B-S1, B-S3, and B-S4 were adapted from Celik (2023), Chen and Jang (2014), and Schmidt et al. (2009), while Section B-S2 was based solely on Celik (2023). All constructs were measured using a five-point Likert scale, with 5 representing Strongly Agree (SA), 4 Agree (A), 3 Uncertain (U), 2 Disagree (D), and 1 Strongly Disagree (SD).

This research instrument was adapted to meet the objectives of the study and underwent a back-translation process to ensure accuracy. According to Liu (2002), culture-based language translation requires two translators and the conclusions are subsequently drawn based on both translations. Therefore, this study appointed a first and second translator to translate the instrument from English to Malay, which was then retranslated back into English using a third translator to ensure that the original meaning of the instrument was preserved.

In order to facilitate the data collection and analysis processes, coding was performed for each construct to systematically record the information into a computer for analysis purposes (Fuad, 2017). In addition, the study had established certain codes for each construct, such as the technological knowledge construct was coded as TK, technological content knowledge as TCK, and technological pedagogical knowledge as TPK. Finally, the technological pedagogical content knowledge construct included all three aspects and was coded as TPACK.

Validity and Reliability

The survey instrument was analysed to assess its validity and reliability. In terms of validity, the study conducted face validity and content validity using subjective judgement made by a group of experts (Taherdoost, 2018). The study appointed a panel comprising six evaluators consisting of teachers, lecturers, officials from the District Education Office (PPD) and Terengganu State Education Department (JPNT), and professional evaluators. According to Ghazali and Sufean (2021), this approach ensures that the instrument is relevant, accurate and reflective of the aspects being measured.

In terms of reliability, this study used the Cronbach's alpha coefficient as it is a frequently used measure to assess the internal consistency of a construct (Cronbach, 1982; Norusis, 1994). Table 1 shows the Cronbach's alpha coefficient values for each construct, where these values were analysed using the Statistical Package for the Social Sciences (SPSS) software version 29.

Table 1: Cronbach's Alpha Mean Value for Each Construct

Construct	Item Numbers	Cronbach's Alpha Value
TK	5	0.897
TCK	4	0.909
TPK	7	0.921
TPACK	7	0.957

Based on Table 1, Cronbach's alpha values for the four constructs are in the range of 0.897 to 0.957, which indicate a very high and acceptable level of reliability (Ghazali & Sufean, 2021; Konting, 1990;

Pallant, 2020; Rahmat et al., 2019). This high level of reliability indicates that the survey instrument can consistently measure the specified constructs.

Ethical Guidelines

Research ethics are crucial for ensuring the integrity and safeguarding of participants in a study (Cohen et al., 2018; Lay & Khoo, 2016). This study obtained permission to use and adapt the survey instrument from the original researchers, namely Celik (2023), Chen and Jang (2014), and Schmidt et al. (2009) as documented by Chua (2021). Ethical approval for this study was granted by the Educational Research Application System (eRAS) 2.0 and JPNT (JPNT.SPS.500-8/3/2 Jld.7, [30]). The respective schools were informed, and the voluntary participation of teachers was secured during data collection (Creswell, 2018). The study had maintained its integrity during the analysis and reporting by adhering to ethical standards and principles (Cohen et al., 2018; Creswell, 2018). The ethical considerations employed in this study based on these expert-recommended methods had strengthened its overall credibility.

The Collection of Data

Several key considerations were emphasized prior to the distribution of the questionnaire for data collection, guided by the framework provided by Mills and Gay (2016), to ensure the smooth execution of the data collection process (see Figure 3).

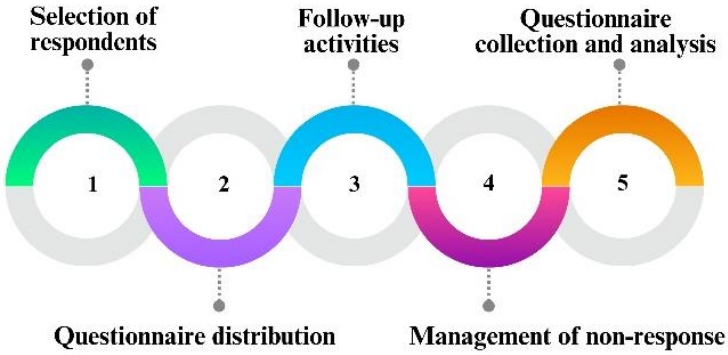

Figure 3. The questionnaire administration process (adapted and visualized from Mills and Gay, 2016).

Based on Figure 3, the questionnaire administration process involved five distinct stages. Participants were purposively selected based on their involvement in teaching vocational subjects in daily secondary schools across Terengganu. Questionnaires were distributed electronically using Google Forms over a two-week period to maximize accessibility and response rates. To ensure comprehensive coverage, collaboration was established with vocational education supervisors who assisted in disseminating the questionnaire link to eligible teachers. In cases of non-response, follow-up was conducted via WhatsApp to encourage participation. Collected data were analyzed using SPSS version 29 for statistical computations and Microsoft Excel for data organization and preliminary analysis.

Analysed the Data

This study adopted an approach that utilized mean values for each construct assessed in order to achieve its objectives. This approach involved classifying and interpreting the data into three main

categories, namely low, moderate, and high, which is a widely accepted practice in data analysis and interpretation (Mahmood & Noor, 2020; Saim et al., 2017). Mean scores ranging from 1.00 to 2.33 were categorized as low, scores from 2.34 to 3.67 as moderate, and scores from 3.68 to 5.00 as high. This approach allowed for a more detailed and structured analysis of the data collected in this study.

FINDINGS AND DISCUSSION

The study employed mean scores derived from a five-point Likert scale to conduct a descriptive analysis of the data. Table 2 shows the mean scores for the four constructs, namely, TK, TCK, TPK, and TPACK. The subsequent section offers a detailed analysis of the findings for each construct, complemented by a comprehensive discussion of their implications.

Table 2: Mean Score for Each Construct

Construct	Mean Score	Standard Deviation	Data Interpretation
TK	3.39	0.82	Moderate
TCK	3.22	0.89	Moderate
TPK	3.29	0.79	Moderate
TPACK	3.25	0.77	Moderate
Overall	3.29	0.82	Moderate

Technological Knowledge Stage (TK)

Technological knowledge (TK) refers to the extent to which teachers understand and effectively use GC in the teaching and learning process. Findings indicate that TK is at a moderate level, with a mean score of 3.39 and a standard deviation of 0.82. Notably, this construct is prominent in this study, which indicates that teachers have a basic understanding of GC's features, but are unable to fully utilize them for effective teaching.

Similar findings were observed in studies that examined teachers from various disciplines and technologies (Schmid et al., 2021; Surahman et al., 2020). However, contrasting findings were reported in studies where the TK level in their research was found to be high (Juwait & Siew, 2022; Zhou et al., 2022). This indicates that respondents in these studies possessed extensive knowledge in the selected teaching technologies. On the other hand, Chieng and Tan (2021) found the TK level to be low. These differences suggest that the TK level is influenced by the type of technology used in teaching and the background of the respondents.

The findings also suggest that respondents lacked knowledge of GC features, such as student assignment management and integration of the platform with other digital education applications. In addition, teachers also experienced constraints whenever there are issues arising when using GC, such as log in problems and so on. Therefore, to ensure widespread use of the platform among teachers, the provision of practical training or experience needs to be emphasized (Belousova et al., 2021). Effective technical support can help teachers deal with technical issues, such as performance issues, software errors or configuration issues (Gruzdova et al., 2021). Resources such as user guides,

support lines and practice workshops not only address technical issues, but also increase teachers' confidence when using the platform.

Technological Content Knowledge (TCK) Stage

TCK refers to the teacher's ability to integrate the subject content with GC for better delivery and understanding. Findings on the TCK domain among vocational subject teachers indicate a moderate level, with a mean score of 3.22 and a standard deviation of 0.89, and it is the least mastered domain among other TPACK aspects, in line with previous studies (Akturk & Ozturk, 2019; Schmid et al., 2021). This shows that vocational teachers face limitations in mastering the skills required to use GC as a tool for distributing and managing digital instructional materials. This is related to a lack of understanding of GC's features and a lack of knowledge about how to integrate this platform with other educational technology applications commonly used by educators. This situation has contributed to the ineffective management of learning, which includes teaching materials, activities, communication, and assessment of students' progress.

Some studies have shown that the TCK domain is at a high level (Li et al., 2022; Ab Aziz & Maat, 2021), which indicates a good mastery in integrating technology with teaching content. The wide variation in TCK scores is influenced by various factors, including the understanding of teaching content and suitability of technology. The use of technology in education depends on the teacher's ability to innovate and adapt the subject content according to the available technology.

The importance of TCK, which was developed by Mishra and Koehler (2006), in the TPACK framework plays an important role in the field of teaching. Mastery in TCK allows teachers to enhance their understanding of the subject matter at hand (Tafazoli & Meihami, 2022). This can be achieved through their ability to share teaching materials with other teachers as well as communicate using this platform. Therefore, emphasizing the mastery of this TCK construct is critical for maximizing the use of technology in education, particularly through the use of GC.

Technological Pedagogical Knowledge Stage (TPK)

TPK refers to the teacher's proficiency in combining GC with effective teaching methods. Findings of this study show that the TPK level among teachers is at a moderate level, with a mean score of 3.29 and a standard deviation of 0.79. This indicates that teachers have a moderate level of proficiency in integrating technology, specifically GC, with their teaching practices. This finding is consistent with a previous study where the TPK level was also found to be at a moderate level (Akturk & Ozturk, 2019). This reflects the need to assess this aspect in greater detail in the context of teachers' technological pedagogy skills.

Findings of this study highlight that teachers understand the pedagogical potential of GC, particularly in terms of the pedagogical contribution and effectiveness in teaching and learning. However, there are limitations in their ability to fully utilize GC's features, especially in terms of monitoring the student's learning achievements. This indicates the importance of TPK in equipping teachers with the skills required to effectively use technology in a dynamic and interactive learning context. In contrast, some studies have found that the TPK level was high when ICT technologies were involved, compared to specialized technologies, such as GC (Li et al., 2022; Schmid et al., 2021). This suggests that the successful integration of technology with pedagogy depends on the teacher's understanding and mastery of TPK. Meanwhile, a lower level of TPK was found among science teachers who used ICT (Chieng & Tan, 2021).

These diverse findings reflect how background, geography, and technology selection affect the mastery of TPK. A technology's ease of use greatly influences a teacher's ability to integrate innovation with teaching and learning (Hosseini & Kinnunen, 2021). In this regard, TPK plays an important role in helping teachers fully utilize GC's features. It is not only about mastering the basic functions of the technology, but also understanding how the technology can be utilized to improve pedagogical quality. The use of GC allows teachers to easily implement a student-centred approach, provide more interactive learning materials, and increase student engagement and motivation in the learning process.

Technological Pedagogical Content Knowledge Stage (TPACK)

TPACK refers to the overall ability of teachers to combine subject content, teaching methods, and GC for delivering effective teaching to students. Results of TPACK indicate that it is at a moderate level, with a mean score of 3.25 and a standard deviation of 0.77, thus, implying that the mastery of this domain is at the second lowest category compared to the other TPACK components. This finding is consistent with previous studies, where the TPACK level was also found to be at a moderate level (Akturk & Ozturk, 2019). This also indicates that teachers' proficiency in integrating technology with pedagogy and subject content is less than satisfactory, which tends to impact their ability to promote the use of GC among colleagues. In this context, the need to focus on teachers' professional development in TPACK is an important step in promoting the integration of technology, pedagogy, and subject content in a more effective teaching approach.

However, some studies that have found high levels of TPACK (Juwait & Siew, 2022; Surahman et al., 2020). These studies found that the respondents had mastered all three types of knowledge to ensure effective teaching and learning, which is consistent with the demands of 21st Century Skills (PAK 21). Conversely, low TPACK scores were reported in a study that focused on ICT in the general context (Chieng & Tan, 2021). This indicates variations in teachers' mastery and application of TPACK, which depends on three main aspects, namely content integration, pedagogy, and technology selection. Therefore, teachers need to understand their subject content and identify appropriate pedagogical teaching methods compatible with educational technology to ensure effective use in the classroom.

In the 21st century education era, it is vital for teachers to have a greater understanding of the subject matter and pedagogical principles aligned with educational technology. This ensures that the use of technology in the classroom meets today's educational needs. This approach reflects the TPACK model, which emphasizes the importance of the interaction between content knowledge, pedagogy, and technology in classroom practices. Implementation of the TPACK model has been shown to improve the teaching and learning process (Nisa et al., 2023) and the need for 21st century teachers to understand and master the teaching skills of this century, including the effective integration of technology (Shafie et al., 2019).

Limitation

This study acknowledges several limitations that could affect its findings and their applicability. First, the sample size is relatively small, which is a consequence of focusing on a specific population. The small sample size of teachers was due to the fact that each school only allocated one elective subject to one or two classes, which justifies the allocation of only one or two teachers to teach vocational subjects per school. This limitation was caused by factors such as the requirement for teachers with specific skills in the field and high costs associated with workshops and tools, inherently limiting the pool of potential participants. In addition, the geographical focus of the study in Terengganu might

affect the generalizability of the findings to other regions. Furthermore, the study focused exclusively on the competency elements found in the TPACK framework, specifically the integration of technology with content and pedagogy. While this focus provides valuable insight into these specific areas, it does not include the full spectrum of the TPACK framework. Finally, this study did not address other potential aspects of teacher competence, such as pedagogical knowledge, besides that involving technology or content, or the interaction of these various elements in more diverse educational contexts. These limitations should be considered when interpreting the study's findings, as they may affect the extent to which the results can be generalized to broader populations or different educational settings.

Recommendation

This study had proposed several interventions to improve the use of GC among educators. It recommended training modules focusing on GC's features in order to build TK, including hands-on practice, troubleshooting, and exploring advanced functionalities. Workshops should focus on teachers' subject-specific expertise through collaborative sessions and sharing of best practices and resources to improve their CK. Training to enhance PK should emphasize innovative teaching methods, classroom management, student engagement, and assessment techniques integrated with digital tools. Teachers should learn to integrate technology with the subject content to upgrade their TCK. Training should provide examples of pertaining to the implementation of GC in vocational education, such as interactive notes, video tutorials, and virtual simulations. When addressing TPK, teachers should be equipped to combine technology and pedagogy. This includes designing interactive and collaborative lessons using GC, creating multimedia content, utilizing discussion forums, and setting up collaborative assignments. A holistic approach should integrate all aspects of the TPACK framework. Training should develop comprehensive lesson plans that cohesively incorporate technology, pedagogy, and content, including case studies of successful TPACK integration with vocational education.

These interventions aim to refine educational policies by adopting the TPACK model, which emphasises the intersection of technology, pedagogy, and content knowledge that is crucial for enhancing teachers' competency in vocational settings. This approach fosters a technologically proficient teacher workforce adept at navigating modern challenges in education and equipping them with the skills necessary for excelling in today's dynamic educational landscape.

CONCLUSION

The total mean score across all domains is 3.29, thus, indicating that teachers' competence is at a moderate level, with TK being the most proficient domain. This indicates that the teachers in this study have a good command of technology. However, the TCK, TPK, and TPACK domains recorded moderate scores and were in the lower category compared to other TPACK domains. This clearly indicates that technology-based knowledge and pedagogy should be improved to ensure technological integration occurs in the teaching and learning process.

The moderate scores of TCK (3.22), TPK (3.29), and TPACK (3.25) suggest that teachers are struggling to effectively integrate technology into their content and pedagogical practices. These scores highlight specific areas where teachers need more support and development. For example, while teachers are relatively proficient in technology, they might not be as skilled in using technology to enhance subject-specific content or to apply pedagogical strategies that leverage technological tools. Hence, to address this issue, mitigating interventions should be implemented to mitigate this problem by providing

training and workshops to improve teachers' understanding and skills in using GC. These interventions should focus not only on the technical aspects but also on how to effectively integrate technology with content and pedagogy. In addition, an emphasis on technology-based pedagogy is also important to ensure a more effective education process that aligns with the needs of the Industrial Revolution 4.0 (IR4.0).

Application of the TPACK model is deemed imperative for the improvement of teachers' competencies for achieving a more holistic and effective approach to teaching in the digital age. Therefore, by providing comprehensive training sessions that address all aspects of the TPACK framework, teachers can develop the necessary skills for effectively integrating technology with their teaching practices, thereby enhancing the overall quality of education.

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