RELATIONSHIP BETWEEN TECHNOLOGICAL COMPONENTS AND INVENTIVE SKILLS AMONG MALAY LANGUAGE TEACHERS

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ABSTRACT

Technology use in classroom can improve teachers' ability to deliver effective and relevant content. Teachers should be more prepared to apply technology to ensure that students will have more fun and have a high interest in continuing to learn in the era of globalisation which is based on the use of these information communication technology elements in the classroom during the teaching and facilitation process. This study identifies the relationship between technological knowledge, technological content knowledge, technological pedagogical knowledge, technological pedagogical content knowledge, and inventive skills for teachers. A total of 400 questionnaires were distributed to teachers who taught Malay language subjects in secondary schools in Malaysia. To test the hypothesis, the structural equation using the PLS-SEM framework was used. The results showed that technological knowledge, technological content knowledge, technological pedagogical knowledge, and technological pedagogical content knowledge have a positive relationship with inventive skills for teachers.

Keywords: technological knowledge; technological content knowledge; technological pedagogical knowledge; technological pedagogical content knowledge; inventive skills

Introduction

New technologies have created new challenges and opportunities for individuals all around the world. To meet the new demands of today's society, teachers need to have the necessary knowledge and skills. Part of this is through a reform of teachers' teaching and learning methods using technology (Oke & Fernandes, 2020). The 4th Industrial Revolution (IR 4.0) demands have become more prevalent in today's classrooms, which means that teachers must adopt new teaching methods that are geared toward the needs of the 21st century. One of the most important factors that teachers should consider is the shift toward Education 4.0, which is a concept that aims to align the human and technology resources to enable new possibilities (Oliveira & de Souza, 2022). The rapid emergence and evolution of new technologies such as artificial intelligence, the Internet of Things, and robotics are expected to have a significant impact on the future employment of humans. This is why it is important that students develop the necessary skills to be successful in the 21st century workforce, and to ensure this, teachers and schools must be well-equipped and continuously train students for the future (Shafie et al., 2019).

However, some teachers are less sensitive to the current development of technology as teaching aids in the classroom. Even though technology equipment are available in schools, some teachers are still not proficient enough to take advantage of the opportunity. This is in line with the views of Cansoy and Parlar (2018) and Joo et al. (2018) who stated that the lack of knowledge of teachers to apply technology is one of the factors that contribute to the weakness of students in skills such as communication, critical thinking, and problem-solving. Although classes have access to and are equipped with technological facilities, ineffective professional development, teachers' self-efficacy, and teachers' perceptions are still affecting effective implementation of the technology (Ravendran & Daud, 2020).

Furthermore, there are others issues that are often raised such as failure of teachers to implement quality teaching and facilitation processes, the absence of a complete basic infrastructure, lack of qualified teachers (options), limited teaching material resources, and drastic curriculum changes (Puspitarini & Hanif, 2019).This shows that the level of skills and knowledge of teachers in applying technology is still at a rather worrying level (Hatlevik & Hatlevik, 2018; Roslee & Tisebio, 2020).

Studies conducted by Spiteri and Chang (2020) further revealed that many teachers have a hard time using technology in their daily work. They cited several factors that prevented them from effectively using technology, such as the lack of knowledge and skills and the time taken to learn new technology. The results of the study revealed that knowledge about the use of technology in the classroom is very important to improve the teaching process.

A study carried out by Md Darus and Hamid (2018) concluded that while 71% of teachers applied technology in school, this application was for their own purpose and not for teaching and facilitation. The teachers applied technology to keep records and to

record student grades. This shows that there is a lack of knowledge and mastery regarding the use of technology in schools, particularly involving teaching and learning (Mohammad Rusdi, 2017). Teachers are more likely to use technology for educational management than for the facilitation of the classroom. They also refrain from using technology for teaching purposes even though it can provide them with various advantages (Md Darus & Hamid, 2018).

To satisfy the needs of the workforce, educational institutions have started to place more emphasis on teaching strategies based on 21st-century skills components (Sulaiman & Ismail, 2020). One of these skills, inventive skill, IS considered as one of the most important criteria in 21st-century skills and is highly pivotal in the development of critical and innovative thinking. Hence, there is a need for teachers to be prepared and ready to try new and fresh solutions concerning inventive skill elements in their teaching. However, research revealed that teachers may not be prepared in this aspect. For instance, Mohd Qhairil (2018) found that Malay language teachers were not able to implement the necessary teaching and facilitation methods that can help improve the learning environment.

In addition, the lack of existing experience, style, interest, and exposure to the elements of inventive skills present obstacles to teachers when it comes to preparing students who are skilled in creative thinking. This is in line with the view of Ngaewkoodrua and Yuenyong (2018) who stated that teachers who have knowledge related to the elements of inventive skills can think positively, dare to take risks, can be creative, and are able to teach effectively and can change students' views. Malay language teachers need to play a role in attracting students' interest and focus more on the process of teaching as well as facilitating Malay language learning based on the 21st-century education (Hasin & Nasir, 2021).

Therefore, there is a need to carry out a study that aims to identify the relationship between technological knowledge, technological content knowledge, technological pedagogical knowledge, technological pedagogical content knowledge, and inventive skills for teachers. The results of this study can help the concerned parties, especially the Ministry of Education and school management, to develop teachers' knowledge in integrating technology. The research findings about the composition of technological pedagogical content knowledge and inventive skills components among Malay language teachers can contribute to the curriculum design and structure of effective teacher professional development training programs, especially in the field of educational technology.

Literature Review

Inventive Skills for Teachers

Inventive skills, one of the skills of the 21st century as stated by NCREL and Metiri Group (2003), can be defined as a cognitive skill that is critical in order to make a task easier and simpler to implement with the help of technology integration. Inventive skills are required for activities that can help teachers apply critical and creative thinking. NCREL and Metiri Group (2003) provided several elements found in inventive skills, namely adaptation and difficulty management, self-regulation, curiosity, creativity, daring to take risks, and high-level thinking and good reasoning.

The six elements found in inventive skills need to be mastered by teachers in school since inventive skills is a current necessity to produce students who are not only mature in their thinking, but capable of thinking creatively, critically, and innovatively. Due to the current educational needs which are more complex and competitive in nature, inventive skills are given focus in the implementation of the teaching process and facilitation of the teachers in the classroom. This is because the elements in inventive skills can mobilise students' potential to deal with upcoming challenges, especially during employment (Saleh et al., 2020).

Technological Knowledge and Inventive Skills for Teachers

Technological knowledge refers to knowledge related to digital technology such as the use of computers, laptops, hardware technology, smart phones, the Internet, and software programs. This knowledge also includes the skills needed to master, operate, and adapt to digital technology (Graham et al., 2011). The technological knowledge in the context of this study refers to the teacher's knowledge to apply basic technology to carry out various tasks at school, especially during the teaching and learning process in the classroom.

Sakdiah and Jamilah (2022) analysed the perceptions of students on various platforms and the use of technology in their studies, and found that 67.5% of students think that Google is the most appropriate tool for learning. The most common use of information technology in the classroom is to improve the efficiency and effectiveness of learning. The study was conducted to provide a comprehensive view of the various factors that influence the development and implementation of information technology in schools. It also aims to provide a basis for the development of effective instructional technology.

Based on the review of literature, hypothesis H1 is developed.
H1: There is a relationship between technological knowledge and inventive skills.

Technological Content Knowledge and Inventive Skills for Teachers

Technological content knowledge relates to the teacher's understanding of how the content of a subject can be changed using technology applications (Graham, 2011). For this study, the technological content knowledge component refers to the teacher's knowledge to apply appropriate educational technology equipment to be used for the purpose of conveying the content of Malay subject. According to Gupta and Jain (2017), the use of technology in the classroom can help improve the learning experience for students. With the help of these technological elements, teachers will be able to create a fun learning environment.

Conceptually, knowledge about technology includes teachers' understanding of basic technologies such as books, chalk, and blackboards and then to more sophisticated technologies such as the Internet and digital video (Mishra & Koehler, 2006). This knowledge also involves the skills needed to operate certain technologies. Teachers must have basic technology skills if they want to prepare their students to be able to use technology. In fact, technological content knowledge and skills are crucial if teachers want to stay relevant on the educational stage. The integration of technology into the teaching process through various forms of media such as video, audio, and graphics can make it easier for instructors to deliver effective and systematic content (Asad et al., 2021), and to be able to do this, teachers need to have a good grasp of technological content knowledge and skills.

Based on the review of literature, hypothesis H2 is developed.
H2: There is a relationship between technological content knowledge and inventive skills

Technological Pedagogical Knowledge and Inventive Skills for Teachers

Technological pedagogical knowledge refers to teachers' knowledge of how the teaching and learning process (pedagogy) can be changed by digital technology and how that technology is used (Graham, 2011). In the context of this study, the technological pedagogical knowledge component is the teacher's knowledge about the application of educational technology that is appropriate to implement teaching strategies (pedagogy) that involve various activities for students in the classroom.

The content of pedagogic technological knowledge is directly related to the teaching process of the 21st-century skills such as learning and innovation skills, media and technology, life and career skills, necessary literacy skills, and information skills (Shafie et al., 2019). Akhwani and Rahayu (2021) found that technological pedagogical knowledge components can have a direct impact on the improvement of teacher inventive skills elements during the teaching and facilitation process in the classroom. A study carried out by Arifin and Yunus (2017) established that with the help of technological tools in the teaching and guidance process in the classroom, effective, interesting, and interactive teacher-teaching practices can be conducted to meet the needs of the students' learning process. In addition, Kusaini et al. (2022) showed that

technological facilities can be adapted for the teaching and facilitation strategies of teachers to make students' learning process more meaningful.

The integration of technology in pedagogy can help students achieve their learning goals as well as motivate and interest them in classroom lessons (Puspitarini & Hanif, 2019). Hence, teachers need to continuously update their technological pedagogical knowledge component, in addition to being prepared to practice more up-to-date, relevant, effective, and systematic teaching methods (Alwaished et al., 2020). The changing times and aspects of current development need to be taken seriously to ensure that the teaching and facilitation process for a subject remains relevant.

Based on the review of literature, hypothesis H3 is developed.
H3: There is a relationship between technological pedagogical knowledge and inventive skills

Technological Pedagogical Content Knowledge and Inventive Skills for Teachers

Technological pedagogical content knowledge refers to the teacher's knowledge about the application of technology that is appropriate for conducting interesting activities and to effectively deliver content based on the Malay subject. A study conducted by Chai et al. (2019) revealed that the use of technological pedagogical knowledge can improve the skills of teachers. It can also create a favourable impact on the students' performance. This approach can be used to develop a more suitable teaching and learning environment. Rachmadtullah et al. (2020) found that using technological tools in classrooms enhanced both teachers' expertise and students' learning. The researchers also recommended using this approach to guide the development of the teachers' abilities to be effective in the 21st-century classroom.

Koh and Chai (2014) analysed the various aspects of the technological pedagogical knowledge component. They found that technological pedagogical knowledge component can help teachers and students improve their skills and knowledge. Although the concept of technological content knowledge has been used in numerous studies related to the teaching of technology, Tanak (2020) explored the relationship between these knowledge frameworks and the development of teachers. The study showed that the various aspects of technical and pedagogical knowledge are related to the use of ICT in the classroom. Furthermore, the results revealed that when the use of technology is implemented in the classroom, teachers are more confident about their ability to develop a technological pedagogical knowledge component. It is easier to build this type of knowledge component when it is based on a teaching design that uses ICT (Malik et al., 2019).

Based on the review of literature, hypothesis H4 is developed.
H4: There is a relationship between technological pedagogical content knowledge and inventive skills.

Method

The study employed questionnaires to identify the level of mastery, influence, and relationship between technological elements with inventive skills among Malay secondary school teachers in Malaysia. In this study, the study population was 46,613 Malay language teachers in Malaysia's national secondary schools. The sample was 400 teachers. A structural equation modelling procedure was then conducted to test our hypotheses. The models use data collected from measures and latent variables, which are consequently used for statistical analysis (Williams et al., 2009). The PLS-SEM approach was chosen after following the accepted procedure for choosing a structural equation model (Ringle et al., 2012). We performed the analysis using the SmartPLS 3.3 software (Ringle et al., 2014), which was developed by Wold (1982). The algorithm used to estimate the parameters were derived from the works from previous researchers in similar studies, such as Susanti and Mukminin (2022), Lai et al. (2022), and Absari et al. (2020).

Results and Discussion

This section presents the results of the measurement and structural model parameters. Figure 1 shows the results of the PLS algorithm.

Measurement Model

To ensure that the research model is correctly measured, several steps are performed. The first step is to determine whether the indicators are reliable. Then, the validity and consistency of the measurement are examined. The reliability analysis is a process that involves evaluating the various factors that affect the reliability of a particular item. It involves examining the difference between the factors that affect the item's reliability and the latent variables that are related to it. An indicator can be considered a standard in the measurement model if it has factor loadings greater than 0.60 (Hair et al., 2017). All the indicators are above 0.60 and therefore meet the requirement.

Scale reliability is a process utilised by researchers to ensure that the various indicators used in measuring concepts are consistent. This is done using composite reliability. For basic research, Hair et al. (2017) recommends 0.70 for small reliability. As shown in Table 1, all the constructs that are related to this concept exceed this value.
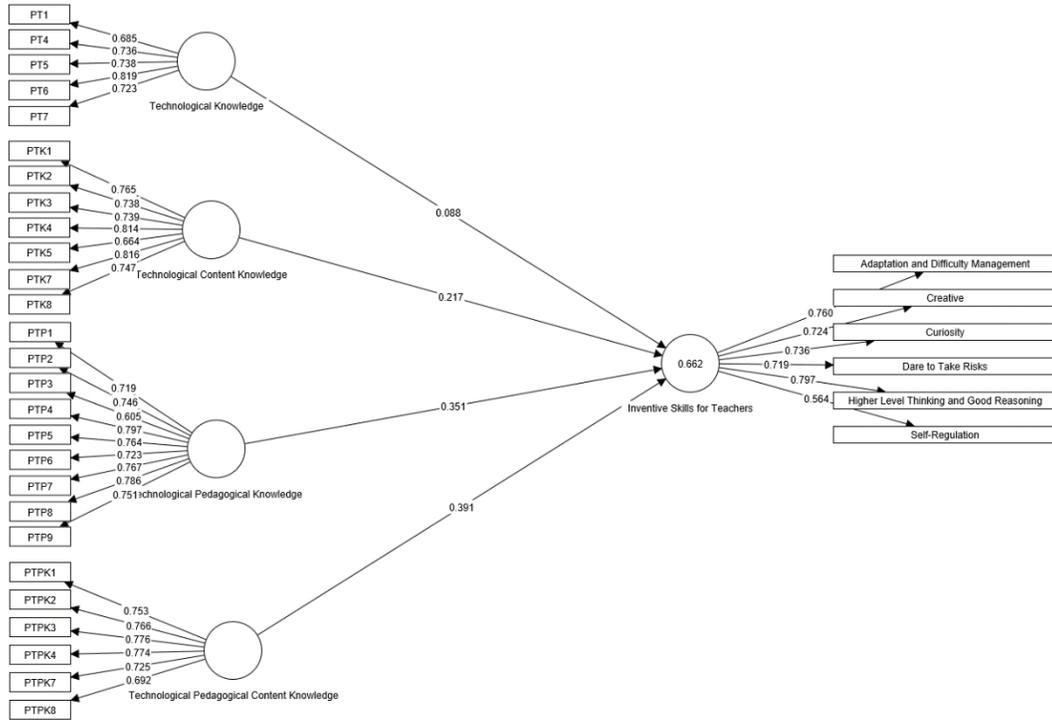
Figure 1
Measurement Model

Table 1
Reliability and validity indicators

Indicator	Loading	Composite Reliability (CR)	Average Variance Extracted (AVE)
Technological Knowledge		0.804	0.550
PT1	0.685		
PT4	0.736		
PT5	0.738		
PT6	0.819		
PT7	0.723		
Technological Content Knowledge		0.879	0.572
PTK1	0.765		
PTK2	0.738		

PTK3	0.739		
PTK4	0.814		
PTK5	0.664		
PTK7	0.816		
PTK8	0.747		
Technological Pedagogical Knowledge		0.898	0.550
PTP1	0.719		
PTP2	0.746		
PTP3	0.605		
PTP4	0.797		
PTP5	0.764		
PTP6	0.723		
PTP7	0.767		
PTP8	0.786		
PTP9	0.751		
Technological Pedagogical Content Knowledge		0.844	0.560
PTPK1	0.753		
PTPK2	0.766		
PTPK3	0.776		
PTPK4	0.774		
PTPK7	0.725		
PTPK8	0.692		
Inventive Skills		0.831	0.519
Adaptation and Difficulty Management	0.760		
Creative	0.724		
Curiosity	0.736		
Dare to Take Risks	0.719		
Higher Level Thinking and Good Reasoning	0.797		
Self-Regulation	0.564		

The validity analysis is carried out to evaluate the convergent and divergent validity of a construct. It involves the various indicators that are related to the underlying construct. The AVE, which is a statistical measure of variance, is used to perform this procedure. According to Fornell and Larcker (1981), the AVE should be above 0.5, which means that more than 50% of the variance in a construct can be attributed to its indicators. Table 1 shows that all the major constructs have values exceeding this level.

Discriminant validity is a measure of how different a given construct is from other constructs. This means that a construct's AVE should be greater than its variance with the other constructs. To determine the correlation between the various constructs, we must first show that the AVE is lower than the square root of the variance (bold) (Table 2). Table

2 shows that the square root of the AVE (bold) constructs is of a greater value than the correlations between constructs. Thus, the discriminant validity of the measurement model was established.

Table 2
Discriminant Validity

	Inventive Skills for Teachers	Technological Content Knowledge	Technological Knowledge	Technological Pedagogical Content Knowledge	Technological Pedagogical Knowledge
Inventive Skills for Teachers	**0.720**				
Technological Content Knowledge	0.554	**0.756**			
Technological Knowledge	0.392	0.570	**0.742**		
Technological Pedagogical Content Knowledge	0.705	0.442	0.250	**0.748**	
Technological Pedagogical Knowledge	0.659	0.321	0.235	0.555	**0.742**

Structural Model

After validating the fit of the measurement model by examining its relation between variables, we can then analyse its structural model. This process involves evaluating the significance and strength of the relationships between the variables. The analysis involves the variance explained by the endogenous variables and their path coefficients or beta. The R^2 value of a model is a measure of its predictive power. It indicates the share of variance that the model has explained. Cohen (1988) suggested the following thresholds: From 0.35, "substantial"; from 0.15, "medium"; and from 0.02, "small". For this study, the R^2 value obtained in this model is substantial for the variable inventive skills ($R^2 = 0.662$).

The evaluation of the path coefficients significance was carried out using a resampling technique known as the bootstrapping method. The subsamples are produced with 5,000 observations, the subsamples were extracted at random and replaced with the original data. This ensures that the results are consistent and conform to the literature's recommendations (Hair et al., 2017). Table 3 shows the p values results.
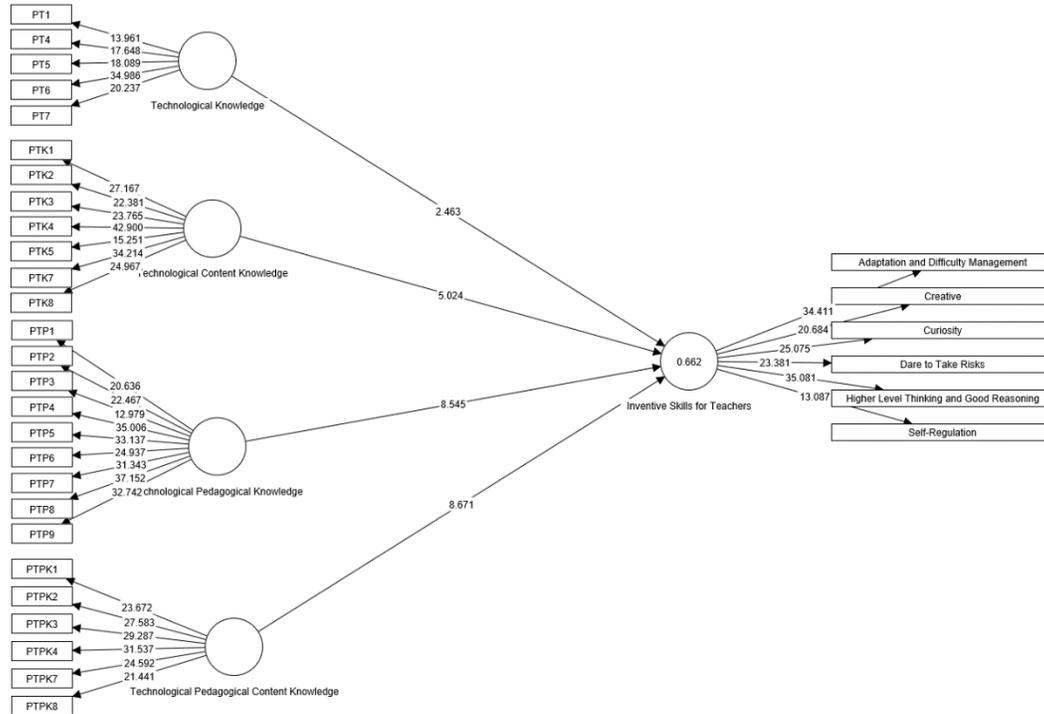
Figure 2
Structural Model

Table 3
Result of Structural Model

	Beta	Standard Deviation	T Statistics	P Values	R²
H1: Technological Knowledge → Inventive Skills	0.088	0.036	2.463	0.007	
H2: Technological Content Knowledge → Inventive Skills	0.217	0.043	5.024	0.000	
H3: Technological Pedagogical Knowledge → Inventive Skills	0.351	0.041	8.545	0.000	0.662
H4: Technological Pedagogical Content Knowledge → Inventive Skills	0.391	0.045	8.671	0.000	

The results provide support for Hypothesis 1 (ß = 0.088; p-value = 0.007), Hypothesis 2 (ß = 0.217; p-value = 0.000), Hypothesis 3 (ß = 0.351; p-value = 0.000), and

Hypothesis 4 (ß = 0.391; p-value = 0.000). Technological knowledge, technological content knowledge, technological pedagogical knowledge, and technological pedagogical content knowledge increase inventive skills. The most dominant variable with high relation is the technological pedagogical content knowledge whose beta value is 0.391.

This study aims to identify the relationship between technological knowledge, technological content knowledge, technological pedagogical knowledge, and technological pedagogical content knowledge with inventive skills for teachers.

Based on the statistical results for Hypothesis 1, there is a significant relationship between technological knowledge and inventive skills, hence Hypothesis 1 is supported. This finding is consistent with Rahayu (2021), who found that technological knowledge component has a positive effect on teachers' inventive skills. This means that technological knowledge component is one of the aspects that can improve the elements of inventive skills among teachers. In other words, teachers' knowledge of integrating aspects of technology in their lessons is useful in helping them teach effectively and creatively. This knowledge can also create a learning environment that is more focused on students. That said, due to the ever-changing nature of technology in the classroom, teachers must constantly expand their technological expertise, which affect their creative capacities positively.

Findings showed that there was a significant relationship between technological content knowledge and inventive skills, thus Hypothesis 2 is supported. The findings of this study are similar to findings by Chee et al. (2018), who found that technological content knowledge components can assist in the improvement of teachers' inventive skills. According to Gupta and Jain (2017), using technology to aid instruction and classroom management is a valuable strategy for creating a productive learning environment for students. Teachers would be better able to engage their students with the materials that they are teaching if they have access to the technological content knowledge component. The results of this study also generally support Amran and Rosli (2017), whose findings showed that teachers' methods to implement creative and innovative teaching and facilitation process through the incorporation of technology elements in the classroom can support 21st-century education goals. It is thus vital for teachers to master content standards and learning standards, understand students' existing knowledge, and become proficient in technology selection, material preparation, and strategy selection (Arifin & Yunus, 2017).

Hypothesis 3 posits that there is a relationship between technological pedagogical knowledge and inventive skills. Results from the analysis showed significant relationship between the two, thus Hypothesis 3 is supported. This finding is similar to Akhwani and Rahayu (2021), who found that technological pedagogical knowledge components can have a direct impact on the improvement of teachers' inventive skills elements. Moreover, this finding supports the view of Arifin and Yunus (2017), who stated that effective, interesting, and interactive teacher pedagogical practices can be aided by the use of technological tools during the teaching and facilitation process. This means that teachers not only need to master the elements of this technology, but also needs to be

smart to plan various types of interesting activities in the classroom. A study by Hazram and Effandi (2018) also provided evidence that technological facilities can be adapted for enhanced teaching strategies and teacher facilitation. Hence, technological pedagogical knowledge needs to be included in Malay language teachers' repertoire of pedagogy to aid them in creating meaningful, student-centred, and learning-by-doing approach that stimulates students' thinking skills.

Hypothesis 4 posits that there is a significant relationship between technological pedagogical content knowledge and inventive skills. As the findings confirmed this, Hypothesis 4 is supported. This finding is in line with studies carried out by Kamary and Hamzah (2019) who found that the technological pedagogical content knowledge component affects the improvement of teachers' inventive skills where this technological pedagogical content knowledge component is a teaching and facilitation strategy capable of producing a positive effect or impact on the students in the class to form a situation that is more relevant to the 21st century. A crucial turning point for the effective application of 21st-century skills practises has always been the integration of practical knowledge and contextual information by teachers using the method of continuous reflection. Studies conducted on a global scale generally have found encouraging trends in the development of excellent educator competencies (Arbaa et al., 2017). The benefit to students comes from a teacher who is effective. Additionally, educators can assess their use of ICT to raise the calibre of student instruction and learning. In the meantime, the overall findings of this study are also consistent with the findings of Srisawasdi (2014) and Voogt et al. (2013) who found that this technological pedagogical content knowledge model is very suitable to be used as a guide in building the knowledge and skills that must be mastered by teachers to be an effective teacher in the 21st century. Likewise, Koh and Chai (2014) also asserted that technological pedagogical content knowledge component is one of the frameworks of the technology integration model that focuses on the effective integration of technology related to mastery, knowledge, skills, abilities, and competence among trainee teachers and in-service teachers. Teachers who are required to teach technology-related subjects can master the technology pedagogical content knowledge component through specialised training (Chai et al., 2019).

Following this finding, it would be beneficial for Malay language teachers to apply aspects of knowledge that include technology, pedagogy, and content in teaching as found in the Content Pedagogy Technology Knowledge Model (Mishra & Koehler, 2006). The model emphasises the importance of technological knowledge that every teacher needs to have to apply to pedagogy and content. Teachers with technological pedagogical content knowledge have the abilities and expertise to utilise and apply the same technology to offer knowledge content or curriculum for the teaching process and facilitation of subjects taught in school. Similarly, this study discovered that expertise in terms of pedagogical technology, content technology, content pedagogy, and content pedagogical technology assist teachers in teaching more creatively.

Conclusion

This study investigated the relationship between technological knowledge, technological content knowledge, technological pedagogical knowledge, and technological pedagogical content knowledge and inventive skills. The results showed that all four knowledge are related to inventive skill, although the strongest relationship is between technological pedagogical content knowledge and inventive skill. Teachers today have access to a wealth of resources and the ability to adapt their methods of instruction to meet the needs of their students, and an interactive and meaningful learning environment can be fostered using technology. The study also found that Malay language teachers have a good level of mastery of inventive skill elements in implementing teaching and facilitation processes. This involves elements of self-adaptation and difficulty management, self-regulation, curiosity, creativity, daring to take risks and high-level thinking, and good reasoning.

The results from this study can assist the education community, particularly the Ministry of Education and school management, to design programmes or training that develop teachers' competence in the various skills. The research findings about the relationship between technological knowledge, technological content knowledge, technological pedagogical knowledge, technological pedagogical content knowledge, and inventive skills among Malay teachers can contribute to the curriculum design and structure of effective teacher professional development training programs. With the present data, such programmes can be structured to target specific needs rather than generic needs of teachers in schools, especially concerning technological adaptation in teaching and learning. Future research can include teachers of other subjects to determine whether the results of the present study can be extrapolated.

Acknowledgement

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