

Validation Instrumentation and Measurement of Technological Pedagogical Content Knowledge (TPACK) for Teachers

Ezwafahmey Ahmad Kusaini, Zamri Mahamod, Wan Muna Ruzanna Wan Mohammad

Faculty of Education, Universiti Kebangsaan Malaysia, Bangi, Malaysia

Email: ezafrin86@gmail.com, d-zam@ukm.edu.my, munaruzanna@ukm.edu.my

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Abstract

The aim of this study was to develop and verify a questionnaire to evaluate the demand for technological pedagogical content knowledge (TPACK) measurement towards teachers, as there is a demand in the TPACK components domain to amplify their capability in education, such as technological knowledge, pedagogical knowledge, content knowledge, technological pedagogical knowledge, technological content knowledge, and pedagogical content knowledge. This study added two new components such as technological pedagogical content knowledge and contextual knowledge. Questionnaire verification was performed through literature review, and content verification was performed by experts, concluded by a factorial and reliability verification. The instrument was implemented with 400 teachers who teach Malay language subject at Secondary school in Malaysia. The verified questionnaire had eight components, and the dependability of the instrument was quantified using Cronbach's alpha coefficient, with a scale comprising eight subscales: technological knowledge (.934), pedagogical knowledge (.963), content knowledge (.967), pedagogical content knowledge (.975), technological content knowledge (.966), technological pedagogical knowledge (.979), technological pedagogical content knowledge (.969), and contextual knowledge (.955). Eight components were analysed using confirmatory factor analysis (CFA) to determine the credibility of the structure. The results showed that the eight-factor variable model fits well and met the requirements of goodness of fit indices ($>.90$) and RMSEA ($<.80$). The knowledge and teaching skills possessed by teachers will grow in line with their experience in national education arena. Therefore, the validation of instrumentation was to measure and determine the components of TPACK, which are technological knowledge, pedagogical knowledge, content knowledge, technological pedagogical knowledge, technological content knowledge, pedagogical content knowledge, technological pedagogical con-

tent knowledge and contextual knowledge for teachers.

Keywords

Technological Pedagogical Content Knowledge, Contextual Knowledge, Validation Instrument

1. Introduction

Beginning in 2014, education in Malaysia has undergone a phase of dynamic transformation that focuses on the use of Information and Communication Technology (Nordin & Yunus, 2021). The progress of the world as well as the development of fast-moving technology requires that the education system must also move smoothly and in line with the current needs and changes. Therefore, teachers are the main motivating agents to disseminate all aspects related to the syllabus or curriculum content to the students at school. Teachers have the opportunity to change the status, attitudes and cognitive abilities of students towards becoming more effective, high quality and systematic in a particular subject (Hursen, 2021). This means that teachers in schools are agents of transformation to bring about change, especially in the context of 21st century education in Malaysia. The highly rapid development in the field of Information and Communication Technology has also given a significant impact and change to the national education system (Setati-Legodi & Goosen, 2022; Sayaf et al., 2021). The field of Information and Communication Technology has opened up opportunities and given different and new challenges to teachers and students in improving the practice of teaching and facilitation process and increasing the effectiveness of learning compared to traditional teaching and facilitation practices that have long been practised (Olimov & Mamurova, 2022; Qazi et al., 2021). Recognizing the fact that teachers also play an important role in implementing effective and quality teaching and facilitation processes, and can provide a positive impact, then teachers should prepare themselves with in-depth knowledge, especially in terms of knowledge relevant to the content of the subjects taught, effective control and delivery methods (pedagogy) as well as mastery to apply technology in the classroom (Akhmedov, 2022; Erbas et al., 2021).

Several past studies had proven that most teachers are still unable to master the pedagogical content knowledge component in their respective fields or subjects (Muhamad Hafizan & Anuar, 2017; Valencia et al., 2021). According to Muhamad Hafizan and Anuar (2017), there is also a very significant difference between the knowledge of new teachers with teachers who have experience related to the level of pedagogical content knowledge and effective teaching and facilitation process in the classroom. Experienced teachers are said to possess the ability in mastering the content of curriculum, pedagogy, technology and in analysing the information, concepts and procedures related to the teaching and facilitation process efficiently and more systematically (Miswan & Adnan, 2015;

Zakaria & Ahmad, 2021). Therefore, the knowledge and teaching skills possessed by teachers will grow in line with their experience in the national education arena. Hence, every weakness in the teaching process and facilitation of teachers at schools must be addressed immediately to further strengthen the teaching profession and education system in Malaysia.

In the meantime, there are teachers of Malay language subjects who are still unable to master the content and teaching strategies that are more effective, appropriate and according to the level of development of students in the classroom. Those teachers simply use the same strategies throughout the process of teaching and facilitation to all students. The success and excellence of the students are entirely dependent on the teacher and how the teacher can shape those students. Teaching techniques need to be diversified by teachers in order to attract more students to learn and even improve the thinking skills of students. The evidence, a study conducted by Che Zanariah and Fadzilah (2011) and Tan (2022) found that teachers are still weak in applying effective teaching techniques to create a conducive learning situation, attract students and make the process of teaching and facilitation in the classroom become more fun. Issues related to the use of ineffective teaching strategies and these students' learning problems can result in the main goals and objectives of the teaching and facilitation process not being fully achieved.

Furthermore, issues related to unskilled teachers and inability to master the pedagogy and content in a subject are also a major factor to the deterioration of students' academic achievement in schools. Teachers are not able to achieve the objectives of the teaching and facilitation process due to the poor level of mastery of the subject content and because the teaching delivery process is purely teacher centered. The evidence, Nurul Ashikin et al. (2020) concluded that the delivery of teaching process and facilitation of teachers should be diversified because the same and bland delivery methods or methods cannot stimulate cognitive, interest and motivation of students to continue to learn effectively and actively in the classroom. This can cause students to feel bored and unmotivated easily because they are not interested in a subject, particularly for this Malay language subject.

Although the education system in Malaysia has made some changes and adaptations to 21st century skills, it is not perfectly implemented among teachers in schools. The evidence Tee et al. (2018) concluded that classroom approaches and practices by teachers whether pre-service or in-service, teachers lack activities that can build 21st century skills. In addition, Shafie et al. (2019) also mentioned in his study that some teachers agreed that their training is less focused on the application of 21st century skills among teachers and the 21st century skills are also not specifically mentioned (Teo et al., 2021). If teachers do not have specific training on how to teach 21st century skills, they will be facing some difficulties in teaching such skills to students in the classroom. According to Yusoff, Jamaludin & Hameed (2015), teachers do not bother about the aspects related to the understanding and mastery of students whether they could master the know-

ledge or vice versa. Sometimes, every concept presented by teachers is not very clear; it even strays from the real context. Therefore, this study had to be implemented to study the actual situation and situation of application and mastery of the content technological pedagogical content knowledge component of teachers in Malay language subjects at secondary schools throughout Malaysia. This can provide a positive impact on the success and quality of teacher to teach based on Malaysian Education Quality System Wave 2 (MOE, 2017).

2. Literature Review

2.1. Technological Knowledge

The technology related component of teacher knowledge includes basic technology and advanced technology which teachers can use and apply as an aid tool in the teaching process and facilitation in the classroom. Basic technologies refer to the whiteboards, chalk, textbooks and the like while the use of advanced technology includes computers or laptops, internet, digital video and so on (Chee et al., 2018). This means the components related to technological knowledge include aspects of a teacher's knowledge to use, operate, download, delete, produce and store all documents related to the teaching process and facilitation in the classroom with the help of technological elements. According to Koehler and Mishra (2009), technological knowledge components will change in accordance with current technological developments because these technology components are dynamic. Therefore, matters related to the technological knowledge component of teachers will also change with the passage of time. For example, Chee et al. (2018) stated that soft disks and cassettes are now less used and potentially no longer exist today after the function of both materials is replaced with flash drives that are easier to carry, stylish or replaced with external hard disks, or perhaps more sophisticated tools will exist in the future. This means that teachers need to improve the need to master the aspects related to technological knowledge because of the current needs that are constantly changing in line with the rapid development of information and communication technology in Malaysia.

In addition, the application of technology in the teaching process and facilitation can be seen from two aspects, namely how teachers can apply technology in teaching and the second on how students can use technology in their learning process (Tahar & Alias, 2003). In the context of teaching, technology is used as a presentation tool such as the use of power point which is easier and more interesting because it contains graphics, tables and various colours (Tsakeni, 2021). Information technology demonstration tools are used in word processing, electronic spreadsheets, database construction, video presentations, compact discs and as a communication tool that can be applied with the use of e-mail, group discussions and teleconferencing (Chee et al., 2018). This is said so because the use of this technology is easier and can stimulate students' interest to continue learning and can create an active and student-centered learning process. There-

fore, teachers only act as facilitators to help the learning process of students by using educational technology applications or appropriate learning websites. In the meantime, teachers who are willing to use this technology equipment depends on various aspects, namely from the teacher himself or the environment and technological facilities available at school. According to [Abd Rahman et al. \(2010\)](#) and [Susanty et al. \(2021\)](#), several researchers have shown that factors influencing the tendency of teachers in choosing the teaching materials are the attitude of teachers, skills or skills, training, administration as well as the facilities of the equipment itself. The teaching and facilitation process will show a positive impact with the integration of technology and teaching aids that are attractive to students. Moreover, a study conducted by [Chen \(2010\)](#) and [Beardsley et al. \(2021\)](#) proved that internal factors related to teacher effectiveness indicate whether the teacher wants to use technology or vice versa. Therefore, teachers should have a high technological knowledge component to create an atmosphere of teaching and facilitation process that can stimulate the interest, attitude and motivation of students to continue learning in the classroom.

2.2. Pedagogical Knowledge

The field of pedagogy is a field or study of the methods and principles of teaching for a teacher in a school. Pedagogy is also the art of how to teach in schools where pedagogy is a broad field, which covers the process of teaching and facilitation, classroom management, school organization and interaction between teachers and students ([Jain et al., 2018](#)). The teacher education system in Malaysia requires prospective teachers to take pedagogical subjects while undergoing courses or teacher training in the field of education. This is said because knowledge related to pedagogical aspects is very important in preparing teachers to be able to deliver the teaching and learning process at school in a controlled manner. Meanwhile, the definition by [Kreber and Cranton \(2000\)](#) of the pedagogical knowledge component is the knowledge of how a person learns and how this learning can be facilitated in the context of teaching students in the classroom. Pedagogical knowledge components include an understanding of learning styles, cognitive styles, cognitive processes in learning and group dynamics. In other words, the pedagogical knowledge component also focuses a lot on how to teach the subject content, how to help students to master the learning process and how teachers use critical thinking and self-learning. [Kreber and Cranton \(2000\)](#) had also given examples of pedagogical knowledge components based on a process of reflection guided by their experience as teachers, i.e. know how to motivate students, know when to use teaching aids, be able to teach well and interesting, know how to mobilize cooperation among students, can help students overcome learning difficulties, can help students think critically, be aware of specific techniques needed to teach, know when and how to get meaningful feedback and be able to assess the quality of specific techniques used in teaching. All examples of this knowledge are very important for a teacher because one of the factors of

teaching satisfaction in a subject is dependent on the level of knowledge related to the pedagogical aspects of the teacher (Mohammad Rusdi, 2017; Escudero-Ávila et al., 2021).

In addition, in-depth knowledge of the processes and practices or methods of teaching and facilitation as well as its relationship with goals, values, philosophy and purpose in an education system is also the purpose of this component of pedagogical knowledge. The pedagogical knowledge component is a generic knowledge that covers issues of the learning process, classroom management, the construction of teaching preparation and its implementation as well as the process of assessing the learning outcomes of students. This knowledge includes techniques and methods that will be used in the classroom; knowledge of students; and tactics or strategies for assessing students' comprehension (Joshua, 2019). This means that teachers who have a precise pedagogical knowledge component are able to understand how students acquire knowledge, build skills and form ways of thinking and attitudes towards the learning process. Thus, the pedagogical knowledge component requires teachers' understanding of cognitive, social and learning development theories as well as the skills to apply them to students in the classroom.

2.3. Content Knowledge

In the context of this study, the component of content knowledge can be referred as a teacher who is trained in their respective fields must have knowledge related to subject matter content knowledge to ensure that the teacher can convey the knowledge possessed so it can be understood by students in the classroom. A study conducted by Greeno and Hall (1997) also support this statement stating that a well-developed content knowledge component framework should belong to a teacher so that such teachers can impart knowledge flexibly, dynamically and to the maximum even when using only minimal effort to students. According to Mishra and Koehler (2006), content knowledge component is the knowledge of specific topics that will be taught by teachers and learned by students in the classroom. Teachers should know, understand and master the topics or subjects taught, including knowledge of important contents, concepts, theories and even procedures in a particular field or discipline (Joshua, 2019; Jain et al., 2018). This is because in order to aid students' understanding, teachers not only need to understand the facts, concepts or procedures being taught, but teachers must also understand how to relate one idea to another in the same discipline.

In-depth mastery of content knowledge components by teachers is very important to help students to learn and subsequently able to master the content of the subject (Joshua, 2019). This knowledge also includes term and terms used and even differences in concepts, terms or terms with other fields that also use them, but with different meanings (Chee et al., 2018). For example, the use of the term or terms of events in Literature is not the same as the events used in the subject of History, while the motives in Literature are not the same as the mo-

tives used in the legal system in the courts. Teachers who have knowledge in high content aspects emphasize more concepts, problem-solving and inquiry aspects in their subjects to the students (Magdeline & Zamri, 2014; Tan et al., 2022). Teachers who lack mastery and knowledge in the content aspect will emphasize more facts, rules, procedures and are too tied to lesson plans and textbooks alone. Joshua (2019) sees this as something that teachers miss the opportunity to focus on important ideas and fail to relate one idea to another. This will affect the level of mastery of students on a lesson content that the teacher wants to convey in the classroom. Such things will affect the interest, motivation and even lower the level of mastery of students on the content of a particular subject.

2.4. Pedagogical Content Knowledge

According to Mishra and Koehler (2006), pedagogical content knowledge is one of the Shulman's idea to teach a topic specifically to students. The pedagogical content knowledge component is the result of the interaction of the relationship between the pedagogy knowledge component and the pedagogy content component (Shulman, 1987, 1986). Conceptually, the pedagogical content knowledge component is the teacher's understanding of how to help students understand a particular subject. This pedagogical content knowledge component covers the process of delivery, processing and translation of pedagogy content components in a subject into a form that is adapted according to the existing knowledge, abilities, interests of students and easily understood by students. The pedagogical content knowledge component demands the involvement and most effective way of presenting teachers on an idea, strong analogies, interesting illustrations, accurate and reasonable examples, clear explanations as well as effective guidance (Shulman, 1987). In addition, this knowledge includes the skill of identifying appropriate approaches to teach subject content with the ability to organize content presentations or subject content elements to implement an effective teaching process to students of different backgrounds of understanding. The pedagogical content knowledge component is very different from the general pedagogy knowledge component that is also known by teachers in any subject (Joshua, 2019). This happens when teachers who can master this component of pedagogical content knowledge are able to formulate difficult concepts, problems of student misunderstanding, identify the cause of a difficult concept, identify easy ways or methods to learn concepts and are able to produce simple formulas to learn concepts that are difficult as well as produce presentation or presentation techniques that are easy for students to follow. With the knowledge pedagogy content, teachers are able to choose appropriate techniques, methods, approaches or strategies to facilitate the learning process, address misunderstandings and ensure a meaningful learning process for students at school (Hanuscin, Cisterna, & Lipsitz, 2018).

In addition, the pedagogical content knowledge component in a subject or subjects taught is very important for a teacher and is considered the key to the

process of knowledge transfer and delivery of skills to students in the classroom. The mastery and application of pedagogical content knowledge components in a particular subject is also a determining factor to the success or failure of the teaching process and 21st century pedagogical skills implemented by teachers in schools (Nahar & Safar, 2017). Therefore, the pedagogical content knowledge component of teachers in the subjects they teach should first go beyond the requirements of the current mainstream of education in order to be in line with the needs and skills of the 21st century. This coincides with the view put forward by Chong et al. (2017) who explained that Malay language teachers need to convey Malay language knowledge in the classroom that is appropriate to the approach, methods and teaching techniques to attract students to follow the lessons taught by them.

2.5. Technological Content Knowledge

Technological content knowledge component is the teacher's knowledge of the connection between the application of technology to convey the content of relevant subjects to students in the classroom. The relationship between the pedagogy technology component and the pedagogy content component allows the occurrence of mutual influence between the elements of technology and the content of a subject to be presented to students (Mishra & Koehler, 2008). In other words, the content that the teacher wants to convey to the students' needs a little modification in order to be delivered through the use of a particular application medium or technology. However, the application of technology can also be modified, for example in terms of its function so that it can be used to deliver a particular subject or subject content more systematically and effectively (Chee et al., 2018). Technology can generally be defined as the equipment produced through human knowledge by combining natural resources to produce a product that is desired to solve problems, meets human needs and wants (Mishra & Koehler, 2008). In line with that definition, the integration of technology in the classroom should aim to solve problems and meet the requirements towards an effective teaching and facilitation process. The concept of technology integration needs to be clear and not just a substitute for other teaching aids, but it is time to shift from considering technology as an additional teaching tool to a view that emphasizes the obligation and importance of using technology to produce successful learning sessions (Jain et al., 2018). In a simpler sense, the integration of technology in the classroom can be said to be complementary to a more effective teaching delivery and facilitation process. In the meantime, teachers need sufficient knowledge and skills to implement the teaching process effectively using technology (Dilworth-Anderson et al., 2012; Loveless, 2011; Santos & Castro, 2021). This is because the knowledge possessed by a teacher will be able to influence the teacher's behavior in the classroom (Rohaani et al., 2012).

Aspects related to teachers' knowledge can have a significant impact on the

way technology is applied in the teaching and facilitation process. [Ertmer and Ottenbreit-Leftwich \(2010\)](#) and [Hughes \(2005\)](#) stated that the process of technology integration requires teachers to have two types of knowledge, namely knowledge of technology and technology-supporting-pedagogy (technology-supported-pedagogy knowledge). Conceptually, knowledge of technology encompasses teachers' understanding of basic technologies such as books, chalk and blackboards and subsequently to more sophisticated technologies such as the Internet and digital video ([Huang & Lajoie, 2021](#)). This knowledge also involves the skills required to operate certain technologies. Teachers must have basic technology skills if they want to prepare their students with the ability to learn using technology. In fact, teachers' skills in the field of technology enable them to emerge as relevant teachers in today's educational arena. In addition, teachers also need technology-supported pedagogy knowledge when planning to integrate technology in the teaching and learning process ([Hughes, 2005](#)). This means that the integration of technology can help and support the pedagogy of teachers to launch the process of delivering content in a subject to students in a planned and effective manner.

2.6. Technological Pedagogical Knowledge

In the technological pedagogical content knowledge content Model ([Mishra & Koehler, 2006](#)), the technological pedagogical knowledge component refers to the component of teachers' knowledge of the existence, capabilities and functions of various types of technology, particularly those used in the context of general teaching and facilitation are able to know the effect of the influence of certain technologies on education thus changing the process of teaching and facilitation in schools. This technological pedagogical knowledge component is also related to aspects of teachers' knowledge which include awareness of the function of certain technological tools or materials available for a particular purpose, knowledge to select tools based on their function and suitability, strategies to use the advantages of certain technologies, available technological facilities and ability to adapt it to teaching and facilitation strategies in general ([Chee, Nor, Othman, & Rahman, 2018](#)).

In addition to the need for technology for the teaching process and general facilitation, teachers also need to know the application of technology in the management of students, classes and side assignments at schools, for example, related to student performance records (School Examination Analysis System), attendance records (Application Student Database), student discipline and personality (Student Misconduct and Discipline System), school website and school related information system. However, knowledge of technology alone is still insufficient to enable teachers integrate technology effectively in the classroom. Knowing how to operate and identify the nature of the capabilities of a piece of hardware or software technology is just a basic thing to use the technology ([Ertmer & Ottenbreit-Leftwich, 2010](#)). This is said so because knowledge of tech-

nology can only answer the question of “what is technology” but has not been able to answer the question of “how to integrate technology in the teaching and learning process?” To answer the issue of how to integrate technology, teachers should master another knowledge known as knowledge about technology for the purpose of diversifying teaching methods or approaches based on the elements of ICT in the classroom (Joshua, 2019).

2.7. Technological Pedagogical Content Knowledge

The technological pedagogical content knowledge (TPACK) component is the teacher’s knowledge of the application of technology in accordance with the strategy in the teaching process and facilitation of a particular topic or subject. The TPACK component is a combination of all knowledge between knowledge related to the use of certain technologies, knowledge related to certain pedagogical aspects and knowledge of the content of certain subjects (Nor, Nik Yusoff, & Haron, 2019). These three components are combined to select teaching and facilitation process strategies that are able to produce the desired effect or impact on students in the classroom. In addition, this TPACK component is a synthesis or consolidation of six other knowledge components, namely technological knowledge, pedagogical knowledge, content knowledge, technological pedagogical knowledge, technological content knowledge, and pedagogical content knowledge (Chai et al., 2013). This technological pedagogical content knowledge (TPACK) component is the basis for an effective teaching and facilitation process by applying technology that requires teachers’ in-depth understanding of pedagogical techniques that help technological elements in a constructive way to teach subject content, knowledge of what makes concepts difficult or easy to learn and how technology can help solve learning problems faced by students, knowledge of students’ existing knowledge and epistemological theory as well as knowledge of how technology can be used to enhance existing knowledge and develop new epistemology or strengthen old ones (Koehler & Mishra, 2009).

The findings of a study conducted by Lau and Rosli (2020) proved that teachers have high knowledge in learning applications such as YouTube, Quizizz, Edpuzzle and learning platform management systems such as Google Classroom. According to Osman (2020), Malaysia recorded the highest “Google Classroom” phase search in the world proving that teachers in Malaysia are very dedicated and committed to their work. This positive development is clearly seen when many teachers are able to provide their own digital learning materials for online teaching and facilitation processes such as CikgoTube, Google Classroom Malaysia Telegram group and Library and Media Teachers Facebook (Azlan et al., 2020). Overall, this TPACK Model emphasizes the need to help teachers connect between components of knowledge related to technology, pedagogy and content because it is this relationship that will determine teachers’ expertise in integrating technology (Mishra & Koehler, 2006). However, the understanding of the interaction of relationships between these components of

knowledge is very limited especially on how the formation of TPACK relationships occurs among teachers (Chai, Koh, Lo, & Tsai, 2012). This explains why the framework of the TPACK Model is still weak in terms of practice or practical to teachers at schools although studies related to the TPACK Model often get the attention of many researchers locally and globally.

2.8. Contextual Knowledge

This contextually related component is one of the important aspects to researchers in the field of education and this TPACK Model. However, this contextually relevant knowledge component often does not receive widespread attention, has not been developed and most researchers do not focus on technological pedagogical knowledge component in studies on the technological pedagogical knowledge content Model (Rosenberg & Koehler, 2015). This is said to be so because the context-related knowledge component when teachers present the content of a particular subject or subjects in the classroom is a unique and case-specific problem for Mishra and Koehler (2008). Furthermore, they believe that every class, every student, every topic or subject taught is a specific case and different experiences between one teacher and another teacher even if the same subjects are taught. Thus, teachers who are able to master and understand the pedagogy technology and pedagogical content knowledge components well are experts in the context of the teaching process and content facilitation in a subject or subject. This is because the demands or needs of the context of teaching and facilitation process require the skills of teachers to apply the knowledge of components in TPACK, not teachers of other subjects, nor technologists and pedagogists. In addition, Mishra and Koehler (2008) also argue that a subject or subject teacher is the designer and presenter of a curriculum.

The view of teachers as designers and presenters of curriculum content is based on the fact that the decision of an application of a technique, method, approach or strategy is basically the responsibility of certain teachers in certain classes. Teachers need to plan the teaching and facilitation process more effectively according to appropriate considerations so that the goals and objectives of education can be fully achieved. Accordingly, teachers as curriculum designers need to be skilled and knowledgeable to succeed in the requirements of the curriculum in accordance with the context of teaching and facilitation implemented. This intended context includes teachers' knowledge of students and teachers' knowledge of the environment and the place of the teaching process and facilitation to deliver the content of a subject in the classroom (Mishra, 2019).

3. Theory/Model of Study

In this study, the model that apply framework of study namely Technological Pedagogical Content Knowledge Model (TPACK) improved by Mishra (2019). Based on a review of the literature the TPACK Model is not a new idea because

Mishra and Koehler (2006) have developed the original idea of Shulman (1987) with the addition of a third circle or component called the technological knowledge component. Opinions by Mishra and Koehler (2006) explain that the teaching and facilitation process needs to have an impact, be beneficial to students and be able to apply the latest educational technology developments. The teacher's technological knowledge component that is intended covers basic educational technology such as the use of blackboards, textbooks up to the use of the latest technology such as the Internet, computers, inter-active boards, multimedia and so on which are used to simplify the teaching and facilitation process which aims to help students understand, approach and have a high interest in a subject at school (Meier, 2021).

In the meantime, the application of the latest technology in education is not only capable of influencing the content of the subjects to be delivered to the students, the strategy or method of the teaching and facilitation process, but can also result in changes to the technology itself as Mishra and Koehler (2006) say that the application of new technology elements or a new medium of teaching suddenly forces teachers to face basic issues about education because this new technology or medium reconstructs the dynamic consideration between the three original components, namely pedagogical knowledge, pedagogical knowledge and technological knowledge. Therefore, teachers in this post-modernization era should be more prepared to strengthen knowledge not only about the content of a subject but also about the application of communication and information technology in teaching strategies and facilitation in the classroom. Overall, the TPACK Model is one of the most important ideas that every teacher needs to pay attention to in order to ensure excellence and success, especially when implementing the teaching and facilitation process at school (Mishra, 2019). All knowledge components related to technological pedagogical content knowledge need to be given serious attention, especially the aspects related to mastery of technology, pedagogy and also curriculum content by every teacher to ensure success and success in the education system in Malaysia.

3.1. Instrument Development

Mishra and Koehler (2006), Schmidt et al. (2009), Zahra (2012), Mohammad Rusdi (2017) and Joshua (2019) introduced the questionnaire or survey instrument used in this study based on the TPACK Model. The questionnaire instrument of this study has been widely used by previous researchers in measuring the competencies and knowledge components found in the theoretical framework of TPACK (Chai et al., 2016). All the questionnaire instruments of this study were used as a basic guide to the overall construction process of the items used in this study. However, the items found in the questionnaire instrument of this study had been modified according to the context and appropriateness based on the respondents, field and location done to meet the requirements of this study. Overall, the questionnaire or survey instrument used in

this study is based on the concept of modification or adaptation from the original re-researcher's research questionnaire instrument. This aimed to identify and describe each variable studied and analyze the level of knowledge for each component in the TPACK of Malay language subject teachers in secondary schools in Malaysia. Quantitative data were collected using structured closed-ended questions. In total, the questionnaire consisted of eight (8) components: Section A: Demographic Background, Section B: eight components knowledge. A 7-point Likert scale, ranging from strongly disagree (scale point 1) to strongly agree (scale point 7), with the middle point acting as the control (scale point 4), was used.

3.2. Methodology

Questionnaire method was used to collect data from teachers who teach Malay language subjects or subjects in national secondary schools throughout Malaysia, with a total of 46,613 teachers and sample size of 400 respondents using stratified sampling method. A pretest can be defined as the test run of the questionnaire on a small sample of respondents to determine and remove possible problems (Dugard & Todman, 1995). In a study conducted by Singleton et al. (1999), they alerted that the failure to do enough test runs can cause a study to become meaningless as the amount of effort spent on the research planning and test run is directly linked to reduction of burden in analysing the data and to the quality of the results. Respondents were required to critically assess the questionnaire with respect to its objective, content, clarity, and ease of completion. The main aim of this practice was to decrease partiality and vagueness, in addition to providing and preserving high-quality questions, a high level of reliability, and high rate of construct validity. The responses received from the test run were helpful and beneficial in upgrading the design and success of the instrument. After the test run, an amended version of the questionnaire was developed to conduct the pilot survey. Before it was distributed for pilot testing, the questionnaire had been approved by two experts in their respective fields:

- 1) An academician expert (academician), an experienced researcher in the teaching field, approved the relevancy and validity of every question.
- 2) A language expert to obtain their approval on the translation accuracy from English to Bahasa Melayu, and translation from Bahasa Melayu to English. The selection of words, grammar, and suitable jargon is very important to pass the validity and reliability of the questionnaire.

3.3. Results

This study was to develop and verify a questionnaire to evaluate the demand for technological pedagogical content knowledge (TPACK) measurement. Thus, Statistical Package for Social Science (SPSS) was used for test Exploratory Factor Analysis (EFA) which every country has their unique culture, and one of the countries is Malaysia. Because of the uniqueness of the culture, it gives the effect

of the employee responses (Pallant, 2020). Therefore, it is essential to discover the interrelationships among the items of each construct in this new context. Meanwhile, AMOS software to do validation procedure called confirmatory factor analysis (CFA) (Awang, 2014).

3.4. Exploratory Factor Analysis

An exploratory factor analysis with principal components was performed to determine the practical factor structure of the fifty-one items. The resulting factors were compacted into a simple structure by using the varimax rotation method. The number of factors retained was identified by the following qualities: (1) Kaiser's rule of retaining factors with eigenvalues greater than 1, (2) factors explaining at least 10% of the total variance extracted, and (8) each factor had to have at least three items. The inclusion criterion for the items on the retained factor was that they had loadings of at least .50 on that factor. The analysis yielded eight components: technological knowledge (5 items), pedagogical knowledge (7 items), content knowledge (5 items), pedagogical content knowledge (8 items), technological content knowledge (7 items), technological pedagogical knowledge (8 items), technological pedagogical content knowledge (6 items), contextual knowledge (5 items) in **Table 1**.

Table 1. Factor loadings for the measurement.

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
<i>Technological Knowledge</i>								
PT1	.858							
PT4	.854							
PT5	.924							
PT6	.927							
PT7	.885							
<i>Pedagogical Knowledge</i>								
PP1		.898						
PP2		.909						
PP3		.906						
PP4		.890						
PP5		.916						
PP9		.916						
PP10		.904						
<i>Content Knowledge</i>								
PK1			.914					
PK3			.929					
PK4			.944					
PK5			.952					
PK6			.955					
PK7			.948					

Continued*Pedagogical Content Knowledge*

PPK1	.915
PPK2	.895
PPK3	.936
PPK4	.937
PPK5	.929
PPK6	.931
PPK7	.931
PPK8	.909

Technological Content Knowledge

PTK1	.886
PTK2	.898
PTK3	.942
PTK4	.944
PTK5	.935
PTK7	.904
PTK8	.883

Technological Pedagogical Knowledge

PTP1	.918
PTP2	.908
PTP4	.947
PTP5	.954
PTP6	.924
PTP7	.955
PTP8	.940
PTP9	.927

Technological Pedagogical Content Knowledge

PTPK1	
PTPK2	.924
PTPK3	.909
PTPK4	.946
PTPK7	.914
PTPK8	.947

Contextual Knowledge

PKT1	.908
PKT2	.928
PKT3	.939
PKT9	.908
PKT10	.929

KMO				.987				
Bartlett's Test of Sphericity				2175.944				
Sig.				.000				
Eigenvalue	18.18	3.91	2.99	2.18	1.71	1.60	1.29	1.03
Total Variance (%)	43.30	9.32	7.12	5.21	4.08	3.83	3.08	1.98

3.5. Reliability

To ensure the reliability of the scale, Cronbach's alpha was computed, and the results are shown in **Table 2**. The Cronbach's Alpha should above .70, thus this study show that all components above the requirements (Awang, 2014).

3.6. Structure Validity

Confirmatory factor analysis (CFA) was conducted on the fifty-two items to examine their structural validity in **Figure 1**. The results of confirmatory factor analysis are presented in **Table 3**. The eight components model fits well, and the results meet the criteria for goodness of fit indices ($>.90$) and root mean score residual (RMSEA $< .08$) (Awang, 2014) which indicating that the brief measure has an eight components structure in the Technological Pedagogical Content Knowledge.

Table 2. Cronbach alpha value.

Components	Cronbach Alpha
Technological Knowledge	.934
Pedagogical Knowledge	.963
Content Knowledge	.967
Pedagogical Content Knowledge	.975
Technological Content Knowledge	.966
Technological Pedagogical Knowledge	.979
Technological Pedagogical Content Knowledge	.969
Contextual Knowledge	.955

Table 3. Fitness indexes.

Model	RMSEA	CFI	TLI	Chi-Square
Eight Components	.066	.932	.928	2.755

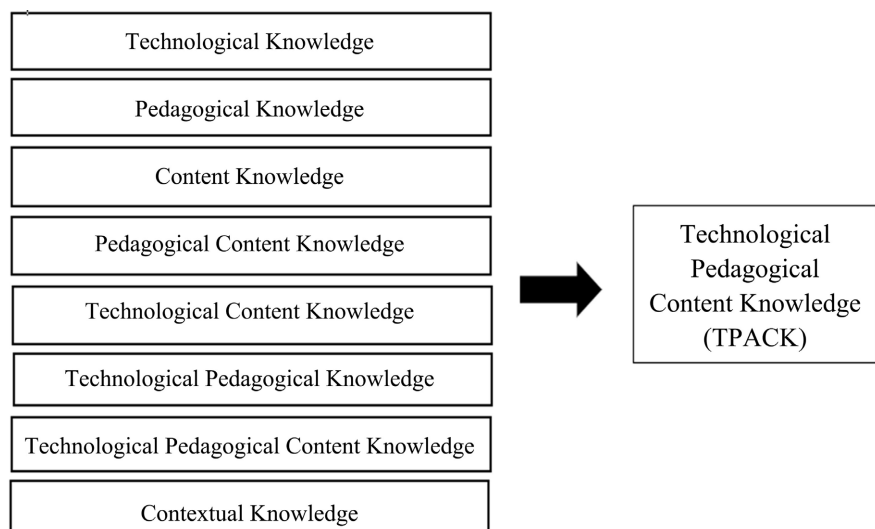


Figure 1. Development of component of technological pedagogical content knowledge (TPACK).

Figure 2 shows that the results of confirmatory factor analysis meet the criteria of goodness of fit indices and the eight components model fitted well which means that the technological knowledge, pedagogical knowledge, content knowledge, technological pedagogical knowledge, technological content knowledge, and pedagogical content knowledge, technological pedagogical content knowledge and contextual knowledge scale have eight components in the TPACK context.

Initially, the items that carry high factor loadings in EFA are employed in the measurement model for the CFA approach. To fulfil the requirement of CFA, specifically for the fitness index, reliability, and discriminant validity, some of the items from each factor should be removed from the measurement model. To rectify the multicollinearity problem, researchers are advised to delete either factor loadings or constraint factor loadings. However, the priority is for the deletion process so that the construct can be defined well with respect to high factor loadings and uncorrelated items. In this study, we deleted one item (PK5) at a

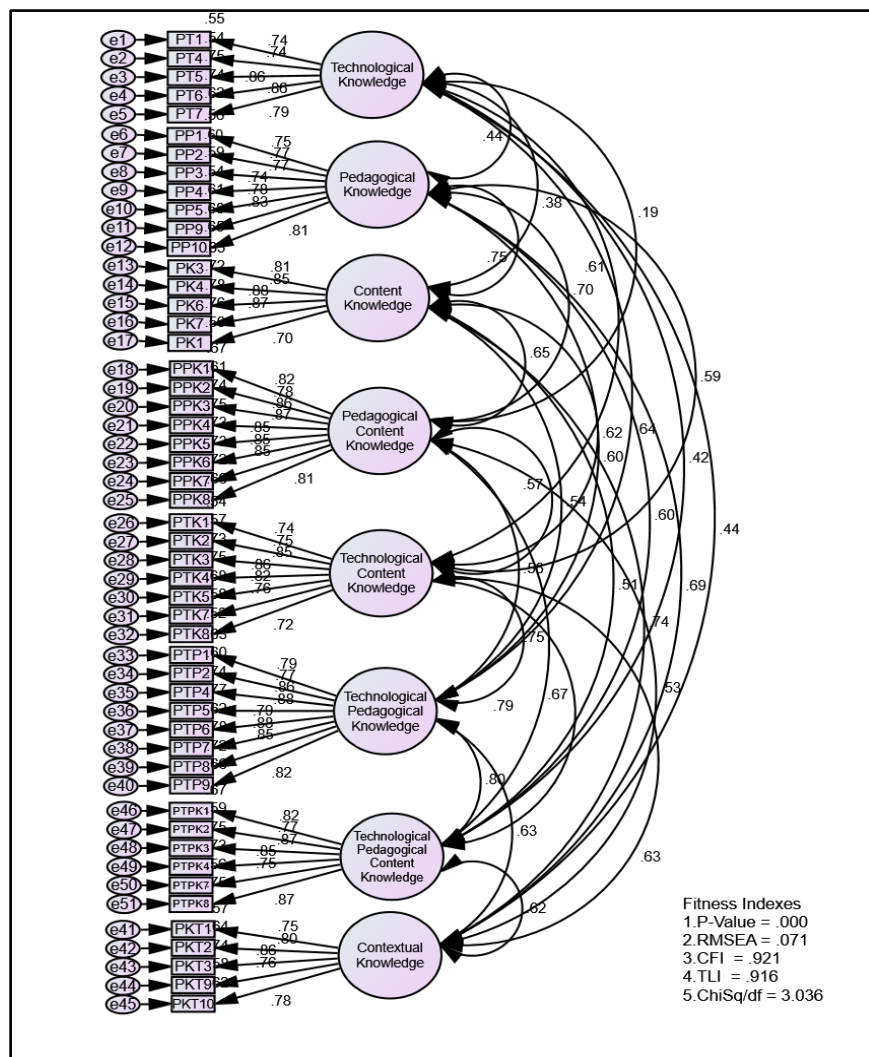


Figure 2. Confirmatory factor analysis of eight components.

time to achieve the minimum fitness index. This procedure is quite difficult because we must consider the bilateral method in determining the fitness index and latent variable correlation. As recommended by Awang (2014), the latent variable correlation should be below .85, which enables researchers to confirm their theory of the measurement model (Table 4). Subsequently, we proceed to the last stage of evaluating the measurement model process.

Table 5 presents the results of discriminant validity. In accordance with

Table 4. Reliability and construct validity.

Component	Item	Factor Loading	CR	AVE
Technological Knowledge	PT1	.74	.898	.640
	PT4	.74		
	PT5	.86		
	PT6	.86		
	PT7	.79		
Pedagogical Knowledge	PP1	.75	.899	.599
	PP2	.77		
	PP3	.77		
	PP4	.74		
	PP5	.78		
	PP9	.83		
	PP10	.81		
Content Knowledge	PK1	.70	.926	.676
	PK3	.81		
	PK4	.85		
	PK5	removed		
	PK6	.88		
	PK7	.87		
Pedagogical Content Knowledge	PPK1	.82	.949	.700
	PPK2	.78		
	PPK3	.86		
	PPK4	.87		
	PPK5	.85		
	PPK6	.85		
	PPK7	.85		
	PPK8	.81		
Technological Content Knowledge	PTK1	.74	.912	.598
	PTK2	.75		
	PTK3	.85		

Continued

	PTK4	.86		
	PTK5	.72		
	PTK7	.76		
	PTK8	.72		
Technological Pedagogical Knowledge	PTP1	.79	.943	.676
	PTP2	.77		
	PTP4	.86		
	PTP5	.88		
	PTP6	.79		
	PTP7	.88		
	PTP8	.85		
	PTP9	.82		
	Technological Pedagogical Content Knowledge	PTPK1	.82	.947
PTPK2		.77		
PTPK3		.87		
PTPK4		.85		
PTPK7		.75		
PTPK8		.87		
Contextual Knowledge	PKT1	.75	.893	.662
	PKT2	.80		
	PKT3	.86		
	PKT9	.76		
	PKT10	.78		

Table 5. Discriminant validity.

	Technological Knowledge	Pedagogical Knowledge	Content Knowledge	Pedagogical Content Knowledge	Technological Content Knowledge	Technological Pedagogical Knowledge	technological Pedagogical Content Knowledge	Contextual Knowledge
Technological Knowledge	.800							
Pedagogical Knowledge	.440	.774						
Content Knowledge	.384	.755	.822					
Pedagogical Content Knowledge	.189	.696	.649	.840				
Technological Content Knowledge	.608	.593	.624	.575	.773			
Technological Pedagogical Knowledge	.640	.602	.543	.558	.790	.822		
Technological Pedagogical Content Knowledge	.420	.603	.513	.753	.671	.797	.831	
Contextual Knowledge	.437	.694	.744	.528	.625	.626	.616	.814

Awang (2014), a correlation of lower than .85 is valid because there are no redundant construct concerns. If the result is greater than .85, the researchers are advised to delete either one of the latent constructs because a redundant construct has occurred. However, we met the requirement of discriminant validity and could accept the structural model in future research. The purpose of this study was to develop a measurement model using quantitative methods, as this technique seems much more meaningful in obtaining the measurement model.

4. Discussion and Conclusion

The main aim of this paper was to validate a scale for the measurement of the eight components of TPACK by teachers. The results of the exploratory factor analysis yielded eight components: technological knowledge, pedagogical knowledge, content knowledge, technological pedagogical knowledge, technological content knowledge, pedagogical content knowledge, technological pedagogical content knowledge and contextual knowledge. The results of confirmatory factor analysis showed that the scale retained the same factorial structure, and the eight components fit well and met the criteria for goodness of fit indices ($>.90$) and ($RMSEA < .08$). The reliability co-efficient obtained by the Cronbach's alpha formula for the eight components of the scale was above .70, indicating that the internal consistency of the developed scale was satisfactorily reliable. As a result, the reliability and validity of the developed measurement tool were ensured and can be regarded as adequate. A study by Hasanah et al. (2022) and Omar et al. (2021) supports that the technological knowledge component of teachers can help them to learn and understand aspects related to the application of educational technology easily. In addition to helping teachers to apply educational technology easily in student learning process, this technology pedagogy component is also seen as able to help teachers to solve their own technical problems that occur when there is a technology-related problem. Furthermore, the aspects of skills mentioned in Shulman's (1987) model are relevant or can be better achieved by utilizing the existing advantages in technology, for instance by providing examples through video programs of the latest applications such as educational websites (web pages), internet technology applications such as Youku can make it easier for teachers to find appropriate teaching materials, download and show appropriate examples to students in the classroom (Hasanah et al., 2022) the technological knowledge that teachers have.

In addition to the statements by Aguinaldo (2017), Padmavathi (2017), Cherner and Smith (2017), Cahyono, Kurnianti and Mutiaraningrum (2016) as well as Hechter et al. (2012) stated that the knowledge and education component for a teacher should also cover knowledge and understanding. This is said because knowledge related to pedagogical aspects is very important in preparing teachers so they are able to deliver the teaching and learning process at school in a controlled manner. This means that the teacher is able to control the class well before, during and after the teaching and facilitation process is implemented in the

classroom. In other words, the learning process of students will be easy and orderly when the teacher is able to control students by performing activities and can provide clear instructions and can make the students understand. In addition, high pedagogical knowledge by teachers means that teachers are able to understand how students acquire knowledge, build skills and form ways of thinking and attitudes towards the learning process. Therefore, the pedagogical knowledge of Malay language teachers has an understanding of cognitive theory, social and learning development theory as well as the skills to apply it to students in the classroom. This can provide a very positive impact for the development of the learning process, motivation and interest of students in certain subjects as required by the Malaysian Education Development Plan 2013 to 2025 (MOE, 2017).

Furthermore, the studies by Baki and Arslan (2022), Mewborn (2001), and Krauss et al. (2008). Content pedagogy component is an important component for teachers to master the content that they want to convey to students and are able to understand well of the purpose of the teaching and facilitation process for this Malay language subject. Pedagogy content creates a smooth teaching and facilitation process to obtain optimal learning effects or outcomes for students at the school (Magdeline & Zamri, 2014). As a teacher, this pedagogy technology component is seen as very important because the teacher is a channeler of information or content of a subject in a systematic way to students in the classroom, especially for Malay language subjects. This is because students will be exposed to aspects related to grammar and language skills to improve the function and ability to communicate using correct and standard Malay language in the context of formal school education in the process of teaching and classroom teaching. It is based on the teacher's level of content knowledge. In addition, changes in the content of the Malay language subject curriculum are intended to equip students not only with aspects of Malay grammar, but also aspects related to language proficiency (Sariyan, 2004), which is in line with language syllabus recommendations. Therefore, teachers should know, understand, and master the subject or subjects taught, including knowledge of important content, concepts, theories, and even procedures in a particular field or discipline (Joshua, 2019).

Studies from the aspect of teacher knowledge in terms of pedagogy and content were studied by Peng and Daud (2017), Demirok and Baglama (2018), Joshua (2019) as well as Jain et al. (2018) where, Joshua (2019) stated that teachers can clearly know the overall objectives of the teaching and facilitation process that needs to be mastered by students by performing various types of fun activities in the classroom. When teachers are able to perform various types of activities, all inputs related to the content of the subject to be presented can indirectly be received easily by students. Moreover, from the findings, teachers have extensive knowledge in choosing communication information technology, hardware and teaching by using the knowledge of content pedagogy technology in their daily teaching. Even teachers were found to be able to use this content pedagogical knowledge approach according to their abilities and needs. Jamilah (2003)

also emphasized that teachers' teaching methods and strategies greatly influence the level of achievement in the learning process that occurs in the classroom. It means that teachers with knowledge relevant to aspects of teaching play an important role in developing the talents, abilities and capabilities of their students. According to [Shulman's \(1987\)](#) model, content pedagogy is the key to knowledge for teachers in the teaching process in the classroom. This is said because the content pedagogy component will trigger the creativity and the selection of alternative teachers to determine the appropriate learning procedures to achieve optimal learning outcomes. When teachers have a higher level of content pedagogy, the teaching learning process will be implemented more effectively and systematically, because teachers become experts in the subjects taught to students in the classroom.

In addition, the technological knowledge component of teacher content is important in mastery among teachers and this is supported by previous studies by [Peng and Daud \(2017\)](#), [Jain et al. \(2018\)](#), [Demirok and Baglama \(2018\)](#) and [Yerdelen-Damar, Boz and Aydın-Günbatar \(2017\)](#). Teachers' knowledge of content technology is in good mastery because teachers who serve at schools in Malaysia have more exposure to ICT when studying at government or private Higher Education Institutes. Almost all courses and learning and projects conducted at the Institute of Higher Education require knowledge and skills that involve the use of technology. This helps teachers to use the knowledge that they have learned previously at the Institute of Higher Education in terms of the use of computer hardware and tools as well as teaching using the latest technology regardless of their field of teaching and educational background. Therefore, the expertise possessed in terms of ICT while studying at the Institute of Higher Education results in a good level of content technological knowledge for teachers. In addition, it also shows that teachers are able to apply and master aspects related to the integration of technology to deliver the content of Malay language subjects effectively. In addition, teachers find a lot of information using the internet medium which is easier because the learning materials are easily accessible at any time, including during the teaching process and facilitation implemented in the classroom.

Meanwhile, a study by [Hashim and Phang \(2013\)](#) and [Wahyuningtyas et al. \(2022\)](#) stressed on the importance of knowledge aspects that include technology, and pedagogy among teachers. This means that teachers can master and apply various types of educational technology to create a fun learning environment with various types of student-centered activities and teaching materials in the classroom. When this component of technological pedagogical knowledge is mastered by the teacher, this can indirectly attract students to learn because the teacher is able to encourage students to continue learning by using various approaches or activities that suit their abilities. In the meantime, the application and application of the latest technology in education is not only able to influence the content of the subjects to be presented to students, strategies or methods of teaching and facilitation process, but it can also result in changes to the technology itself.

Accordingly, the knowledge and application of technology by teachers at schools during the teaching and facilitation process nowadays is very relevant and important (Archambault & Barnett, 2010). The ability and capability of teachers to integrate technology in the teaching and facilitation process does not occur intentionally or automatically, but requires continuous efforts as well as deep interest in learning and applying technology in the classroom (Smith, 2012). Therefore, it is very important for teachers to make a thorough and adequate preparation so that the application of this technology can meet the demands and expectations of the needs in the national education system. This is said so because the ability, confidence and high self-efficacy of teachers can help to improve skills in the teaching process and facilitation of teachers in the classroom.

Furthermore, studies by Gómez-Arizaga, Conejeras-Solar and Martin (2016) as well as Rock et al. (2016) emphasised the importance of knowledge aspects that include technology, pedagogy and content among teachers. The findings of this study support previous studies which found that the level of technological pedagogical content knowledge of teachers is in good mastery. Based on the findings, teachers can apply aspects of knowledge that include technology, pedagogy and content in teaching as found in the TPACK Model (Mishra & Koehler, 2006). The model emphasizes the importance of technological knowledge that every teacher needs to have when applying it along with pedagogy and content. This proves that teachers are able to integrate the three main components of knowledge, namely knowledge related to technology, content and pedagogy. These three components of basic knowledge are able to make the teaching and facilitation process effective. When teachers can find learning materials and are able to deliver the subject content effectively, teachers can perform various types of activities and are able to apply educational technology to help smoothen the learning process. Therefore, the mastery of teachers in this component of TPACK can indirectly stimulate interest, motivation and encourage students to continue learning a subject more effectively in school.

Finally, studies by Yoon and Kim (2022) and Suastika and Rahmawati (2019) proved that knowledge related to the context of student characteristics is the knowledge and beliefs that teachers have about “who” their students are. This technological content knowledge component can be a source of information for teachers to plan the appropriate teaching and facilitation process, which is able to meet the needs and learning styles of their students based on the context of “where” teachers teach, “what” is taught and “how” to deliver content with effective to students. Kelly (2010) classifies the technological content knowledge component as one of the most unique, complex, important and most difficult to understand components of teacher knowledge. Furthermore, the effect of interaction between teacher knowledge and students depends on the teacher’s efforts to adapt to the unique context. The ever changing context includes physical elements such as the classroom environment, the student learning environment and the characteristics of the school environment. In addition, Malay language teachers are able to master and understand the subject well on the teaching process

and content facilitation in a subject or subject. This is said to be so because the demands or needs of the context of the teaching and facilitation process in question require the skills of teachers to apply contextual knowledge. Therefore, the validation of instrumentation is to measure and determine the components of technological pedagogical content knowledge, which are technological knowledge, pedagogical knowledge, content knowledge, technological pedagogical knowledge, technological content knowledge, and pedagogical content knowledge, technological pedagogical content knowledge and contextual knowledge for teachers.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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