TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE (TPCK) ON MATHEMATICS LEARNING: A LITERATURE STUDY

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Abstract

Technological Pedagogical Content Knowledge (TPCK) is currently gaining popularity as both a learning innovation and a research topic. This study is a literature review using a systematic literature review (SLR) method. The goal of this research is to describe various theories about TPCK, analyze various research results about TPCK, and describe various possibilities for the development and application of TPCK in mathematics learning. This study's data was gathered through a variety of books, articles, and research documents. Data analysis was carried out by synthesizing the results of the data source review. The findings of this study indicate that TPCK is highly likely to support mathematics learning, that TPCK can be developed and implemented in mathematics learning, and that TPCK development can take the form of models, teaching materials, and evaluation in mathematics learning.

Keywords: TPCK, mathematics learning, literature study

1. Introduction

Faced with the 21st century learning era, where students are expected to develop and integrate cognitive abilities with their skills, lecturers as educators must be concerned. In this case, students are expected to achieve success in their future careers by combining subject matter mastery with critical thinking skills, communication, collaboration, and creativity. The abilities are expected to have an impact on his ability to apply his knowledge to solve real-world problems. These demands undoubtedly have implications for classroom learning patterns that are geared toward 21st-century learning and pay attention to future needs, such as the development of learning technology that is expected to make the learning process more effective and efficient. TPACK learning is one of today's learning technologies (Technological Pedagogical Content Knowledge). To achieve learning objectives, TPACK learning focuses on the collaboration of technological, pedagogical, and material content knowledge.

Students in the Z generation primarily use television, the internet, and radio to obtain information. Internet access is an important requirement for students today, as they were born in the digital era. Because nearly 97 percent of teenagers can access the internet at home via mobile devices such as smartphones or iPhones, internet cafes have been replaced by homes. It may be an opportunity for educators to seize this moment to create a learning technology based on current student needs for mobile devices. This is one of the goals of TPACK learning development, which involves using technology in the form of apps on mobile devices to improve educators' pedagogical knowledge when delivering material content so that learning objectives can be met optimally.

Currently, one of the most important methods of providing technological support is to use a framework for integrating complex knowledge problems from pedagogy, content, technology, and various forms of interaction among these elements in the classroom (e.g., Koehler et al. 2007; Ferdig 2006; Mishra and Koehler 2006; Koehler and Mishra 2005; Niess 2005). Mishra and Koehler (2006) created the technological pedagogical content knowledge (TPACK) model, which was based on Shulman's Pedagogical Content Knowledge (PCK) (1986).

In any discipline, Technological Pedagogical Content Knowledge (TPACK) is the perfect union of three knowledge domains (content, pedagogy, and technology) to develop a knowledge base from which a teacher can view a lesson and understand how technology can enhance learning opportunities and experiences for students while also knowing the correct pedagogy to enhance the learning content. A teacher with a TPACK perspective in mathematics education is one who understands the proper pedagogy for using this technology. He will be able to engage and motivate students as they explore the content of mathematics to a greater extent if he has a proper TPACK. According to the TPACK framework, integrated knowledge of technology, pedagogy, and content is required for effective and innovative classroom teaching with technology (Abbitt, 2011).

Several studies on the use of the TPACK framework in mathematics education have been conducted (e.g., Meng and Sam, 2013; Stoilescu, 2011; Niess, 2009; Richardson, 2009). According to Guerrero (2010), TPACK in mathematics extends beyond the knowledge of learning a technology tool and its operation to the dimension of how to use a piece of technology to improve mathematics teaching and learning. Although this knowledge includes learning the fundamental operational skills, it embodies the aspects of technology that are most relevant to its ability to be used in instruction to improve teaching and learning. Nowhere are the complexities of technology's impact on content and instruction more varied and relevant than in the mathematics classroom, where technology has the potential to change not only what we teach but also how we teach it.

The appearance of TPACK learning can be an alternative to changing students' paradigms from contemporary to computational using devices, making future work easier (Blevins, 2018). It should be emphasized that the twenty-first century generation requires skills to access, evaluate, use, manage, and enrich information through the various media available at this time. Technological literacy can improve the abilities of the digital generation to think, learn, communicate, collaborate, and create (Triling & Fadel, 2009). TPACK learning will guide students to be able to use technology in the digital era as an alternative learning that facilitates the implementation of learning by using tools that contain material content that is so that educators can practice pedagogical skills, particularly in conveying learning.

2. Method

This study is a literature review using a systematic literature review (SLR) method. A systematic literature review (SLR) identifies, selects, and critically evaluates research to answer a specific question (Dewey, A. & Drahota, A. 2016). Before conducting the review, the systematic review should adhere to a clearly defined protocol or plan in which the criteria are clearly stated. It is a thorough, transparent search of multiple databases and grey literature that other researchers can replicate and reproduce. It entails devising a well-thought-out search strategy that has a specific focus or answers a specific question. The review identifies the type of information sought, analyzed, and reported within specified timeframes. The review must include the search terms, search strategies (including database names, platforms, and search dates), and limits. Pittway (2008) identifies seven key principles underlying systematic literature reviews: transparency, clarity, integration, focus, equality, accessibility, and coverage.

The goal of this research is to describe various theories about TPCK, analyze various research results about TPCK, and describe various possibilities for the development and application of TPCK in mathematics learning. This study's data was gathered through a variety of books, articles, and research documents. Data analysis was carried out by synthesizing the results of the data source review. Data were extracted and synthesized through SLR.

Systematic literature reviews have their origins in medicine and are associated with evidence-based practice. According to Grant and Booth (2009, p. 91), "the expansion of evidence-based practice has resulted in an increasing variety of review types." They compare and contrast 14 review types, listing each review's strengths and weaknesses. Tranfield et al. (2003) discuss the origins of the evidence-based approach to conducting a literature review and how it has been applied to other disciplines such as management and science.

3. Results and Discussion

Technological Pedagogical Content Knowledge (TPACK)

TPACK is the knowledge required to use and integrate computers into any mathematics content's teaching and learning activities and processes. As a result, effective computer utilization and integration necessitates knowledge and understanding of this TPACK model during the course of education and training (Mishra and Koehler, 2006; Doukakis et al., 2010; Jang and Chen, 2010; Graham, 2011; Pamuk, 2012; Srisawasdi, 2012; Chai, Koh, and Tsai, 2013; Koehler, Mishra and Cain, 2013; Koehler, Mishra, Akcaoglu, and Rosenberg, 2013; Maeng, Mulvey, Smetana and Bell, 2013; Voogt et al., 2013; Mouza et al. al., 2014).

Koehler, Mishra, and Cain (2013) proposed a method for developing TPACK. Pedagogical Content Knowledge (PK) and Technological Pedagogical Knowledge (TPK) are two of these, both of which are based on core computer knowledge and experience. By defining, designing, and refining instructional objectives to solve specific learning problems, TPACK centers the experience. Harris, Mishra, and Koehler (2009) have expanded the TPACK framework to include not only teaching, learning, and integrating technology, but also encouraging the development of TPACK-based design professionals and accommodating flexible and inclusive philosophies, strategies, and approaches that enlighten, encourage, and guide the selection of a design that achieves four goals.

The TPACK Model was developed based on a model developed by Shulman (1986) that explained how teachers' understanding of Knowledge and Technology in relation to each other in the creation of effective teaching practices. PCK is generally defined as knowledge developed through the knowledge base, which is a synthesis of three types of knowledge: content knowledge, pedagogy knowledge, and context knowledge. Figure 1.1 depicts Shulman's model as a Venn diagram.

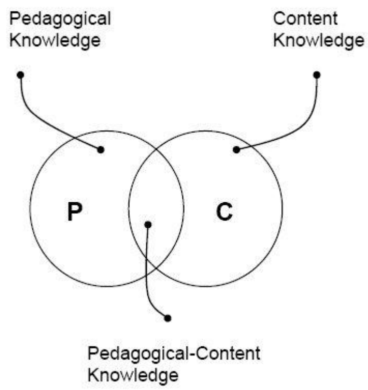

Figure 1.1 depicts Shulman's model as a Venn diagram.

Mishra and Koehler (2006) expanded on this concept by including a third set of Technology and Knowledge, resulting in & TPACK. They are a content-based teaching and learning process that must make use of technological advances. This Model is depicted in Figure 1.2 by the TPACK diagram Venn.

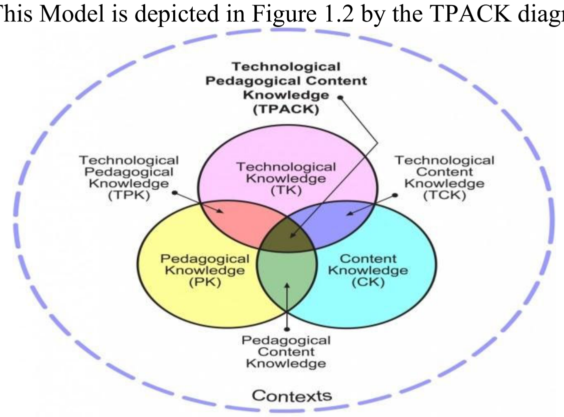

Figure 1.2 TPCK

According to figure 1.2, the TPACK is not only made up of three primary knowledge sets, namely content knowledge, pedagogical knowledge, and technology knowledge, but there are three additional sets of their combined knowledge that are also considered important in the TPACK: pedagogical content knowledge (PCK), technological content knowledge (TCK), and technological pedagogical knowledge (TPK). Furthermore, technological aspects are taken into account in the following ways:

Content Knowledge (CK)

The knowledge about the actual subject matter that is to be learned or taught is referred to as content knowledge. Teachers must be well-versed in their subject matter. This would include, as Shulman (1986) noted, knowledge of concepts, theories, ideas, organizational frameworks, knowledge of evidence and proof, as well as established practices and approaches to developing such knowledge.

Pedagogical Knowledge (PK)

Pedagogical Knowledge is in-depth knowledge of the processes, practices, or methods of teaching and learning, and it includes (among other things) overall educational purposes, values, and aims (Koehler & Mishra, 2008).

Technology Knowledge (TK)

Technology knowledge (TK) refers to knowledge of both basic technologies, such as books and chalk and blackboards, and advanced technologies, such as the Internet and digital video. This includes the abilities required to use specific technologies.

Pedagogical Content Knowledge (PCK)

Shulman's concept of knowledge of pedagogy that is applicable to the teaching of specific content is consistent with and similar to pedagogical content knowledge. PCK addresses the core business of teaching, learning, curriculum, assessment, and reporting, including the conditions that promote learning and the connections between curriculum, assessment, and pedagogy. An understanding of common misconceptions and alternative approaches to them, the importance of forging links and connections between different content ideas, students' prior knowledge, alternative teaching strategies, and the flexibility that comes from exploring alternative approaches to the same idea or problem are all necessary for effective teaching (Koehler & Mishra, 2008).

Technological Content Knowledge (TCK)

Technological pedagogical knowledge (TPK) is the knowledge of the existence, components, and capabilities of various technologies as they are used in teaching and learning settings, as well as knowing how teaching and learning settings may change as a result of using specific technologies (Koehler & Mishra, 2008).

Technological Pedagogical Knowledge (TPK)

TPK is knowledge about improving pedagogical practices and components (such as teaching, assessment, motivation, and so on) through the incorporation of technology into teaching and learning activities. In this knowledge base, teachers must look for ways to enrich or support their teaching through the use of specific technology (Koehler & Mishra, 2008).

Technological Pedagogical Content Knowledge (TPACK)

TPACK is an emerging model for knowledge that extends beyond all of its components (content, pedagogy, and technology). Technological pedagogical content knowledge is a comprehension that results from the interaction of content, pedagogy, and technology knowledge (Koehler &Mishra, 2008). TPACK aims to help teachers improve their ability to acquire and explain how technology-related subject-specific knowledge is applied during teaching and learning activities (Koehler & Mishra, 2009).

TPACK learning can be combined with models or methods that teach students to find new knowledge on their own while still receiving teacher guidance. This demonstrates that TPACK learning is a student-centered learning approach that encourages students to find and construct their own knowledge in order to gain new knowledge (Irmita & Atun, 2017). According to global education trends in the framework of 21st century learning, professional educators should have TPACK competencies, which include the four main competencies of educators such as pedagogical, professional, personality, and social, as well as the integration of skills in learning such as communication, collaboration, creativity, and critical thinking (Nofrion, Wijayanto, Wilis & Novio: 2012).

TPCK on Mathematics Learning

The majority of the TPCK discourse on mathematics education has centered on its importance in the curriculum, professional development models, and measurement methods (Angeli & Valanides, 2009; Archambault, Wetzel, Foulger, & Williams, 2010; Polly, 2011). Several TPACK-related scales have been developed to investigate teachers' perceptions of integrating technology, content, and pedagogy in areas such as Internet use (Lee & Tsai, 2010), preservice education (Schmidt et al., 2009), online distance education (Archambault & Crippern, 2009), and science education (Graham et al., 2009). The TPCK model has been useful in mathematics education for exploring conceptually how teachers articulate content, pedagogy, and technology and for enriching the discourse on using ICTs within the subject area (Grandgenett, 2008; Johnston-Wilder & Pimm, 2004; Niess, 2005; Niess et al., 2009; Polly & Barbour, 2009).

The new educational paradigm necessitates new knowledge and understanding of how technology can be used to improve mathematics learning. As a result, computer skills and teacher competencies are critical in integrating mathematics teaching efforts. The TPACK model identifies the specific knowledge and comprehension required to learn how to integrate instructional design. It also necessitates a design that allows teacher knowledge to be redefined in order to interact with the sole purpose of addressing new teaching and learning strategies. The TPACK model combines content knowledge (CK), technological knowledge (TK), and pedagogical knowledge (PK) with the primary goal of preparing preservice teachers to integrate computers into the mathematics teaching and learning process (Mishra and Koehler, 2006; Harris, Mishra and Koehler, 2009; Gera and Verma, 2012; Koehler, Mishra and Cain, 2013).

Various Related Research

Research conducted by Handal, Campbell, Cavanagh, Petocz, & Kelly (2013) on the integration of technology, pedagogy, and content in secondary mathematics teaching was investigated among 280 secondary mathematics teachers in the Australian state of New South Wales. The study used the technological pedagogical content knowledge (TPCK) model and administered a 30-item instrument called the TPCK-M. The instrument was made up of three major theoretically based constructs: technological content knowledge (TCK), technological pedagogical knowledge (TPK), and technological pedagogical content knowledge (TPCK) (TPCK). According to the findings, PowerPoint and Excel are the two TCK modal technological capabilities, whereas TPK scores revealed teachers' lower capacity to deal with general information and communications technology goals across the curriculum, such as creating digital assessment formats. TPCK-M scores appear to indicate a healthy standard of technological skills in teachers across a range of mathematics education goals. However, given that the study identified a number of instructional, curricular, and organizational factors seriously impeding the integration of technology into teaching and learning, the magnitude of such influence in practice needs to be determined further. In general, in order to take advantage of more novel learning technologies, teachers must be trained in the use of online tools (webquests, wikis), mobile learning, and interactive whiteboards, as well as the creation of digital learning resources.

Research conducted by Rufaida and Nurfadilah (2021) aims to create a device learning based on TPACK (Technological Pedagogical Content Knowledge) in the form of hyper content modules in electronics courses that combine technological, pedagogical, and material content knowledge by using QR code as a learning navigation tool so that it acts as open resources for learning. This device supports the 21st century system and independent learning by allowing students to begin learning the subject needed non-linearly and by facilitating learning styles by providing a variety of learning resources such as site addresses, journal texts, videos, audio, and images that can be accessed with a QR code reader, making learning feel contextual and directing students to think creatively in learning. The Borg and Gall models are used in research and development, with the steps of collecting information, planning, developing product formations, testing, revising, disseminating, and implementing the product. This study demonstrates that device learning based on TPACK in the form of hyper content modules is valid, practicable, and effective for use in electronics courses, as evidenced by improved student learning outcomes.

Research conducted by Ali & Agyei (2016) examines technological, pedagogical, and preservice teacher content knowledge (TPACK) in utilizing Merrill's First Principle to solve problems in polynomial equations to demonstrate their relevance in modern technology discourse. A quasi-experimental and mixed exploratory sequential design was adopted in 25 preservice teachers at the Department of Primary Education, University of Education, Winneba in Ghana. The data collection instrument consisted of 12 items of open-ended knowledge and computer applications using polynomial equations. Thematic analysis and single-subject t-test hypotheses revealed the low pedagogical basis of technology and content knowledge of preservice teachers in solving polynomial problems. Therefore, there is a need to champion the sacred principles of curriculum design with the integration of technology in the teaching and learning of mathematics in primary schools.

4. Conclusion

In the application of TPCK, it is necessary to pay attention to the time for the teacher in delivering the material. This is due to the dense curriculum, whereas the most successful mathematics materials are those that have a good balance of application between digital technology and 'traditional' teaching methods. However, the lack of time to deliver the subject matter is an inhibiting factor for teachers in using TPCK.

The findings of this study indicate that TPCK is highly likely to support mathematics learning, that TPCK can be developed and implemented in mathematics learning, and that TPCK development can take the form of models, teaching materials, and evaluation in mathematics learning. These instructional, curricular, and organizational factors, in general, reveal a variety of issues concerning the translation of TPCK into teaching and learning. All of these factors put additional strain on many teachers, who, while eager to incorporate technology, are constrained by multiple demands as well as limitations inherent in school settings.

Given these considerations, initiatives to improve mathematics education through technology must be innovative and well-thought-out. The responses of teachers indicate that change cannot be limited to providing professional development or logistical resources. Local school factors such as instructional, curricular, and organizational issues must be identified and negotiated with teachers so that change incorporating TPCK becomes more feasible.

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