USEJ 8 (2) (2019)

Unnes Science Education Journal

http://journal.unnes.ac.id/sju/index.php/usej

TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE (TPACK) INSTRUMENT FOR INDONESIA SCIENCE PRE-SERVICE TEACHER: FRAMEWORK, INDICATORS, AND ITEMS DEVELOPMENT

Arif Hidayat[1,✉]

[1] Physics Education, Indonesia University of Education.

Info Artikel

Article History:
Received May 2019
Accepted June 2019
Published July 2019

Keywords:
TPACK

Abstract

Teacher education program design using Shulman's Pedagogical Content Knowledge (PCK) is inadequate in forming the professional capabilities of future teacher to deal with technology integration to enhance teaching and learning in 21st century. Adding Technology as another core component and its relationship to be Technological Pedagogical Content Knowledge (TPACK) by Mishra and Koehler (2005) is widely. The paper presents case that preparing the instrument to measure TPACK for pre-service science teacher is one of important aspect. The research aimed to define indicators and items development of TPACK instrument for Indonesia pre-service science teacher. Seven sub-domain indicators i.e.: Content Knowledge (CK), Pedagogy Knowledge (PK), Technology Knowledge (TK), Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), TPACK itself, and items are developed according to its rational. The paper discuss the rational and its background on 31 indicators with 116 items resulted from this research and seeking for further validation and other necessary statistical processes

p-ISSN 2252-6617
e-ISSN 2252-6232

✉Corresponding author:
Arif Hidayat
Department of Physics Education
Universitas Pendidikan Indonesia
Email: arifhidayat@upi.edu

INTRODUCTION

Since educational reform waved in 2005, a dramatic improvement in the education sector have been occurred and could not be better since then. A commitment to spend 20% of the national budget for education brings impact in many aspects of educational improvement, including the new movement of the national curriculum (MoEC: 2012). According to Yulaelawati (2000), science and technology education has some shortcomings concerning the curriculum, wherein the science textbooks and instruction frequently brought about lecturing approach rather than an activity-based approach. According to the study finding from Third International Mathematics and Science Study (TIMSS) held by International Association for the Evaluation of Educational Achievement (IEA) (2011), science instruction in Indonesia emphasize less on the utilization of laboratory equipment and integration technology as experimenting activities the is rarely performed in the science lesson.

New movement on national curriculum occurred in 2013 and followed by efforts to improve teacher and learning material support such as doubled salary for certified teachers, more on teacher professional development, and reform of curriculum in teacher education institute level. According to the overall objectives of a new curriculum, one of science education is aimed at enabling Indonesian children to utilize technology to solve the problem within daily life (MoEC:2013). This objective is matched with demand for science teacher that " . . . Shall able to elaborate technology updates and its application to support learning . . ." (MoEC:2013) This statement means technology integration, which unfortunately there is no precise definition of technology integration on it.

According to Hew and Brush (2007), researchers lack a unified definition of technology integration; a common element identified by researchers includes variations of a computing device for instruction. Reiser (2007) notes that the initial impact of technology integration on instructional practices included teachers' incorporating less-than-innovative practices for technology use such as drill and practice programs. Ertmer and Ottenbreit-Leftwich (2010) agree that these types of practices are inadequate to meet the needs of 21st-century learners. Inherently, a pervasive gap emerged between technology development and technology used for beneficial and authentic educational purposes (Ertmer & Ottenbreit-Leftwich, 2010).

Pearson and Smart (2009) describe technology integration as "establishing the best ways to incorporate educational technologies in the curriculum as teaching tools" (p. 333- 334). Similarly, Labbo and Place (2010) suggest finding a good fit between technology and the curriculum to integrate technology effectively. Dror (2008) contrasts this perspective and states, "a good fit between the learning and the learners is critical for success and promotes efficient and effective learning." (p. 217). According to Dror, technology-enhanced learning environments should maximize students' cognitive development through active participation rather than through presentations with technology alone. Dror identifies three processes for using technology to activate students' cognitive learning: control, challenge, and commitment.

By gradually shifting control to the learner, teachers promote students' independence and decision-making processes for deciding when, where, and how technology is used to influence metacognitive processes, the pacing of activities, and ownership of the learning process (Dror, 2008). Learning activities should require students to think, reflect, and persevere through challenging and engaging mental processes rather than through activities requiring minimal student effort (Dror, 2008). Dror suggests that the use of technological games can provide students with challenging activities; he cautions that completion of tasks as a progressive attainment toward reaching a goal does not lead to student commitment. Commitment is an intrinsic trait unique to individual learners. Dror promotes a technology-enhanced learning environment which increases engagement, participation, and interaction toward gains in individual student responsibility.

1. Theoretical Famework.

Technology Integration in Science Education

Multiple researchers have discussed technology integration across perspectives of how technology is used to support teaching and learning (Ertmer, 2005; Labbo & Place, 2010; Mishra & Koehler, 2007; Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010). The promise and perils of technology integration have been cited in research (Rakes et al., 2006;), yet the overarching problems of how to effect a change that results in widespread and efficient use remain (Hall, 2010;). Researchers agree that effective technology integration requires teachers to include instructional strategies that use technology as a tool to enhance the curriculum and support pedagogical practices, including student-centered learning (Earle, 2002; Li & Ni, 2010; Mishra & Koehler, 2006). Palak and Walls (2009) indicate that teachers need individual guidance integrating technology within the limitations of their contextual learning environment. Likewise, Lawless and Pellegrino (2007) suggest that researchers should focus on the challenges of defining and evaluating relevant professional development to support technology integration in teaching and learning as recognize that technology provides multiple possibilities for impacting the instructional design of the learning environment.

Dede (2011) views technology integration through a transformational lens that redesigns teaching and learning processes in such unique and seamless ways that the term integration is no longer an accurate description for technology use in 21st-century education. Dede depicts a learning environment in which a combination exists as a natural part of the instructional process. Dede suggests incorporating this goal of teaching, learning, assessment, and productivity within a technology infrastructure enhanced by trained professional educators, including parents, teachers, tutors, and community members.

Technology integration barriers have been in the research literature (Ertmer, 1999; Ertmer, Ottenbreit-Leftwich, & York, 2006; Hew & Brush, 2007; Keengthe researcher, Onchwari, & Wachira, 2008b; Zhao & Bryant, 2006; Lumbantobing: 2014). Innovative technologies have the potential to transform teaching and learning as technology access increases, so do opportunities for teachers to encounter barriers to technology integration. (Ertmer, 2005; Keengthe researcher et al.,2008b). Keengthe researcher et al. emphasize the "real challenges of integrating information technology into the classroom depend on the behavior, investments, and commitment of individual teachers" (p. 562).

Ertmer (1999) classifies barriers into two categories: first-order change, or extrinsic, and second-order change, or intrinsic. Training, time, support, and equipment are examples of external barriers, resulting in significant frustrations for teachers during initial implementation efforts (Ertmer, 1999). Ertmer suggests a gradual process of addressing one barrier at a time rather than attempting to resolve contemporary issues. Second-order barriers pertain to teachers' beliefs about teaching and learning and the processes involved in using technology effectively (Ertmer, 1999). Individual teachers may exhibit second-order barriers in response to first-order barriers. Ertmer cautions that removing a barrier does not readily transfer into meaningful technology integration and concludes that educational change requires teachers to confront obstacles presented by both first-order and second-order barriers attentively.

Hew and Brush (2007) analyzed 48 studies conducted from 1995 to 2006, identifying 123 common obstacles to technology integration among K-12 schools. The following six overarching categories of barriers emerged based on frequency as defined in the literature: (a) resources, (b) knowledge and skills, (c) institution, (d) attitudes and beliefs, (e) assessment, and (f) subject culture. Four of the categories are classified as first-order barriers (resources, institutions, subject culture, and evaluation), while the remaining two categories (teacher attitudes and beliefs and knowledge and skills) pertained to second-order barriers (Hew & Brush, 2007). In the case of Indonesia, Lim and Pannen (2012) mention the lack of funding and staff support as a barrier to technology integration, which classified as the first-order barrier. Although each wall was identified as a separate category, Hew and Brush (2007) ascertain that both direct and indirect relationships exist among the obstacles. The researchers surmise "that technology integration is thought to be directly influenced by the following four barriers: (a) teacher's attitudes and beliefs towards using technology, (b) the teacher's knowledge and skills, (c) the institution, and (d) resources" (Hew & Brush, 2007, p. 232). Hew and Brush note, "technology integration is also thought to be indirectly influenced by the subject culture and assessment" (p. 232). Teachers and school leaders who incorporate innovative technologies for teaching and learning may use the direct and indirect relationships among barriers identified by Hew and Brush to develop strategies for reducing barriers.

Despite increased access to technology and support, many teachers lack confidence in using technology and are hesitant to integrate technology into the curriculum (Moore-Hayes,2011). Glassett and Schrum (2009) propose that research should focus on "how and why teachers' pedagogical beliefs are formed" and the relationship between pedagogical beliefs and technology integration (p. 148). Zhao and Bryant (2006) contend that continuous training and technology mentors who provide one-on-one support and classroom modeling using technology contribute to increasing teachers' confidence and levels of technology integration for teaching and learning. Similarly, Batane (2004) identifies access to technical support and pedagogical support as necessary elements for teachers to know when and how to integrate technology effectively. Ertmer et al. (2012) suggest providing teachers with professional development using the technologies which will be integrated into the curriculum for instruction. Spires et al. (2012) believe that one-to-one expansion initiatives prompt a new learning ecology for transforming educational environments and revising teachers' professional development training. Spires et al. contend, "professional development and ongoing support are critical for teachers as they redesign, recontextualize, and contemporize their instructional practices to take full advantage of available technologies" (p. 9). Spires et al. identify the following five strategies for use with one-to-one teacher professional development models:

1. engaging teachers' technological, pedagogical, and content knowledge;
2. engaging teachers in project-based inquiry;
3. engaging teachers in a new global skill set;
4. engaging teachers in performance-based assessment; and
5. engaging teachers in professional learning communities and networks.

Spires et al. suggest that teachers' professional development experiences for instructional planning typically begin with an introduction to the available technologies. With prolonged technology use, teachers' planning includes adding content and pedagogy through a gradual change. Spires et al. note that achieving full technological, pedagogical, and content knowledge requires a "fundamental conceptual change on the part of the teacher" (p. 12), which can be accelerated within the context of a one-to-one environment. Spires et al. suggest that teachers' technological, pedagogical, and content knowledge expands as teachers reflect on how technology impacts pedagogical changes for teaching and student learning.

Staples, Pugach, and Himes (2005) explore how the intricate relationship among curriculum, technology, and professional development influences three schools' technology integration efforts. Each school had low levels of technology integration (Staples et al., 2005). The teachers reportedly valued technology integration but did not consistently align technology use with the curriculum or content instruction. Technology integration was limited to drill and practice or free-time activities rather than meaningful integration (Staples et al., 2005). A technology specialist provided teachers with varying levels of professional development training, which increased teachers' technological knowledge, but there was only a slight increase in teacher and student application of technology across the curriculum (Staples et al., 2005). Staples et al. perceive that the administrators endorsed integrating technology into the curriculum. These leaders lacked a vision of how to relate technology to the curriculum to impact substantial student learning. Staples et al. infer that administrators should not only selectively invest in technology but also provide ongoing professional development that aligns technology with the curriculum. Additionally, Staples et al. state that teachers should be knowledgeable in pedagogy and curriculum design to maximize the benefits of technology integration with specific content area instruction.

Technological, Pedagogical, and Content Knowledge (TPACK) and its Application

Shulman (1986) states that teachers should be able not only to understand the content being taught but also to discern why the topic is important to a given discipline. Shulman identifies pedagogical content knowledge as "an understanding of what makes the learning of specific topics easy or difficult; the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons" (p. 9). Shulman describes the curriculum as a range of materials and resources with which a teacher designs are varying pedagogical approaches to represent the content or subject matter for instruction. In addition to knowledge of content, pedagogy, and curriculum, Shulman (1987) also identifies learner knowledge, context knowledge, and knowledge of goals and beliefs as essential to developing a teacher's knowledge base.

The use of technology as an instructional tool to meet the needs of 21st-century learners provides new perspectives for examining changes in teachers' knowledge, specifically teachers' pedagogical beliefs (Ertmer & Ottenbreit-Leftwich, 2010). The way teachers use technology for instruction has been the topic of interest to researchers, policymakers, and school leaders for several decades. Ertmer and Ottenbreit-Leftwich state, "teaching with technology requires teachers to expand their knowledge of pedagogical practices across multiple aspects of the planning, implementation, and evaluation processes" (p. 260).

Schuck and Kearney (2008) conducted a study to understand teachers' pedagogical practices in two technology-using classrooms: one classroom used digital videos, and the other classroom using an interactive whiteboard. The teachers' roles varied in each classroom, depending on the instructional approach for using the technology. For the digital video project, the students experienced increased autonomy during the learning experience, with the teacher providing minimal assistance with camera operations and video edits. The teacher maintained primary control using the interactive whiteboard to present content information. The researchers (Schuck & Kearney, 2008) identify this approach as replicating a traditional presentation approach with the addition of using technology.

Schuck and Kearney (2008) suggest that each pedagogical approach was influenced by the technology being used to represent the content. Ertmer and Ottenbreit-Leftwich (2010) maintain that when teachers are introduced to a new pedagogical tool, the decision to use the tool is based on the teacher's belief as to whether the tool aligns with the instructional outcome. Schuck and Kearney note that both teachers expressed using technology to enhance student understanding, increase student motivation, and increase student ownership. The school context, including leadership support for using technology, can also impact a teacher's pedagogical beliefs for integrating technology (Ertmer & Ottenbreit-Leftwich, 2010; Schuck & Kearney, 2008).

The technological, pedagogical, and content knowledge framework incorporates technology with Shulman's (1987) constructs of pedagogical content knowledge. Koehler and Mishra (2005) developed this framework to represent a pragmatic approach to understanding the teachers' knowledge base essential for integrating technology effectively. The technological, pedagogical, and content knowledge framework consists of a dynamic relationship of three core knowledge areas: technology, pedagogy, and content. Koehler and Mishra (2005, 2008, 2009) and Mishra and Koehler (2006, 2007) identify seven knowledge components of the technological, pedagogical, and content knowledge framework that comprise an essential knowledge base for teachers. A brief overview of each component of the framework is below:

1. Content knowledge (CK) is knowledge about the subject matter or specific content such as

mathematics, science, or social studies. Teachers must have knowledge of concepts, theories, and procedures within a given field to teach effectively (Shulman, 1986).

2. Pedagogical knowledge (PK) is knowledge about the processes or methods of teaching and learning including planning; assessment; and cognitive, social, and developmental learning theories (Koehler & Mishra, 2008; Shulman, 1986)
3. Pedagogical content knowledge (PCK) is flexible knowledge about which instructional methods fit with the content and how to represent the content to promote meaningful learning (Koehler & Mishra, 2008; Shulman, 1986).
4. Technology knowledge (TK) is knowledge of both standard and new technologies as the acquisition and adaptation of skills as technological innovations develop (Koehler & Mishra, 2008).
5. Technological content knowledge (TCK) is knowledge about the reciprocal and flexible relationship in which one can use technology to represent content. Both content and technology have affordances and constraints, which may prevent possible representations for curricular planning (Koehler & Mishra, 2008).
6. Technological pedagogical knowledge (TPK) is knowledge of the flexible use of technological tools for teaching and learning as knowledge of the affordances and constraints of technologies within a particular context (Koehler & Mishra, 2008).
7. TPACK is the knowledge that requires teachers to develop an understanding of the relationships between and among technology, content, and pedagogy to integrate technology productively (Harris, Mishra, & Koehler, 2009; Koehler & Mishra, 2008; Koehler & Mishra, 2009).

Koehler and Mishra (2009) recognize, “there is no single technological solution that applies to every teacher, every course, or every view of teaching” (p. 66). These components, as illustrated in the model (Figure 1), comprise an interactive framework that emphasizes the connections among technologies, pedagogy, and content and the complexities of planning for technology integration.

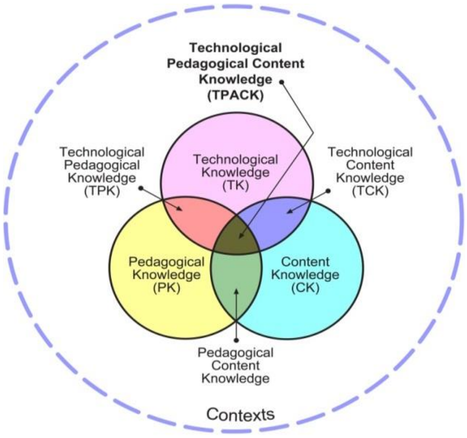

Figure 2. Technological, Pedagogical, and Content Knowledge Framework. Permission to use the technological, pedagogical, and content knowledge image is granted through http://tpack.org.

Using this framework, one avoids the perception that a single pedagogical approach can be used with digital technologies, instead of considering the ways technologies can support various pedagogies and content areas. Similarly, general technological approaches may not be as useful as considering flexible ways that technology can be integrated into specific content areas. Consequently, the diversity of innovative technologies increases options for teachers to cultivate technological, pedagogical, and content knowledge through thoughtful and meaningful technology integration.

METHODS

The researcher designed this instrument background paper to create a measurement of TPACK of Pre-Service Science Teacher in Indonesia. Stages are framework investigation, indicators definition, and items derivation from the indicators are gained through literature review, analyses on the current instrument, finding novelty of designated instrument defining a new instrument for pre-service science teacher in Indonesia case. Seven sub-domain indicators, i.e., Content Knowledge (CK), Pedagogy Knowledge (PK), Technology Knowledge (TK), Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), TPACK itself, and items are developed according to its rational. While this designed instrument adopted a six-point Likert-type scale designed to allow college respondents to rate their perceptions using the following status: "Extremely Poor," "Poor," "Acceptable," "Good," and "Very Good," and "Excellent" corresponding to 1–7 points, respectively.

RESULTS AND DISCUSSION

The TPACK framework has been the focus of professional development and research efforts by school districts and colleges of education pursuing transformational changes in teachers' knowledge base in thinking and planning meaningful ways to integrate technology (Spires et al., 2012). Specifically, researchers have emphasized the importance of teachers' rethinking how technologies can be used for teaching and learning and implementing an action plan based on pedagogy and content knowledge (Spires et al., 2012). Consequently, researchers have explored the technological, pedagogical, and content knowledge framework within a variety of instructional contexts including one-to-one computing environments, online graduate courses, and professional development (Bos, 2011; Hofer & Swan, 2008; Niess, van Zee, & Gillow-Wiles, 2010; Spires et al., 2012).

Hofer and Swan (2008) designed a case study to explore two social studies teachers' experiences implementing a digital documentary project using the TPACK framework. Both teachers, the researchers identified as exhibiting strong knowledge in technology, pedagogy, and content as facilitating student-centered projects; they lacked skills in using technology with students (Hofer & Swan, 2008). The researchers assisted the teachers with planning for technology integration. The process associated with completing a storyboard digitally proved to be challenging for the students, teachers, and researchers during the intersection of technology, pedagogy, and content knowledge (Hofer & Swan, 2008). Hofer and Swan conclude that the teachers' zone of proximal development regarding technology, pedagogy, and content should be a consideration when implementing technology innovations.

The TPACK framework can be a complex yet dynamic tool for professional development and teacher training. Bos (2011) conducted a mixed-methods study using the TPACK framework with 30 elementary teachers. The teachers used instructional tools to design mathematics units that support students' mathematical communication and manipulation of objects (Bos, 2011). Bos found that the teachers' interaction with technology and math content increased their understanding of the importance of both content and pedagogy in using technology as a creative medium to foster student learning. Ultimately, the teachers realized that applying pedagogical knowledge extended their developing scheme of meaningful mathematics representations (Bos, 2011).

Niess et al. (2010) conducted a study of 12 elementary and middle school teachers enrolled in an online graduate course exploring teachers' developing technological, pedagogical, and content knowledge for integrating spreadsheets in mathematics and science instruction. The researchers (Niess et al., 2010) categorized the participants across five levels of development: (a) recognizing, (b) accepting, (c) adapting, (d) exploring, and (e) advancing. Niess et al. used these levels to assess each teacher's knowledge and integration of technologies, specifically the use of spreadsheets. Eight participants, the researchers identified at the accepting level; two at the adapting level; and the remaining two teachers at the exploring level. The researchers (Niess et al., 2010) note the following areas which help teachers strengthen their technological, pedagogical, and content knowledge when integrating new technologies:

1. teachers need to learn how to enhance technology, pedagogy, and content knowledge in addition to learning about specific technologies;
2. teachers need to learn content using technology and the pedagogy of how to use the technology for content-based instruction; and
3. teachers need to learn how to use new technologies for providing challenging

instruction based on the features of technologies.

According to Niess et al. (2010), the differences among teachers' levels of technology integration warrant professional development programs that allow teachers to collaborate on developing strategies to integrate technology within and across content areas. Similarly, McGrath, Karabas, and Willis (2011) found that professional development extends beyond the main ideas of the technological, pedagogical, and content knowledge framework to include differentiated instruction through teacher collaboration and diffusion of innovation and teachers' levels of acceptance for integrating new technologies.

Regarding with current instrument on TPACK, a summary of the literature review can be seen in Table 1 as follow.

Table 1. Summary of literature

Authors	What is measured	Number of items	Scales
Koehler and Mishra 2005	Perceptions of own thinking about TPACK	5	Individual TPCK; seven-point Likert scale, strongly agree–strongly disagree
Koehler and Mishra 2005	Perceptions of one's group thinking about TPACK	9	Group TPCK; seven-point Likert scale, strongly agree–strongly disagree
Schmidt et al. 2009	Perceptions of own TPACK	47	Seven scales: TK, PK, CK, TPK, TCK, PCK, TPCK; five-point Likert scale, strongly disagree–strongly agree
Doering et al. 2009	Perceptions of changes in own TPACK	4	TK, PK, CK (single items) Likert scale items (1 novice–5 expert) +1 open-ended question; TPACK: teachers depict themselves on a graphical representation of TPACK
Archambault and Crippen 2009	Perceptions of own TPACK	24	Three scales: (TK, PCK, Technological Curricular Knowledge); five-point Likert scale, poor–excellent
Chai et al. 2010	Perceptions of own TPACK	18	4 scales: TK, PK, CK, TPCK; seven-point Likert scale, strongly disagree–strongly agree; adapted from Schmidt et al
Chai et al. 2011	Perceptions of own TPACK	46	Seven scales: TK (Web-based competencies), CK, TPK, TCK, PCK, TPCK, pedagogical knowledge for meaningful learning (PKML); seven-point Likert scale, strongly disagree–strongly agree; adapted from Schmidt et al
Koh et al. 2010	Perceptions of own TPACK	27	Five scales: TK, CK, knowledge of pedagogy (KP); knowledge of teaching with technology (KTT), knowledge from critical reflection (KCR) (after factor analysis); seven-point Likert scale, strongly disagree–strongly agree; adapted from Schmidt et al
Lee and Tsai 2010	Perceptions of confidence in TPACK-Web	30	Five scales: Web general, Web communicative , Web pedagogical knowledge; Web content knowledge, Web pedagogical content knowledge; six-point Likert scale, strongly unconfident–strongly confident

Moreover, based on the framework, the indicators and item are developed as follow:

Content Knowledge (CK)

It is widely known that knowledge concerned with the actual subject matter that is to be learned or taught. However, as Sulman (1986) noted that this would include: (1) Knowledge of concepts, theories, ideas, organizational framework (2) Knowledge of evidence and proof, and (3) Knowledge of established practices and approaches towards developing such knowledge. In the case of science, this would include knowledge of scientific facts and theories, the scientific method, and evidence-based reasoning. Why this content knowledge is essential because the student can receive incorrect information and develop misconceptions about the content area (NRC:2000). Shulman (1987) then defined content knowledge referred to as the "knowledge, understanding, skill, and disposition that are to be learned (p.9).

Developing items domain of content knowledge for teachers could be different among subjects. The first knowledge domain, content knowledge (CK), refers to the knowledge teachers must know about for the content they are going to teach and how the nature of that knowledge is different for various content areas as shown in Table 2 i.e.

Table 2. CK items

Content Knowledge (CK)	Items
Factor 1 Developing Concept for Practice	7. Knowing how far / high science concept in certain topic
	4. Knowing the scope of content in curriculum
	11. Sufficient knowledge about science concepts in secondary level
	16. Knowing various ways to understand the particular concept
	17. Using science way of thinking to develop understanding of science concept
	18. Using science way of thinking in the classroom
Factor 2: Content Standard in the Curriculum	1. Identify standard of curriculum related with certain concept
	3. Know about science content that I want to teach
	6. Sequencing certain science concept

Pedagogical Knowledge (PK)

Pedagogical knowledge (PK), the second subdomain, refers to the methods and processes of teaching and would include fundamental knowledge in areas such as classroom management, assessment, lesson plan development, and student learning in Table 3 as followed.

Table 3. PK items

Pedagogy Knowledge (PK)	Items
Factor 1 Student Classroom Management	29. Adapting various way of classroom management in the classroom to keep student-organized, orderly and focus during a class
	31. Adapting various way of teaching to keep student academically productive during a class
	46. Identifying types of different learners
Factor 2 Teaching for Students Learning	19. Adapting teaching based on current student understand or do not understand
	22. Planning sequencing students to acquire targeted skils
	45. Adjust teaching according to the student's feedback
Factor 3 How Students Learn	32. Design a roadmap of lesson plan related to expected objectives
	35. Preparing responses for possible occurred of predicting students response
Factor 4 Teaching Methods	38. Knowing teaching methods theoretically
	40. Identifying characteristic of various teaching methods
Factor 5 Lesson Design	21. Identify students acquire skills needed from standard
	23. Knowing habits of mind can be delivered through particular learning concept
	26. Identifying possible positive disposition through learning a particular concept
	27. Familiar with ordinary students understanding and misconception

Technological Knowledge (TK)

As technology is the application of scientific knowledge for practical purposes, dealing with engineering or applied science, or any modification of the natural world done to fulfill human needs or desires. So, the third knowledge domain, technology knowledge

(TK), refers to understanding how to use various technologies in the following table 4.

Table 4. TK items

Technological Knowledge (TK)	Items
Factor 1 Intellectual Capabilities	52. Able to assist students with hardware problems with their PC or laptops
	54. Able to assist students with hardware problems with their PC or laptops
	56. Able to assist students with hardware problems with their PC or laptops
Factor 2 Contemporary Skills	58. Frequently play around with computer application
	59. Learn about new digital technology easily
Factor 3 Foundation Concept	62. Knowing how to solve my computer
	63. Knowing ideas networking among computers

Pedagogical Content Knowledge (PCK)

According to Grossmann (1989, 1990), it consists of four elements, i.e.: (1) Conception of purposes for teaching subject matter; (2) Knowledge of students understanding; (3) Knowledge of instructional strategies; and (3) Curricular knowledge. This definition then improved according to Magnusson, Krajick band Borko (1999), there are 5 components of PCK as knowledge and belief about : (1) Orientation toward science teaching (2) Curriculum (3) Student's understanding (4) Assessment, and (3) Instructional strategies. Meanwhile, Van Driel, Verlop, and Vos (1998), that PCK most include at least two proposed by Grossman, as Knowledge of student's knowledge and misconception of particular topics and Instructional strategies and representation for teaching particular topics.

For this fourth knowledge domain, the researcher then defining pedagogical content knowledge (PCK) refers to the content knowledge that deals with the teaching process with items as following in Table 5.

Table 5. PCK items

Pedagogical Content Knowledge (PCK)	items
Factor 1 Teaching Concept According to the Standard	72. Selecting appropriate teaching approaches in science
	73. Produce lesson plan with an appropriate for the topic
	74. Knowing various teaching strategy in a particular science concept
	77. Knowing the limitation of concept related to curriculum
	79. Adjusting concept sequencing according to the curriculum objectives
	80. Addressing a particular concept with the learning objective
Factor 2 Representation of Subject Matters	65. Knowing various representation in a particular science concept
	66. Using a better representation for particular science lesson
	82. Addressing particular concept with student proximal development while they learn collaboratively
	83. Identifying scientific literacy on a particular topic
Factor 3 Students' Conception	68. Predicting likely students misconception within a particular topic
	69. Distinguish between genuine concept, not knowing concept and misconception within a particular topic

Technological Content Knowledge (TCK)

The fifth knowledge domain, technological content knowledge (TCK), refers to teachers' understanding of how using a specific technology can change the way learners understand and practice concepts in a specific content area, as followed in Table 6.

Table 6. TCK items

Technological Content Knowledge (TCK)	Items
Factor 1 Navigating Applied Technology for Representation	85. Selecting proper content of science-related with the technology needed (multimedia, visual demo, apps)
	87. Selecting existing technologies as the application of a body of knowledge
	89. Understanding of representations of concepts dealing with available technology
	90. Knowing specific technologies suited used in the classroom
	92. Identify content dictates the technology

Technological Pedagogical Knowledge (TPK)

Technological pedagogical knowledge (TPK) refers to teachers' knowledge of how various technologies can be used in teaching and understanding that using technology may change the way an individual teaches, as follows in Table 7.

Table 7. TPK items

Technological Pedagogical Knowledge (TPK)	Items
Factor 1 Pedagogical Design with Technology	99. Creating an online environment which allows students to build new knowledge and skills
	100. Determining different methods of teaching online
	101. Communicating online with students in a particular online environment
	103. Moderating interactivity among student using ICT
Factor 2 Pedagogical Range for Technological Tools	94. Identify using of technologies learned during the course period
	96. Choosing technologies that enhance the teaching approaches for a lesson
	97. Choosing technologies that enhance students' learning for a lesson

Technological Pedagogical Content Knowledge (TPACK)

The seventh and final knowledge domain, technological pedagogical content knowledge (TPACK), refers to the knowledge teachers require for integrating technology into their teaching—the total package. Teachers must have an intuitive understanding of the complex interplay between the three basic components of knowledge (CK, PK, TK) by teaching content using appropriate pedagogical methods and technologies as follow in Table 8.

Table 8. TPACK items

Technological Pedagogical Content Knowledge (TPACK)	items
Factor 1 Effective Teaching with Technology	108. Using appropriate technology for better representation of content for the lesson
	110. Modify teaching strategies in terms of involving technology at a particular concept
	114. Adjusting technologies for possibility reduce student conception problem
	115. Adjusting technology to describe better existing knowledge of a concept
	116. Adjusting technology to describe new epistemologies in particular concept
Factor 2 Technology in Pedagogy for Knowledge Building	104. Acquire the knowledge, skills, abilities, and attitudes to deal with ongoing technological change
	106. Use strategies that combine content, technologies, and teaching approaches that I learned about in my coursework in my classroom

CONCLUSION

The background and rationale for instrument creation in this study will provide a strong starting point for work designed as an instrument to examine and support preservice science teachers' development of TPACK. The authors plan on seeking further validation and other necessary statistical processes after completing the Likert Scale and different items for each science subject, i.e., physics, chemistry, and biology. Research plans also involve following these instruments to be used by preservice science teachers during their induction years of teaching or teaching practice. Using the specification of science subjects and modification of this instrument should encourage a line of research on measuring the development of TPACK in physics, chemistry, and biology preservice teachers' development.

REFERENCES

American Association of Colleges of Teacher Education (AACTE) Committee on Innovation and Technology. (2008). Handbook of technological pedagogical content knowledge (TPCK) for educators. New York: Routledge/Taylor & Francis Group.

Archambault, L., & Crippen, K. (2009). Examining TPACK among K-12 online distance educators in the United States. *Contemporary issues in technology and teacher education*, *9*(1), 71-88.

Angeli, C., & Valanides, N. (2009). Epistemological and methodological issues for the conceptualization, development, and assessment of ICT–TPCK: Advances in technological pedagogical content knowledge (TPCK). *Computers & education*, *52*(1), 154-168.

Becker, H. J., & Riel, M. M. (2000). Teacher professional engagement and constructive-compatible computer usage (Report no. 7). *Irvine, CA: Teaching, Learning, and Computing*.

Casement, W. (1997). The great canon controversy: The battle of the books in higher education. Somerset, NJ: Transaction Publishers.

Duncker, K. (1945). On problem-solving. (Psychological Monographs, No. 270.).

George, D., & Mallery, P. (2001). SPSS for Windows. Needham Heights, MA: Allyn & Bacon

Holmes, K. (2009). Planning to teach with digital tools: Introducing the interactive whiteboard to pre-service secondary mathematics teachers. *Australasian Journal of Educational Technology*, *25*(3).

Keller, J. B., Bonk, C. J., & Hew, K. (2005). The TICKIT to teacher learning: Designing professional development according to situative principles. *Journal of Educational Computing Research*, *32*(4), 329-340.

Knezek, G., & Christensen, R. (2004). Summary of KIDS project findings for 1999–2004 research and project evaluation. *USD epartm ent of Education, G rant*.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: a new framework for teacher knowledge. Teachers College Record, 108(6), 1017–1054.

National Research Council. (1999). Being fluent with information technology literacy. Computer science and telecommunications board commission on physical sciences, mathematics, and applications. Washington, DC: National Academy Press.

National Research Council. (2000) How people learn: Brain, mind, experience, and school. Washington, DC: National Academy Press.

Niess, M. L., van Zee, E. H., & Gillow-Wiles, H. (2010). Knowledge growth in teaching mathematics/science with spreadsheets: Moving PCK to TPACK through online professional development. *Journal of Digital Learning in Teacher Education*, *27*(2), 42-52.

Pennock, R. (2001). Intelligent design creationism and its critics: Philosophical, theological & scientific perspectives. Cambridge, MA: MIT Press.

Perry, 2004. Teaching Practice for Early Childhood. A guide for Students, Second Edition. Routledge Falmer.

Pfundt, H., & Duit, R. (2000). Bibliography: Student’s alternative frameworks and science education (5th ed.). Kiel, Germany: University of Kiel.

Ruthven, K. (2009). Towards a naturalistic conceptualisation of technology integration in classroom practice: The example of school mathematics. *Éducation et didactique*, *3*(1), 131-159.

Sahin, I., Akturk, A. O., & Schmidt, D. (2009, March). Relationship of preservice teachers’ technological pedagogical content knowledge with their vocational self-efficacy beliefs. In *Society for Information Technology & Teacher Education International Conference* (pp. 4137-4144). Association for the Advancement of Computing in Education (AACE).

Schmidt, D., Baran, E., Thompson, A., Koehler, M., Punya, M., & Shin, T. (2009, March). Examining preservice teachers' development of technological pedagogical content knowledge in an introductory instructional technology course. In *Society for Information Technology & Teacher Education International Conference* (pp. 4145-4151). Association for the Advancement of Computing in Education (AACE).

Schulman, L. S. (1986). Paradigms and research programs in the study of teaching. *Handbook of research on teaching*, 3-36.

Shulman, L (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1-22.

Terpstra, M. J. (2009). Developing Technological Pedagogical Content Knowledge: Preservice Teachers' Perceptions of How They Learn to Use Educational Technology in their Teaching. Unpublished Doctor of Philosophy Dissertation, Michigan State University.