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Exploring In- and Pre-Service Science and Mathematics Teachers' Technology, Pedagogy, and Content Knowledge (TPACK): What Next?

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ABSTRACT
The call to reform education systems is being heard in many countries around the world. The purpose of this study is to develop and apply a framework that captures some of the essential qualities of the knowledge required by teachers for effective pedagogical practice in a technology-enhanced educational environment using technology and pedagogy content knowledge (TPACK). A TPACK Short and Quick (TPACK-SQ) survey questionnaire was used to explore and assess 244 in- and pre-service science and mathematics teachers in Kuwait. The results of the survey showed that in-service teachers needed help with some aspects of TPACK. Therefore, a workshop was developed and 57 in-service teachers were enrolled and trained based on the TPACK-SQ model. The results of posttests for their knowledge were significantly positive as against pretests. The workshop thus provides a rich example of how to support the implementation of essential elements of the TPACK-SQ model.

Keywords: educational technology, integrated technology, professional development, technology pedagogical content knowledge (TPACK)

INTRODUCTION

The State of Kuwait, like many other countries, has been engaged in efforts to improve the national education system, spearheaded by the national Ministry of Education (MOE). The demand to reform the Kuwaiti education system has been spurred by various indicators. First, the National Ministry of Higher Education and Kuwait University have reported a high rate of student dropouts at the college level (Wiseman, Alromi, & Alshumrani, 2014). Second, Kuwait's results on international comparative assessments, such as the Trends in International Mathematics and Science Study (TIMSS) and Progress in International Reading Literacy Study (PIRLS), have been very low over the years (TIMSS, 2015). These results indicate that the education system needs reform to enhance better performance, especially in mathematics and science. Thus, the call for reforming education at both national and international level with focusing on core subjects: literature, math and science was essential demand. The term

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State of the literature

- The findings can be used by science and mathematics head teachers, administrators, and curriculum developers to 1) better understand the nature of TPACK-SQ and its components and their implications for teacher professional development, 2) extend the knowledge of science and mathematics teachers' perceptions of TPACK-SQ, 3) enhance the knowledge of science and mathematics teachers' willingness to adopt TPACK-SQ in learning activities, and 4) based on the challenges identified, make suggestions regarding future research and applications of TPACK-SQ in science and mathematics education.

Contribution of this paper to the literature

- The results of this study should be helpful to science and mathematics head teachers, administrators, and curriculum developers to help them 1) clarify TPACK-SQ and specify its components in a meaningful framework for teacher preparation and professional development; 2) extend our knowledge of science and mathematics teachers' perceptions of TPACK, 3) enhance science and mathematics teachers' willingness to adopt TPACK-SQ and their ability to embody its framework in authentic learning activities during their instruction; and 4) based on the challenges they face, make suggestions regarding future research and applications of TPACK-SQ in science and mathematics education.

reforming is very comprehensive and it includes curriculum, teacher effectiveness, school systems, and the assessments.

While many scholars are interested in the reforming process that is taking place in the system of education, the current effort of this research is interested in teachers' development and their practices. More specific, we also found that the international trend is focusing on the integration of technology into common core curriculum and its related practices in learning and teaching content (National Research Council, 1996, Project 2061; American Association for the Advancement of Science, 1989, 1993; NCTM, 2000). Also, integration refers to integrating subjects together such as Science Technology Engineering and Mathematics (STEM) (Niess, & Gillow-Wiles, 2013). The integration requires capable teachers in the field who can adopt technology while practicing pedagogical skills to transform knowledge to students (Srisawasdi, 2012). Well recognized associations stressed on the concept of integration. The National Council of Teachers of Mathematics (NCTM) states, "Technology is essential in teaching and learning mathematics; it influences mathematics that is taught and enhances students' learning" (NCTM, 2000, p. 24). Also, "effective mathematics teaching requires understanding what students know and need to learn and then challenging and supporting them to learn it well" (NCTM, 2000, p. 16).

Therefore, the result of this study may help in providing a path to support both in-service and pre-service teachers. The focus will be clustered around professional development in the field of pre-service and in-service teachers with a clear vision and using a conceptual model. A Technology, Pedagogy, and Content Knowledge (TPACK) model is extensively used to scaffold teacher's integration knowledge and skills into their practices (Archambault & Crippen, 2009; Niess & Gillow-Wiles, 2013; Koh & Chai, 2014).

Based on the background above, this study explores current pedagogical, content, and technological knowledge with the goals of developing a sustainable program that assists, supports, and guides pre- and in-service teachers. In order to construct a learning program for teachers, we first adopt and justify the adoption of the TPACK conceptual framework of Mishra and Koehler (2006). Thereafter, within it, we focus on sustaining a professional development program from the pre-service stage to actual practice, with emphasis on science and mathematics subjects.

Thus, The main purposes of this study were to (a) explore and examine mathematics and science in-service and pre-service teachers' technology, pedagogy, and content knowledge (TPACK); (b) provide educators and stakeholders with the TPACK Short and Quick (TPACK-SQ) to be used as an assessment tool for teacher preparation programs TPACK related; (c) to provide suggestions and guidelines to enhance professional development programs for teachers based on the results of TPACK-SQ. In this spirit, the research questions taken up are as follows:

1. To what extent can a TPACK-SQ self-report survey provide valid, reliable data about pre- and in-service teachers' TPACK?
2. To what extent do science and mathematics pre- and in-service teacher acquire TPACK?
3. Is there any significant difference between pre- and posttest in-service teachers' responses to the TPACK–SQ survey due to the workshop?

LITERATURE REVIEW

Kuwait Context

Various factors affect students' performance, including curriculum, school environment, assessment tools, and teachers. Effective teachers are facilitators of their students' learning, who deliver the objectives of their lessons while managing the classroom, assessing students, and providing them with the best guidance (Churchill, 2009). Nowadays, many universities and associations collaborate with education ministries and school districts to mount programs for sustaining novice teachers in their profession (Moonen, 2008; Ebrahim, 2012). In general, teachers need continuous professional development programming to maintain their pedagogical skills and need access to well-equipped classrooms with technology and tools (Ajlouni & Aljarrah, 2011; Archambault & Crippen, 2009). More specifically, this current study focused on teachers and how to scaffold their competence of integrating technology into their teaching and learning practices while teaching math or science as stated in both National Research Council, 1996), Project 2061 (American Association for the Advancement of Science, 1989, 1993); and NCTM, (2000).

In Kuwait, the (MOE) supports new and innovative programs to raise teachers' effectiveness, and asserts that using information and communication technology in teaching and learning at Kuwaiti schools will enhance education (MOE, 2014). The government of Kuwait has focused on education as an element for achieving economic development and social progress (Wiseman, Alromi, & Alshumrani,, 2014). In 2014, Kuwait spent about 13% of its total budget on education. Education expenditure has increased from (USD) 3.6 billion in 2010 to (USD) 5 billion in 2011 (16%) of the total budget of the whole country (Wiseman, Alromi, & Alshumrani,, 2014). However, the increase in spending for education is mainly for wages, salaries, and bonuses, which eat up three-quarters of this spending while less amount on professional development (Wiseman, Alromi, & Alshumrani, 2014).

As an example, in 2000, the MOE supported all in-service teachers to complete International Computer Driving License (ICDL) training courses for to gain ICT skills (Alayyar, 2011). It also provides limited training programs, but does not include the majority of teachers, which causes teachers to fall behind in updating themselves in their field (Alhashem, Al-jafar, 2015). The MOE provides three types of training for teachers: two-week training courses for beginner teachers, two-week training courses for promoted head departments, and a training course for development related to curriculum, evaluations, and assessment (NIE, 2013). This limited scope for engaging in state-provided training for teaching skills leads teachers to find other methods of training, such as seeking private training centers or courses and paying out of pocket (Alhashem, Al-jafar, 2015, 2015). Further, the school setting does not help teachers to adopt technology. For example, the lack of Internet connections in schools causes teachers to use their own wireless Internet devices, which is unaffordable for some of them. Schools have internet access, but it is generally limited to computer labs and offices. Equipping classrooms with technology but no access to internet may cause a lack of integration of technology and teaching (Alayyar, 2011).

The College of Education at Kuwait University has adopted a new and novel paradigm to prepare pre-service teachers. First, pre-service teachers take introduction to technology courses, followed by educational technology courses. Students at the college of education learn and practice basic skills that they should use in their lesson plans and in classroom management. Also, students are required to present an e-portfolio in their final year that contains a collection of their work during their studies at college such as projects and lesson plans (College of

Education Kuwait, 2015). The College of Education also provides its students with support to use technology in their program: its Information Technology Center coordinates with the Teaching Practicum Center to help students undergoing field training to reach their objectives, and introduces students to the latest developments in the field of learning technologies (TPCM, 2015). The university also provides varied technological services through the Distance and E-Learning Center, as well as more than 4,000 free e-training courses in information technology, business skills, and desktop courses (Al-Ansari, 2006).

The acronym TPACK refers to "technology and pedagogy content knowledge," and these three elements (technology, pedagogy, and content) are presumed to be familiar to teachers and to be continually applied in their classrooms. Not only are teachers required to understand relevant content knowledge, they also need to know how to convey this content to their students; at the same time, they need to adapt and update their technological knowledge to keep up with technical and lifestyle developments. Therefore, it is essential that teachers understand the concept of TPACK, which will help them connect their skills with content via technological means to produce integrated lesson plans. More broadly, it is very important that teachers know how to add technology into their practice and to use different methods to deliver content. To instill such skills, a redesign of both preparation programs at colleges of education and professional development for pre-service and in-service teachers will be needed, based on the TPACK model. Thomas, Herring, Redmond, & Smaldino, (2013) stated that educational leaders must establish a clear vision for how their programs will develop candidates who are TPACK competent and who can become models/change agents at their schools.

Technology Integration in Education

The concept of integrating in education is a complex task due to its dynamic nature, especially when it comes to the involvement of technology. Integration in education is beneficial, "Research indicates that using an interdisciplinary or integrated curriculum provides opportunities for more relevant, less fragmented, and more stimulating experiences for learners" (Furner & Kumar, 2007; p.186). Many teachers have lack or gaps in their own subject content knowledge (Stinson, Harkness, Meyer & Stallworth, 2009) and asking math and science teachers to teach using technology may create new knowledge gaps and challenges (Stinson et al., 2009).

A main factor for improving and developing the education deals with integration in education. Previous studies, showed that integrating technology in education is challenging, complex and required strategic planning by the policy and decision makers (Hashim, 2007; Ghavifekr & Sufean, 2010). Moreover, Moonen (2008), stated that it is not difficult to have policies for IT (Information Technology) integration accepted for core technologies than for complementary technologies, which leaves technology isolated from integration while teaching other subjects.

Richardson (2009) designed a development project for in-service mathematics teachers to develop and explore TPACK in teaching and learning Algebra 1. They tried to transform content by integrating technology and pedagogical knowledge. After sixty hours of summer sessions and sixty hours of academic sessions, the researcher noticed the need to provide teachers with a special program to develop the integration of the technology, content, and pedagogy knowledge, allowing the teachers to clearly understand the benefit of teaching with technology.

In sum, students depend on their teacher's knowledge and practices. To provide best education, teachers must deeply understand math or science content; recognize the instructions and methods that need to be applied in the classroom according to the difference in students' abilities; utilize the best technology tools and embed them while teaching. While teachers need to know relevant content knowledge, they also need to know how to convey this content to their students; at the same time, they need to adapt and update their technological knowledge to keep up with technical and lifestyle developments. Therefore, it is essential that teachers understand the concept of TPACK, which will help them connect their skills with the content via technological means to produce integrated lesson plans. More broadly, it is very important that teachers know how to add technology into their practice and to use different methods to deliver content. To instill such skills a redesign of both preparation programs at colleges of education and professional development for pre-service and in-service teachers will be needed, based on the TPACK model.

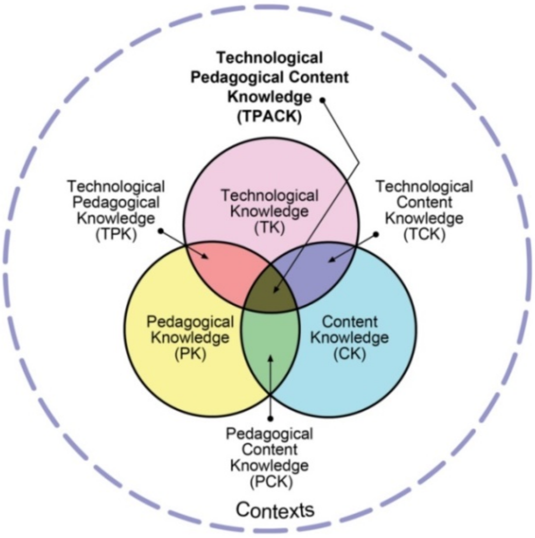

Figure 1. The components of the TPACK framework (Mishra & Koehler, 2006)

CONCEPTUAL FRAMEWORK

Mishra and Koehler (2006) introduced TPACK, which is an expansion of Shulman's pedagogical content knowledge theory. They built their model to effectively integrate technology into classroom practice in the context of advancements in its affordances as an educational tool.

The TPACK framework (Mishra & Koehler, 2006) breaks target knowledge down into three kinds: content, pedagogical, and technology. Intertwining these three produces four important domains: pedagogy content knowledge (PCK), technology content knowledge (TCK), technology pedagogy knowledge (TPK), and technology, pedagogy, and content knowledge (TPACK). Definitions of the knowledge constructs of the TPACK model, based on Mishra and Koehler (2006), follow:

- **Knowledge constructs** are the basic professional knowledge teachers must have in order to be prepared to teach. This includes up-to-date knowledge of their subject or specialization (NCED, 2014).
- **Technology knowledge (TK)** in the TPACK framework is similar to Fluency of Information Technology (NRC, 2012).
- **Content knowledge (CK)** is teachers' knowledge about the subject matter to be taught.
- **Pedagogical knowledge (PK)** is teachers' deep knowledge about the processes and practices or methods of teaching and learning, encompassing, among other factors, overall educational purposes, values, and aims.
- **Pedagogical content knowledge (PCK),** knowledge of pedagogy that is applicable to teaching specific content.
- **Technological content knowledge (TCK)** is an understanding of the manner in which technology and content influence and constrain one another.
- **Technological pedagogical knowledge (TPK)** is an understanding of how teaching and learning can change when particular technologies are used in particular ways.

The main goal of TPACK is to demonstrate how teaching and learning using technological tools can change and improve students' understanding of any subject (Koehler, Mishra, & Yahya, 2007).

The TPACK model has informed the structure of many professional development programs for teachers (Jason, 2011). Many education systems have adopted TPACK as a framework for professional development and a guide for their progress towards 21st century teaching (Thompson & Mishra, 2008).

Many researchers have adopted TPACK as the framework for professional development as a guide for their progress towards 21st century learning (Thompson & Mishra, 2008; Archambault & Barnett, 2010; Thomas, et, al 2013; Koh & Chai, 2014). They have adopted the TPACK model of Schmidt, Koehler, Mishra & Shin, 2009); the original survey consisted of 58 items and measured 124 pre-K to grade 6 pre-service teachers. TPACK instrument showed internal consistency of reliability ranged from .75 to .92 for the seven domains. Participants were prepared with common core curriculum content knowledge to reflect, mathematics, science, social studies, and literacy. Schmidt, et al. (2009) results suggested that 18 items of survey can be modified and still be reliable as an instrument to help educators design longitudinal studies to assess pre-service teachers' development of TPACK.

Koh & Chai, 2014 made slight adaptations to Schmidt et al.'s (2009) survey, mainly replacing the specific subjects (Math and Science) with the term curriculum study, to allow the Singaporean pre-service teachers to make reference to the teaching subjects they are trained to teach. They explored the adapted survey factor structure using a large sample (N > 1000). The analyses yielded 5 factors instead of seven factors. The results indicated that further refinement of the instrument has to be out carried.

In another study, Archambault & Barnett (2010) examined the nature of (TPACK) through the use of a factor analysis using a survey with 24 items designed to measure each of domains described in TPACK framework, each domain consisted of 3-4 items in each domain. The first domain had 10 items load in domain (1), 11items load in domain (2) and 3 items load in domain (3). They suggested that measuring each of these domains is complicated and interleaved, potentially due to the notion that they were not separate.

Tee and Lee (2011) investigated how an improved problem-based learning approach can help in-service teachers in different subject areas support TPACK application while teaching. They designed a special 14-week course on technology and teaching based on TPACK, and noticed that over the progression of the course, teachers became more efficient at utilizing TPACK in teaching. They also noted that teachers gained better understanding of the role of technology in teaching. Harris and Hofer (2011) investigated how TPACK can inform their instructional planning and how it can enhance knowledge. In addition, they sought to discover clues to the nature and development of participating teachers' TPACK-in-action as it was expressed in the teachers' planning processes. The results showed that a) the type of selections, usage of learning activities and technology applications became more conscious, strategic, and varied; (b) instructional planning became more student-centered; and (c) quality standards for technology integration were raised. Olofson, Swallow, and Neumann (2016) used TPACK as a tool to foster changes in the teaching process for teacher with prior knowledge TPACK model. Their findings pointed to the relevance of TPACK in analyzing teacher practice.

Niessand and Gillow-Wiles (2013), focused on advancing teachers' interdisciplinary math and science content knowledge while integrating appropriate digital technologies such as learning and teaching tools. They used a mixed-method and interpretive study to examine in-service teachers' (TPACK) within the context of (STEM). The results outlined methods for coursework, and redefined interdisciplinary concept for teachers including students' understanding, instructional strategies, and use of technology within the curriculum.

In a different study on math and science teachers, Jang and Tsai (2012) explored TPACK model to develop a valid questionnaire and was used in elementary school context. The developed questionnaire contained 30 items in the four new components: 1) CK, 5 items; 2) PCK in the Context (PCK, 9 items); 3) (TK, 4 items); and 4) TPCK in the Context (TPCKC, 12 items). The results of Jang and Tsai (2012) showed that the Ministry of Education in Taiwan supported using technology in school settings (Jang & Tsai, 2012).

In regard to preserves teachers, Thomas et, al (2013), set a direction for transforming teacher education programs. They said those faculties are likely best positioned to relate how the knowledge and skills inherent in TPACK will best fit in the courses and field experiences of their program, as well as to identify the knowledge and skills they, themselves, require to create these learning experiences for their students. Thus, setting expectations for performance and monitoring progress is required on two levels to understand both how students and teachers are making progress toward the goals. They identified, 1) resources, ways, and the support needed for a professional development, 2) initiative might scaffold work at the college level; and 3) supports needed in-service, college-level, context-specific products or processes.

Koh and Chai (2014) employed an instrument to categorize teachers into groups based on their self-reported TPACK before they were engaged in lesson design activities as part of their professional development. Based on the pre-course survey, the cluster analyses revealed two categories of pre-service and in-service teachers respectively. Pre-service teachers deepened the connections among TPK and TCK, and TPACK. In-service teachers who were more confident in their pre-course TPACK deepened the connections between CK and TPACK after ICT lesson design. In a similar case, Shinas, Yilmaz-Ozden, Mouza, Karchmer-Klein, and Glutting (2013) surveyed 365 pre-service teachers where they completed methods courses and field experience concurrent to the educational technology. The results showed that participants did not always make conceptual distinctions between the TPACK domains.

Archambault and Barnett, (2010) examined the validity of a TPACK survey that was employed in a 12-week ICT (Information communication technology) course designed for Singaporean primary school pre-service teachers. They were able to uncover five of the seven TPACK domains, which were a better model suitable as compared with several extant studies of TPACK surveys. They also found that PK had a direct impact on TPACK at the beginning of the course. As teachers made connections between their TC and PK to form TPK during the course, the direct relation between PK and TPACK became insignificant; whereas the relations between PK and TPK, and TPK and TPACK were strengthened. The comparison between the pre- and post-course models also revealed that the pre-service teachers' perceived relations between CK and TPACK changes from insignificant to significant.

Nevertheless, the challenge was laying in creating and validating an instrument that would be applicable in a multitude of contexts, including different content areas. "If this is not possible, then the conceptualization of TPACK may need to be different for every imaginable content area, including subject domains within each of these areas" (Archambault & Barnett, 2010, P 1660). One of the major opportunities has been given to the researchers in this current study was attempting to measure content knowledge, as knowledge of the subject matter to be taught (e.g. science, mathematics, language arts, etc.).

METHOD

The study is mainly quantitative, with a design, instruments, and settings created based on the conceptual framework. The 34 self-report items to reflect TPACK Schmidt, et al. (2009) were adopted and modified, based on results Archambault and Crippen (2009), and Koh & Chai (2014) and customized to the context of this research. So that participants rate the extent, to which they applied each of the item responses after the exposure to tow, 3-cridit courses "technology in education and "learning media & resources" planned for pre-service teachers; and a designed workshop (see Appendix 2) for in-service one.

Participants

As of 2014, there were 6,763 mathematics teachers and 6,638 science teachers in Kuwaiti schools (Kuwaiti Ministry of Education, 2014) and 236 pre-service teachers of mathematics and 530 of science (College of Education (Kuwait), 2015). The sample of this study consisted of 244 participants Table participants **Table 1** shows the participants' positions and specializations.

Table 1. Participants

	Pre-service	In-service	Total
Science	64	68	132
Mathematics	26	86	112
Total	90	154	244

Instruments

The instrument used was modified to reflect the theoretical framework of Schmidt et al. (2009). In that study, internal consistency reliability ranged from .75 to .92 for the seven TPACK subscales. The instrument showed with internal consistency reliability ranged from .75 to .92 for the seven TPACK subscales. In a similar study, Koh & Chai, 2014 made slight modifications to Schmidt et al.'s (2009) instrument in replacing core subjects (Mathematic, Science etc.) with the term curriculum study. The analyses yielded five factors instead of seven factors. Archambault & Barnett (2010) examined the nature of (TPACK) through the use of a factor analysis using a survey of 24 items, 10 items load in Factor (1), 11 items load in factor (2) and 3 items load in factor (3). Since TPACK presents an unmanageable number of test items, researches reduced the number of items, as mentioned above, developing a fast, reliable, and teacher-related survey. The focus of the present study is science and mathematics education, we modified it to meet the context of this research.

TPACK Internal Structure

In order to assess the internal structure of TPACK when applied to different contexts (i.e. Kuwait), we applied Exploratory Factor Analysis (EFA) procedures to the 34-item survey. Prior to analyses, standard data screening procedures did not identify any univariate outliers. Sample size requirements were met (n=244 and within acceptable range). In addition, all 34 items bivariate correlations were at least 0.3 suggesting reasonable factorability. Secondly, the Kaiser-Meyer-Olkin measure of sampling adequacy was .93, above the commonly recommended value of .6, and Bartlett's test of sphericity was significant (χ^2 (561) = 8383.37.26, $p < .05$). Moreover, all communalities were above 0.6. Given these overall indicators, factor analysis was suitable with all 34 items. EFA results showed that five factors could be retained with Eignevalues >1, with first five factors explaining 50%, 9.4%, and 4%, 3.5%, 3.2% of the variance respectively. The five-factor solution, which explained 70.9% of the variance, was retained using Kaiser rule. Items-Factor loading ranges for each factor (from 0.4 to 0.85). Three Complex items, which was relaying on more than one factor, were seen (TK7, PCK5, andTPK1). CK2, Items were modified based on the results in the instrument which was led by the results of EFA. (see, appendix 1). Overall, these analyses indicated that five distinct factors were underlying participant's responses to the TPACK-SQ items and that these factors were moderately internally consistent. The instrument was reviewed and approved by educational technology and educational psychology scholars for content validity. The final instrument—TPACK-SQ—consists of 34 items for exploration of in- and pre-service teachers' TPACK.

Validity

The content validity of TPACK-SQ was assessed and statistically significant correlations among its subscales explored using Pearson correlation coefficients. These correlations were statically significant, meaning that the knowledge of technology, pedagogy, content, and their intersections are related. See **Table 2**.

Reliability

Reliability statistics were conducted on the seven TPACK-SQ subscales within each knowledge domain. The internal consistency reliability (coefficient alpha) ranged from .817 to .882 for the seven TPACK-SQ subscales. According to George and Mallery (2001), this range is considered acceptable to excellent.

The final version of TPACK-SQ was tested for reliability through a test-retest method; 20 pre-service teachers and 30 in-service teachers took the final survey (in Arabic), and then again after two weeks. For the pre-service teachers, reliability was 0.82 and for the in-service teachers it was 0.73, which is consistent with Schmidt et al. (2009).

Procedures

As part of this research plan, we collected data on in-service and pre-service mathematics and science teachers' self-assessment of their knowledge of the seven knowledge components within the TPACK framework.

Table 2. Pearson Correlation Coefficients Between TPACK-SQ Subscales

		TK	CK	PK	PCK	TCK	TPK	TPACK
TK	Pearson correlation	1	.19**	.21**	.13*	.40**	.42**	.35**
	Sig. (2-tailed)		.00	.00	.03	.00	.00	.00
CK	Pearson correlation	.19**	1	.59**	.52**	.46**	.45**	.50**
	Sig. (2-tailed)	.00		.00	.00	.00	.00	.00
PK	Pearson correlation	.21**	.59**	1	.60**	.48**	.54**	.52**
	Sig. (2-tailed)	.00	.00		.00	.00	.00	.00
PCK	Pearson correlation	.13*	.52**	.60**	1	.56**	.58**	.51**
	Sig. (2-tailed)	.03	.00	.00		.00	.00	.00
TCK	Pearson correlation	.40**	.46**	.48**	.56**	1	.80**	.72**
	Sig. (2-tailed)	.00	.00	.00	.00		.00	.00
TPK	Pearson correlation	.42**	.45**	.54**	.58**	.80**	1	.75**
	Sig. (2-tailed)	.00	.00	.00	.00	.00		.00
TPACK	Pearson correlation	.35**	.50**	.52**	.51**	.72**	.75**	1
	Sig. (2-tailed)	.000	.00	.00	.00	.00	.00	

**. Correlation is significant at the p<.05, **p<.01 level (2-tailed)

Table 3. Developed TPACK Workshops

Day	Activity	Lecturers
Day one	Introduction to TPACK-SQ; adapting technology into teaching in science and mathematics; explaining the study	The researchers
Day two	Workshop modeling technology in teaching	Technology professor
Day three	Workshop on pedagogical skills for teaching science or mathematics	Curriculum professors
Day four	Assigning groups; matching the TPACK-SQ model with science and math lessons	The researchers
Day five	Working day—groups work on lesson plans based on TPACK-SQ model.	Mathematics and science supervisors/ professors
Day six	Presentation/assessment and evaluation of participants' work	The researchers

The modified instrument was then field-tested among Kuwaiti pre-service and in-service teachers and revised based on information gathered from this pilot.

The first phase of the study was conducted with both pre-service and in-service teachers in order to explore the effectiveness of the TPACK-SQ model. In regard of time duration of the survey, we calculated eight groups of 20 to 57 participants' time responses, and the time was ranged from 4:50 to 5:00 minutes.

In-service teachers who scored low on the first phase were invited to participate in the second phase of the study. Only 57 teachers participated, on a voluntary basis, responding to the TPACK-SQ survey anonymously. Then, they completed a workshop about TPACK-SQ (Table 3).

The workshop was designed to explain the intersection of the seven components of TPACK to participants, with a particular focus on the overlap of TCK, PCK, and TPK. The main goal was to train participants on how to

Table 4. T-Test Results for Pre-Service and In-Service Teachers' Means for TPACK-SQ Subscales

Subscale	Position	M	SD	t	p
TK	Pre-service	3.89	0.72	.772	.442
	In-service	3.77	0.65		
CK	Pre-service	4.38	0.63	5.412	.000
	In-service	3.80	0.40		
PK	Pre-service	4.16	0.49	3.192	.002
	In-service	3.88	0.33		
PCK	Pre-service	4.21	0.51	5.340	.000
	In-service	3.71	0.38		
TCK	Pre-service	4.11	0.77	2.206	.030
	In-service	3.85	0.38		
TPK	Pre-service	4.17	0.68	4.301	.000
	In-service	3.67	0.43		
TPACK	Pre-service	4.17	0.60	4.732	.000
	In-service	3.66	0.42		

transform mathematics and science topics from a traditional style of instruction to one that utilizes and integrates TPACK. The most important steps in the workshop are listed below:

- Introduction of TPACK.
- Explaining the effects on students of teaching methods and students' abilities and skills.
- Introduction to the role of technological tools in lesson planning.
- Each group chose a topic and designed a lesson based on the TPACK model.

RESULTS

The current study used a quantitative research method. The Cronbach's alpha was calculated for each subscale of the TPACK-SQ survey to ensure the reliability of each result. Respondents' (that is, pre- and in-service teachers') descriptive data were reported for each subscale; and Pearson correlation analysis was undertaken to explore how the subscales are related to each component.

In addition, in- and pre-service mean scores and standard deviations were calculated to evaluate participants knowledge of how to adopt pedagogical strategies to foster learners' understanding of the subject matter (PCK), evaluate knowledge of novel and specific technologies to teach or facilitate instruction (TCK), probe their knowledge of how the technology can be used in teaching the subject (PTK), and assess their understanding as it emerges from interactions among content, pedagogy, and technology knowledge (TPACK).

Next, a series of *t*-tests were used to explore the responses on each factor of the TPACK-SQ survey.

An independent-samples t-test was conducted to explore differences and similarities in responses between pre-service and in-service teachers (see **Table 4**). There was a significant difference between the scores for pre-service (M=4.17, SD=0.60) and in-service (M=3.66, SD=0.42) teachers (t=4.732, p=0.00), with in-service teachers scoring quite low. In any case, there appear to be knowledge gaps between university and workplace. Being successful in the former institution does not guarantee success in the latter (Zeichner, 2010).

An independent-samples t-test was conducted to compare pre-service teachers' results in math with those in science. All subscales and the overall TPACK-SQ did not show significant differences between science pre-service teachers (M=3.87, SD=0.57) and mathematics pre-service teachers (M=3.79, SD=0.49); t=0.597, p=0.552. These results suggest that both science and mathematics pre-service teachers are experiencing more or less the same type of learning and training for teaching, and that in both cases TPACK-SQ can be used as a assessment tool survey to

Table 5. T-Test Results for Pre-Service Specialization-Based Means for TPACK-SQ Subscales

Subscale	Specialization	N	M	SD	t	p
TK	Science	64	3.84	0.64	.481	.632
	Mathematics	26	3.76	0.76		
CK	Science	64	4.01	0.50	.153	.879
	Mathematics	26	4.03	0.73		
PK	Science	64	3.99	0.43	.281	.779
	Mathematics	26	3.96	0.39		
PCK	Science	64	3.89	0.53	.215	.830
	Mathematics	26	3.91	0.41		
TCK	Science	64	3.99	0.50	1.156	.251
	Mathematics	26	3.84	0.70		
TPK	Science	64	3.87	0.56	.447	.656
	Mathematics	26	3.81	0.65		
TPACK	Science	64	3.87	0.57	.597	.552
	Mathematics	26	3.79	0.49		

Table 6. T-Test Results for In-Service Specialization-Based Means for TPACK-SQ Subscales

Subscale	Specialization	M	SD	t	p
TK	Science	3.96	0.65	1.950	0.05
	Mathematics	3.71	0.76		
CK	Science	4.07	0.60	2.178	0.03
	Mathematics	3.75	0.28		
PK	Science	4.01	0.43	1.930	0.054
	Mathematics	3.79	0.27		
PCK	Science	3.93	0.51	1.560	0.12
	Mathematics	3.73	0.38		
TCK	Science	4.09	0.58	2.21	0.035
	Mathematics	3.64	0.43		
TPK	Science	3.95	0.60	1.907	0.05
	Mathematics	3.60	0.45		
TPACK	Science	3.93	0.56	2.965	0.01
	Mathematics	3.51	0.35		

(re)design and (re)structure their education. This result aligns with the observation of Jang and Chen (2010) that TPACK model could help pre-service teachers develop technological pedagogical methods and strategies for integrating subject-matter knowledge into lessons, further enhancing their TPACK-SQ results.

An independent-samples t-test (**Table 6**) was conducted to compare the responses of in-service teachers in science to those in mathematics. Science teachers were found to do significantly better than mathematics teachers in TPACK, TCK, and TPK, while there was no significant difference in PCK.

Table 7 shows the mean score differences between pretest (before the workshop) and posttest (after it).

On the basis of the above results, an independent-samples t-test was conducted to compare pretest and posttest results for the 57 in-service teachers. The results indicated significant differences in TK, TCK, and TPACK. The TK subscale for posttest was significant (M=3.82, SD=0.67), as were pretest results (M=3.51, SD=0.70) (t=3.389, p=0.001). The TCK subscale showed a significant difference from the posttest (M=3.95, SD=0.56) and pretest results (M=3.78, SD=0.58) (t=2.156, p=0.032). The TPACK model t-test showed a significant difference form posttest (M=3.85, SD=0.55) (t=2.095, p=0.037). These results suggest that the workshop for in-service teachers had an encouraging impact on the TPACK model and could be helpful in integrating technology and pedagogy skills while

Table 7. T-Test Results for Pre- and Posttest Means for TPACK-SQ Subscales

Subscale	Group	M	SD	t	p
TK	Pretest	3.51	0.70	3.389	.001
	Posttest	3.82	0.67		
CK	Pretest	3.88	0.60	1.685	.093
	Posttest	4.01	0.57		
PK	Pretest	4.02	0.54	.529	.597
	Posttest	3.98	0.42		
PCK	Pretest	3.95	0.58	.732	.465
	Posttest	3.89	0.49		
TCK	Pretest	3.78	0.58	2.156	.032
	Posttest	3.95	0.56		
TPK	Pretest	3.77	0.61	.968	.334
	Posttest	3.85	0.58		
TPACK	Pretest	3.68	0.60	2.095	.037
	Posttest	3.85	0.55		

teaching science and mathematics. Even more, the results allow us to articulate specific considerations for school-based professional development (re)design to help do a better job preparing science and mathematics teachers for their careers and the workplace.

DISCUSSION

This study adopted the 34 self-report TPACK items (Schmidt, et al. 2009) with modifications reported by Archambault and Crippen (2009) and Koh & Chai (2014) while being customized to the context of this research. Participants rated the extent to which they applied each item after the exposure to two 3-credit courses "technology in education and "learning media & resources" planned for pre-service teachers; and a workshop for in-service one.

The TPACK- SQ survey showed a valid and a reliable data about pre- and post-teachers' knowledge. The study focused on helping teachers learn about TPACK-SQ and implement it, investigating both pre-service and in-service teachers in both science and mathematics. It was shown that the streamlined survey employed here can be used as an assessment tool to identify the training needed. The survey items duration time came to average of 4:30 to 5:00 minutes. Thus, the results of TPACK-SQ can guide the development and implementation of programs to prepare future teachers for a K-12 science/mathematics classroom environment in which technology significantly impacts and changes teaching and learning; aligned with Thomas et, al (2013) notions of setting institutional direction for TPACK. This approach also allows us to articulate principles for the redesign of university education to do a better job in preparing science and mathematics pre-service teachers for their future workplaces.

Within the review of the literature, TPACK has been conceptualized as a seven-factor construct to describe teacher's integration of T in their teaching and their students' learning. However, this framework has yet to be successfully validated through survey instruments (Archambault & Barnett, 2010; Ozgun-Koca, Meagher, & Edwards, 2010); Shinas, et, al, 2013; Koh & Chai, 2014).

Referring to the extension of how much teachers acquire, results showed that pre-service teachers appeared to be more confident in integrating technology than in service ones. Pre-service teachers were capable in their instructional and pedagogical practices, which may reflect the valid use of technology in learning environment of college of education. This confirms the existence of a technological gap between higher education institutions and workplace, due to the availability and accessibility of technology (COE, 2015; Alqahtani & Al-Enezi, 2012).

No significant difference was found among pre-service teachers in terms of specialization (science or mathematics). In contrast, in-service science teachers did significantly better than in-service mathematics teachers on TPACK, TCK, and TPK, which confirmed Jang, & Tsai (2012) results. This could be due to more technology exposure, or greater availability of science materials, devices, and tools in school's laboratory learning environment. The results supported previous studies showed that teacher in service lack of using the technology while teaching (Koh, & Chai, 2014) . Liang, Chair, Koh, Yang, and Tsai (2013) showed that senior teachers might show a certain degree of resistance toward technology integrated teaching environment. Inopportunely, when it comes to technology application, the focus clustered around providing hardware and equipping the place with less attention on software and programs (Moonen, 2008). Moreover, most of efforts have been put into utilizing instead of integration technologies. (Ozgun-Koca, et al., 2010); Koh, & Chai, 2014).

The results of the survey showed that pre-service teachers had more opportunities to practice TPACK than in-service ones. Pre-service teachers tended to use eLearning resources on campus more than in-service teachers at school due to the school culture and settings, which caused a limitation due to shortages in wireless access. The results reflected back on providing the support through the Teaching Practicum Center at the college of education for pre-service teachers with support needed during their training (Alqahtani & AlEnezi, 2012). The advantage of having access to internet on camps for pre-service teachers helped in integrating technology while practicing teaching science or mathematics, which may have had an effect on the results of the survey.

In the results, there was no significant difference in terms of the specialization (science or mathematics) at the college of education. These results may indicate that both mathematics and science pre-service teachers are being trained and experience the same type of teaching the same way. These results positively echo the recommendations of National Science Education Standards (NSES), (NRC, 1996); mathematics education (NCTM, 2000); STEM, (Niess, & Gillow-Wiles, 2013) of integration of technology into common core curriculum and its related practices in learning and teaching content Project 2061, (1989); NCTM, (2000) or the integration of subjects such as STEM.

Moreover, the workshop provided opportunities for 57 in-service teachers to participate and make meaningful contributions throughout the design process. Elements of the workshop supported teachers' efforts to implement the TPACK-SQ, especially in science and mathematics. Moreover, the professional development afforded by TPACK-SQ provided a rich example of how to support the implementation of some of essential elements of the TPACK model. The results of the workshop were thus meaningful for in-service teachers in both science and math.

Professional training and development refers to many types of educational experiences to learn and apply new knowledge and skills that will improve teacher performance on the job related to the individual's work (Thompson & Mishra, 2008; Archambault & Barnett, 2010)). No doubt, training and professional development programs for teachers would allow them to have opportunities to learn more from time to time. Moreover, such programs will ensure teachers stay up-to-date on education information in certain research areas and the latest curriculum implemented and that teachers are engaging with new technology available and several resources that help to improve their teaching. The training provided by central office will provide a platform for teachers to upgrade their skills and knowledge, sharing knowledge with peers, and connecting to the latest changes in the education field (Niess, & Gillow-Wiles, 2013; Koh & Chai (2014).

CONCLUSION

This study comes out with a valid and reliable instrument to reflect TPACK domains. In addition, TPACK conceptual framework has been put into practices, and reveal an intertwine domains, which is required be adapt to content, pedagogy and technology knowledge to meet updated knowledge and technology essential for 21st century requirements.

Bridging Technological gap between the colleges and the school settings is important. This requires the involvement of policy makers and stakeholders to identify the needs; such as better schools settings, comprehensive professional development program for elevating the qualities of teaching, and learning to overcome 21st challenges.

The present study applied Technology, Pedagogy, and Content Knowledge Short and Quick (TPACK-SQ), a notion built on an integrated framework determined by the theoretical principles of the TPACK model found by Schmidt et al. (2009). This framework was developed and implemented among pre- and in-service teachers in the attempt to validate and sustain TPACK-SQ overall and its components collectively (TPK, TCK and PCK).

The investigation showed that TPACK-SQ can be used effectively to further in-school professional development of science and mathematics teachers in relation to the integration of educational technology in their practice. This includes classrooms, schools, and virtual learning environments.

The presentation of the general outcome of TPACK-SQ is followed by a report on the impact of workshop participants' representations of TPACK-SQ components and their views of and ability to integrate technology in science and mathematics practice. TPACK- SQ is reliable with respect to exploratory factor analysis in a new setting, or contexts.

Finally, in light of the challenges that emerged in relation to the use of this framework, we make suggestions regarding future research and applications of TPACK-SQ in science and mathematics teacher preparation.

The findings can be used by science and mathematics head teachers, administrators, and curriculum developers to 1) better understand the nature of TPACK-SQ and its components and their implications for teacher professional development, 2) extend the knowledge of science and mathematics teachers' perceptions of TPACK-SQ, 3) enhance the knowledge of science and mathematics teachers' willingness to adopt TPACK-SQ in learning activities, and 4) based on the challenges identified, make suggestions regarding future research and applications of TPACK-SQ in science and mathematics education. Finally, in light of the challenges that emerged in relation to the use of this framework, we make suggestions regarding future research and applications of TPACK-SQ in science and mathematics teacher preparation.

In addition, the in-service teachers may have no choice other than shifting to the traditional method because of the school context (Alhashem, & Alkandri, 2015). Teaching science or mathematics with a traditional method due to the lack of resources at schools and few or no professional development courses may have affected the in-service teachers results. The findings showed a gap between the college and field settings. In-service teachers' lack of professional development during their service at school may also have an effect on teachers' abilities to reflect back on their knowledge (Alhashem, & Alkandri, 2015).

Implications for Further Studies

Our final thought for this study is that TPACK-SQ can be used as reliable and valid assessment tool survey. We hope that curriculum developers, professional development leaders, and teachers will take advantage of the TPACK-SQ model to integrate its domains into the teaching of science and mathematics. We recommend that stakeholders mount TPACK-SQ model workshops, not only for math and science teachers but also in other subjects.

More research is needed to expand the TPACK model as a form of professional development or curriculum implementation. The presentation of the general outcome of TPACK-SQ is followed by a report on the impact of workshop participants' representations of TPACK-SQ components and their views of and ability to integrate technology in science and mathematics practice.

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APPENDICES

APPENDIX 1

Appendix Table 1 Rotated component matrix

		1	2	3	4	5
1	TK1			.755		
2	TK2		.460	.693		
3	TK3			.781		
4	TK4			.704		
5	TK5			.751		
6	TK6			.721		.439
7	TK7		.401	.477	.551	
8	CK1	.487			.610	
9	CK2				.714	
10	CK3				.766	
11	PK1	.696	.356			
12	PK2	.774				
13	PK3	.740	.396			
14	PK4	.609	.426			
15	PK5	.706	.450			
16	PK6	.760				
17	PK7	.703				
18	PCK1	.713	.413			
19	PCK2	.696	.397			
20	PCK3	.659				
21	PCK4	.482		.490		
22	PCK5	.619	.435	.414		
23	PCK6	.576	.539			
24	PCK7	.529	.590			
25	TPK1	.478	.468	.421		
26	TPK2	.469	.537			
27	TPK3		.634	.411		
28	TPK4					.742
29	TPK5	.532	.564			
30	TPACK1		.684			.405
31	TPACK2	.396	.751			
32	TPACK3		.750			
33	TPACK4		.699			
34	TPACK5		.681			

APPENDIX 2

Appendix Table 2 TPACK Workshops for Pre-/In-Service Mathematics and Science Teachers in Kuwait

CK (Knowledge of subject area)	**PK** (How to teach)	**TCK/TPK** (How to integrate content and pedagogy with technology)	**TPACK**
The content was focused, limited to mathematics and science learning for middle and high school grades (6–12)	Developing lecturer pedagogical content knowledge through focused professional conversations	TPK: Blog, forums, discussion board, and various social media	An integrated interactive web discussion about science and mathematics topics
	Individualizing group assessment using an e-portfolio	TPK: Cloud-based assessment & reporting -Interdisciplinary evaluation of integration of e-portfolio as a learning and teaching (L&T) tool during professional experience placement	Evaluating science and mathematics work using advanced technological tools
	-Using technology while teaching -Interactive tools to improve students' understanding of environmental aspects of membrane-transport processes in plants	TCK: Digital media content	Utilize digital media while teaching science/mathematics
	-Theseus: A video game for teaching math -Development of experimental and learning environment	TPK: Editing/sharing videos (e.g., Jing, Animoto Photo–Realistic 3D Virtual Models) -Virtual visits: exploring the learning environment	Teaching mathematics/science through videos and 3D virtual models
	Computing & Information Systems Theseus: A video game for teaching philosophy	Maintaining a personal social-media site: Facebook, Myspace, wiki (e.g., Confluence)	Introduce teachers to how to facilitate it in teaching and learning
	YouTube earth science lesson	TPK/TCK: YouTube channels	Connecting teachers to YouTube channels
	Connecting with students, parents, and society -Cultural competence for life	TPK: Editing/sharing documents (e.g., Google online office, blog, interest group forum, digital storytelling) -Web-based course management software (e.g., Moodle, BlackBoard) for learning/content management -Engaging in community of practice (learning discourse approach)	Make teachers active in school society through technology and advanced pedagogical tools