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Technological Pedagogical Content Knowledge: Testing the Assumptions with Teachers of Bhutan

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

There has been an increased and rejuvenated interest in integrating technology in the day to day lives of the teachers, either due to forced circumstances or to catch up to the global education trend. Teachers' knowledge and skills in using technology in the classroom is governed by Technological Pedagogical Content Knowledge (TPACK). While there is a plentiful of assumptions regarding the use of technology in the classrooms, this research investigated the technological components of the TPACK framework. Data was collected from 271 teachers in the various parts of the country. Using descriptive and inferential statistics, the scales in the TPACK was analyzed based on participants' demographic information, such as age, gender, location of the school they are placed at, and teacher certification. Results suggests that there is a gender gap in the scales of TPACK, age and teacher certification are major variables on teachers' competency and knowledge. Recommendations are discussed.

Keywords: TPACK; gender; age; years of service; teacher certification.

1. INTRODUCTION

Teaching is a complicated art that requires teachers to interweave various kinds of knowledge. The dynamism of classroom further requires teachers to constantly shift, evolve and hone their crafts. Emerging context in educational field dictates importance of teachers

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for not only knowing what to teach but how also to teach too. For instance, a study by Polly and Brantly-Dias [1] revealed that though teachers knowledge impact students learning, however, it was observed that what teachers did mattered more than what teachers knew. Koehler et al. [2] assert that for effective teaching there should be flexible access to rich, well organized, and integrated knowledge from different domains including knowledge of student thinking and learning; knowledge of subject matter; and increasingly, knowledge of technology. The authors also assert that at the heart of good teaching are three core components: content, pedagogy, and technology, plus the relationships among and between them. The interactions between and among the three components, playing out differently across diverse contexts, account for the wide variations in the extent and quality of educational technology integration. These three knowledge bases form the core of the technology, pedagogy, and content knowledge (TPACK) framework. Thus, the framework for integration of technology in the field of teaching-learning process called TPACK an acronym for Technology, Pedagogy, and Content Knowledge was born. The TPACK was called initially called “TPCK” in the literature and remained so until 2008 when some in the research community proposed using the more easily spoken term [3].

The framework for TPACK is built on Lee Shulman’s [4] (1986, 1987) construct of pedagogical content knowledge (PCK) by explicitly integrating the component of technological knowledge into the model. It explains how teachers’ understanding of educational technologies and PCK interact with one another to produce effective teaching with technology (Graham [3], Koehler et al. [2]). In the same vein, Margaret [5] defines TPACK as dynamic framework for describing teachers' knowledge required for designing, implementing, and evaluating curriculum and instruction with technology. She adds TPACK strategic thinking includes knowing when, where, and how to use domain-specific knowledge and strategies for guiding students' learning with appropriate information and communication technologies.

There is a predominant notion among the Bhutanese teachers that strong subject matter knowledge is enough for them to be able to teach new content. Conversely, in reality this notion shifts with the awareness of the importance of pedagogical knowledge and knowledge of the content with the advancement of technology in the field of Education. Further, in the era of technology, teaching requires extensively more than delivering subject matter knowledge to students, and student learning is considerably more than absorbing information for later retrieval. Therefore, knowledge of technology becomes an important aspect of overall teacher knowledge in this globalization age as one of the strengths of technology is to support student learning rather than as a tool to deliver the content. Subsequently, teachers not only need to know how to use information and communication technologies (ICT), but also have an awareness of the strategies to incorporate them into teaching a particular subject’s content to enhance students learning. Thus, this study examined the teachers’ knowledge and skills in using technology in the classroom governed by Technological Pedagogical Content Knowledge (TPACK).

1.1 Why Integrate Technology into PCK?

For teachers to be successful in their career, they need to develop themselves in pedagogy, technology, and their content areas. By using information and communication technologies, teachers can follow developments in their areas, transfer the contemporary approaches and applications regarding teaching methods into their instruction, and keep themselves up-to-date. For these reasons, technology plays a critical role for teacher knowledge improvement. In recent years, computer and instructional technologies have become an important part of our lives by affecting our learning and communication. Uses of these technologies in our daily lives become widespread since these technologies provide individuals with many benefits and opportunities. For instance a study by Sahin [6] revealed that computer and instructional technologies not only brought significant novelties to teachers and their classroom instruction when teachers integrated technology into instruction, their students became more interested in the subject and their performance improved.

1.2 Challenges of TPACK

However, integration of technology in teaching learning process is easier said than done. There is no one best method to integrate technology into curriculum. Rather, integration efforts should be creatively designed or structured for particular subject matter ideas in specific classroom contexts. While Graham [3] laments the lack of clear definition of TPACK framework even after decades of research in the field, Koehler et al. [2] list teachers' incapability of overcoming the challenges posed by the emerging newer technologies at their disposal. For instance, particular technologies have their own propensities, potentials, affordances, and constraints that make them more suitable for certain tasks than others. Moreover, the TPACK framework built on the PCK framework and increased the conceptual complexity by at least an order of magnitude. This is because since PCK is foundational to the TPACK framework, researchers must clearly understand PCK before they can productively understand and effectively measure TPACK constructs [2]. Even social and contextual factors also complicate the relationships between teaching and technology. Teachers often have inadequate (or inappropriate) experience with using digital technologies for teaching and learning. Many teachers earned degrees at a time when educational technology was at a very different stage of development than it is today. This claim was supported by a study by Jang and Tsai [7] where they observed that experienced science teachers (seniors) rated their content knowledge and pedagogical content knowledge significantly higher than did novice science teachers (juniors) while it was other way round with technology knowledge and technological content knowledge. Thus, it is not surprising that they do not consider themselves sufficiently prepared to use technology in the classroom and often do not appreciate its value or relevance to teaching and learning. Acquiring a new knowledge base and skill set can be challenging, particularly if it is a time-intensive activity that must fit into a busy schedule. Moreover, this knowledge is unlikely to be used unless teachers can conceive of technology uses that are consistent with their existing pedagogical beliefs [8]. Furthermore, teachers have often been provided with inadequate training for this task. Many approaches to teachers' professional development offer a one-size-fits-all approach to technology integration when, in fact, teachers operate in diverse contexts of teaching and learning.

1.3 TPACK Framework

The concept of TPACK described here has developed over time and through a series of publications, with the most complete descriptions of the framework found in Mishra and Koehler (2006) and Koehler and Mishra (2008) Koehler et al. [2]. The TPACK framework is most commonly represented using a Venn diagram with three overlapping circles, each representing a distinct form of teacher knowledge (see Fig. 1). The framework includes three core categories of knowledge: pedagogical knowledge (PK), content knowledge (CK), and technological knowledge (TK). The framework proposes that combining these three core types of knowledge results in four additional types of knowledge: pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPACK). Often contextual knowledge is also included as a part of the model (Koehler et al. [2]; Graham [3]. In the ensuing paragraphs, a brief description of each of the knowledge shall be presented.

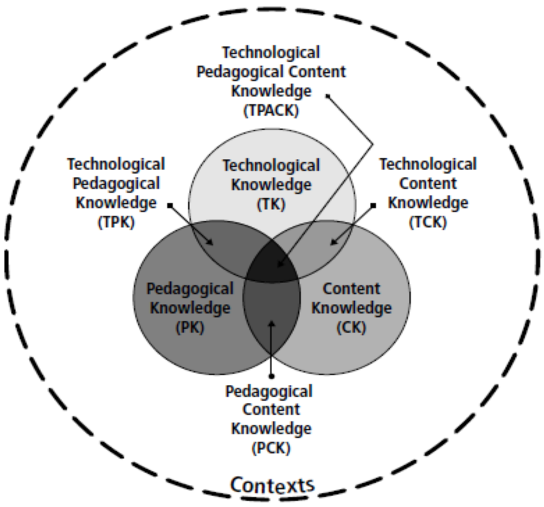

Fig. 1. The Technological Pedagogical Content Knowledge (TPACK) framework

1.4 Content Knowledge (CK)

Content Knowledge deals with "What to teach and learn" part of the TPACK frame work. According to Illustration of Practice of Bhutan Professional Standard for Teachers (hereafter referred to as BPST (Ministry of Education (MoE) [9]). Content knowledge refers to competencies that teachers are expected to master for them to teach efficiently and effectively. It' is teachers' knowledge about the subject matter to be learned or taught [2]. Shulman [4] elaborated content knowledge (CK) as "knowledge about the actual subject matter that is to be learned or taught. . . . including knowledge of central facts, concepts, theories, and procedures within a given field; knowledge of explanatory frameworks that organize and connect ideas; and knowledge of the rules of evidence and proof" (p. 1026). The content to be covered is different for different grades and steam of studies. Knowledge of content is of critical importance for teachers. Like our HM said, you cannot give what you do not have. The cost of not having a comprehensive base of content knowledge can be prohibitive; for example, students can receive incorrect information and develop misconceptions about the content area.

1.5 Pedagogical Knowledge (PK)

Pedagogical knowledge deal with "How to teach and learn" part of the TPACK framework. According to Illustration of Practice of Bhutan Professional Standard for Teachers (hereafter referred to as BPST, MoE [9]) Pedagogical knowledge refers to a teacher's ability to apply knowledge on classroom management, teaching methods, teaching strategies, and assessment practice in the subject taught. It "is deep knowledge about the processes and practices or methods of teaching and learning and how it encompasses, among other things, overall educational purposes, values, and aims. This is a generic form of knowledge that is involved in all issues of student learning, classroom management, lesson plan development and implementation. It includes knowledge about techniques or methods to be used in the classroom; the nature of the target audience; and strategies for evaluating student understanding." (Shulman [4], p. 1026-1027). A teacher with deep pedagogical knowledge understands how students construct knowledge and acquire skills, and how they develop habits of mind and positive dispositions toward learning. As such, pedagogical knowledge requires an understanding of cognitive, social, and developmental theories of learning and how they apply to students in the classroom [2].

1.6 Pedagogical Content Knowledge (PCK)

The union of content knowledge and pedagogical knowledge gives Pedagogical Content Knowledge (PCK). Every day, a teacher applies his/her knowledge of content and pedagogy in the teaching-learning process. A teacher's knowledge of subject content and application of pedagogical knowledge influences learners' engagement and achievement. A teacher must possess appropriate, in-depth and broad knowledge of concepts and pedagogical practices to make every learning meaningful (MoE, [9]). It "exists at the intersection of content and pedagogy. Thus, it goes beyond a simple consideration of content and pedagogy in isolation from one another. PCK represents the blending of content and pedagogy into an understanding of how particular aspects of subject matter are organized, adapted, and represented for instruction." (p. 1021). PCK is the transformation of knowledge for teaching. According to Shulman [4] this transformation occurs as the teacher simplifies the subject matter, resorts to multiple ways to represent it, and adapts and tailors the instructional materials to alternative conceptions and students' prior knowledge. PCK also covers the core business of teaching, learning, curriculum, assessment, and reporting, as well [2].

1.7 Technological Knowledge (TK)

It is difficult to define Technology Knowledge (TK) in the TPACK framework as it is always in a dynamic state compared to other two core knowledge domains [2]. However, Shulman [4] defines it as "knowledge of operating systems and computer hardware, and the ability to use standard sets of software tools such as word processors, spreadsheets, browsers, and e-mail. TK includes knowledge of how to install and remove peripheral devices, install and remove software programs, and create and archive documents." (p. 1027). On the contrary Koehler et al. [2] argue that TK must go beyond traditional notions of computer literacy but requires that persons to understand and master information technology for information processing, communication, and problem solving than does the traditional definition of computer literacy.

1.8 Technological Content Knowledge (TCK)

According to Shulman [4] "TCK is knowledge about the manner in which technology and content are reciprocally related. Although technology constrains the kinds of representation possible, newer technologies often afford newer and more varied representation and greater flexibility in navigating across these representations." (p. 1028). Koehler et al. [2] reiterate that TCK is an understanding of the manner in which technology and content influence and constrain one another. Teachers need to master more than the subject matter they teach; they must also have a deep understanding of the manner in which the subject matter can be changed by the application of particular technologies.

1.9 Technological Pedagogical Knowledge (TPK)

TPK is an understanding of how teaching and learning can change when particular technologies are used in particular ways. Shulman [4] defines TPK as “knowledge of the existence, components, and capabilities of various technologies as they are used in teaching and learning settings, and conversely, knowing how teaching might change as the result of using particular technologies.” (p. 1028). Thus, TPK requires a forward- looking, creative, and open-minded seeking of technology use, not for its own sake but for the sake of advancing student learning and understanding [2].

1.10 Technological Pedagogical Content Knowledge (TPACK)

Technological Pedagogical Content Knowledge (TPACK) is an emergent form of knowledge that goes beyond all three “core” components. It is peaceful fusion of core three components. As asserted by Koehler et al. [2] TPACK is the basis of effective teaching with technology, requiring an understanding of the representation of concepts using technologies, pedagogical techniques that use technologies in constructive ways to teach content, knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face (p. 1029). By simultaneously integrating knowledge of technology, pedagogy, content, and the contexts, expert teachers bring TPACK into play any time they teach. Each situation presented to teachers is a unique combination of these three factors.

1.11 Hypothesis

The following hypothesis were tested in this research;

1. H_0 Technical competencies are not dependent on teachers’ gender.
2. H_0 There is no relationship between teachers’ qualification and the use of technology for teaching
3. H_0 There is no statistically significant differences between teachers’ years of experience and technical skills.
4. H_0 There is no difference in the use of technology for teaching based on the location of the school.

2. RESEARCH METHODOLOGY

The researcher employed quantitative method with a cross sectional survey design to collect data from twenty six school teachers.

2.1 Sampling and Data Collection Procedure

Twenty-six schools from rural, three from semi-urban, and ten each from semi-rural and urban schools contributed data for the study. 42.8 % of these schools were Primary school, 28.6 % each were Lower secondary schools and Middle secondary school. Out of the 271 teacher participants, 116 were female and 154 were male.

7.8 percent of the participant were below the age of 25, 28.3 percent were between 26 and 30, 28.3 percent were between 31 and 35, 21.9 percent were between 36 and 40, and 13.8 percent of the participants were more than 41 years old.

Data was collected using and adapted version of TPACK Questionnaire [10]. Four scales from the original questionnaire were retained to focus on the research objectives; Technology Knowledge (TK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPACK). Demographic questions, such as age, years of teaching experience, subject(s) taught in the school and level of school were included.

2.2 Data Analysis

In order to test the hypotheses formulated for the study, both descriptive and inferential statistics such as mean standard deviation, ANOVA and M ANOVA were adopted.

3. RESULTS AND DISCUSSION

A principal component factor analysis was conducted on items adopted from the TPACK questionnaire by Schmidt et al. [10] including

Varimax (orthogonal) rotation with Kaiser Normalization. Kaiser-Meyer-Olkin Measure of Sampling Adequacy was obtained at .927 and the Bartlett's tests of sphericity was significant at p< .000. Cronbach's alpha for all the scales in the questionnaire was calculated. Factor loading and the internal consistency measured through Cronbach's alpha is given in Table 2. The extracted factors explained a total of 66.51% of the variance. Factor 1 explained 46.47%. factor 2 explained 8.18%, factor 3 explained 6.84% and factor 4 explained 5.02 percent of the variance.

Factor 1 corresponds to the items in the TPACK scale, Factor 2 to TPK, Factor 3 corresponds to TK scale, and Factor 4 to TCK.

Teachers' technology knowledge (TK) was assessed through six 5-point Likert items. TS refers to teacher knowledge about traditional and new ways technologies that can be integrated into the curriculum. The means obtained for all the statements were in the range of 3.09 to 3.80, while the standard deviation ranged from 0.788 to 1.020. The mean and standard deviation for the scale was obtained at 3.44 and 0.88 respectively. Results indicate that teachers are fairly competent in technological knowledge. However, with a standard deviation of 0.88, there appears to be variations among the participants regarding their competence in technological skills.

Teachers' technological content knowledge (TCK) was measured using four 5-point Likert items scale. TCK refers to the knowledge of the reciprocal relationship between technology and content. According to Koehler et al. (2014) disciplinary knowledge can be defined and constrained by technologies and their representational and functional capabilities. The mean and standard deviation for this scale were obtained as 3.73 and 0.90 respectively. Results suggest that teachers are able to integrate technology and content together for instruction in the classroom. The mean standard deviation obtained for this scale indicated that there were wider variations among the participants' scores.

Technological pedagogical knowledge (TPK), defined as an understanding that technology can constrain and assist specific pedagogical practices, was measured through six 5-point Likert items. The mean obtained was 3.86 and the standard deviation was 0.74. From among the three scales, teachers understanding of TPK was better than TK and TCK.

TPACK is defined as the knowledge about the complex relations among technology, pedagogy, and content that enables teachers to develop appropriate and context-specific teaching strategies (Koehler et al., 2014). TPACK was measured through 4 Likert type items. The descriptive results of TK, TCK, TPK, and TPACK is shown in Table 3.

Table 1. Representing participants demographic results

Demographics	**Variations**	**n**	**Planning**	**Teaching**
			Yes (%)	**Yes (%)**
Years of teaching experience	1 to 5	83	83.1	78.3
	6 to 10	89	87.5	83.1
	11 to 15	43	83.3	76.2
	16 and more	55	72.2	55.6
Location	Rural	117	86.3	78.6
	Semi-Rural	64	90.6	71.9
	Semi-Urban	20	80	75
	Urban	70	67.6	72.1
School Level	Lower Primary	2	50	50
	Upper Primary	120	74.8	64.4
	Lower Secondary	73	86.3	84.9
	Middle Secondary	76	91.9	82.9
Gender	Male	154	85.5	74.5
	Female	116	79.1	75.7
Subject(s) Taught	English	133	78.9	76.7
	Dzongkha	65	72.3	67.2
	History/civics/ geo	79	81.8	76.9
	Mathematics	107	80	72.4
	Science	76	89.5	82.9
	Other	37	80.6	81.1

Table 2. Representing factor loadings of the items and Cronbach's alpha

	Component (Alpha)			
	1 (.894)	**2 (.872)**	**3 (.857)**	**4 (.826)**
18. I know how to solve my own technical problems.			.630	
19. I can learn technology easily.			.625	
20. I keep up with important new technologies.			.733	
21. I frequently play around with technology.			.757	
22. I know about a lot of different technologies.			.738	
23. I have the technical skills I need to use technology.			.582	
24. I know about technologies that I can use for understanding and doing mathematics.				.624
25. I know about technologies that I can use for understanding and doing language.				.705
26. I know about technologies that I can use for understanding and doing science.				.669
27. I know about technologies that I can use for understanding and doing social studies.				.719
28. I can choose technologies that enhance the teaching approaches for a lesson.		.757		
29. I can choose technologies that enhance students' learning for a lesson.		.772		
30. I am thinking critically about how to use technology in my classroom.		.681		
31. I can adapt the use of the technologies that I am learning about to different teaching activities.		.648		
32. I can select technologies to use in my classroom that enhance what I teach, how I teach and what students learn.		.738		
34. I can choose technologies that enhance the content for a lesson.		.625		
35. I can teach lessons that appropriately combine mathematics, technologies and teaching approaches.	.770			
36. I can teach lessons that appropriately combine literacy, technologies and teaching approaches.	.726			
37. I can teach lessons that appropriately combine science, technologies and teaching approaches.	.804			
38. I can teach lessons that appropriately combine social studies, technologies and teaching approaches.	.774			

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 6 iterations.

Table 3. Showing Scale means and standard deviations

	N	**Mean**	**Std. Deviation**
	Statistic	**Statistic**	**Statistic**
TK	271	3.4669	.67166
TCK	271	3.3733	.72527
TPK	271	3.8560	.57727
TPACK	269	3.3346	.76074
Valid N (listwise)	269		

3.1 Analysis of Variations within the Population

To determine the variations within the samples of the population, Analysis of Variance (ANOVA) and Multiple Analysis of Variance (MANOVA) were performed using the means of the scales of TPACK and teacher demographics. We obtained non-significant differences for the following independent variables, region, location, category of school (Autonomous or other), boarding school or day school, teacher qualification, and level of school. On the contrary, we obtained significant differences within the scores while using gender and age range as independent variables.

3.1.1 Gender

Teachers' mean scores of TS, TCK, TPK, and TPACK were analyzed using gender to determine if they differed significantly. One-way ANOVA revealed that the difference between male and female teachers' competencies in all the scales were significant, see Table 4. The scores on TK differed significantly between male and female teachers at $F\ (1,\ 268) = 9.556,\ p = .002.$ Male and female teachers' scores on TCK differed significantly at $F\ (1,\ 268) = 9.000,\ p = .003.$ Similarly, for TPK the following equation was obtained, $F\ (1,\ 268) = 4.213,\ p = .041.$ In terms of TPACK, the scores of male and female teachers differed significantly at $F\ (1,\ 268) = 12.4999,\ p <.000.$ Male teachers reported a higher mean score in all the scales compared to female teachers. This indicates that male teachers reported that they were comparatively more proficient in technology knowledge, technological content knowledge, technological pedagogical knowledge, and technological pedagogical content knowledge than their female counter-parts.

3.1.1.1 H_0 technical competencies are not dependent on teachers' gender

Technical competence, or Information Communications Technology (ICT) use, differ based on gender [11]. Male teachers are reported to be more proficient and confident in the use of technology in the teaching and learning process. Cai, Fan, and Du [12], based on a meta-analysis of literature from 1997 to 2014 concluded that male still hold a more favourable attitudes towards technology use. Specifically in terms of teaching faculty, Šabić, Baranović, & Rogošić [13] asserts that there are minor gender differences in teachers' self-efficacy for using ICT in Croatia today, male teachers being more proficient and willing to use technology in the classrooms. The findings of this research resonate with the differences reported in literature about the male and female teachers' adoption and use of ICT in the classrooms. In all the scales used in this research, TK, TCK, TPK, and TPACK female teachers were lagging behind male teachers, and the differences were significant.

3.1.2 Qualification

7.7 percent of the teachers held a master's degree, 74.9 percent held a bachelor's degree, 4.8 percent had diploma, and 12.5 percent had certificate. Results from Table 5 indicate that teachers with a master's qualification are more competent in TK, TPK, and TPACK. Teachers' holding a bachelors degree had the highest mean score in TCK.

One way ANOVA results suggest that there were significant differences between the groups of participants since the equations obtained was $F = (3,\ 267) = 3.829,\ p = .010.$ Post-hoc analysis revealed that there were no significant differences between teachers' holding a bachelors and master's degree in any of the scales. However, teachers with Master's (M = 4.03, SD = .48) and Bachelor's degree (M = 3.39, SD = .55) had a greater knowledge of TPK compared to teachers with Diploma (M = 3.49, SD = .72) and Certificate level (M = 3.26, SD = .65) certifications.

3.1.2.1 H_0 There is no relationship between teachers' certification and the use of technology for teaching

Teacher certification in the context of this research refers to teacher training. In this research data was gather for four teacher certifications; Certificate, Diploma, Bachelors, and Masters. Darling-Hammond, Berry, and Thoreson [14] assert that teacher certification matter, since the professional teacher preparation has different focus and procedures. Dunst, et al. [15] based on the review of different professional teacher preparation found that ICT based instruction were significantly associated with larger student achievement outcome. The results of this research confirms that there are significant differences in teachers' technological pedagogical knowledge based on their certification. Teachers who had at least either

Master's and Bachelor's certification were more competent in TPK compared to teachers with Diploma and who held a teaching Certificate.

3.1.3 Age

Literature suggests that an individual's Technology Skills, Technological Content Knowledge, and Technological Pedagogical Knowledge depends on their age. The distribution of teachers' years of teaching experience against their age is shown in Table 6. Thirty-seven teachers were beyond forty-one years of age and thirty-six had more than 16 years of teaching experience. To find out if the mean scores on the three scales within the population differed in terms of age a one-way MANOVA was conducted.

Table 4. Summary of ANOVA results

		Sum of Squares	df	F	Sig.	Gender	N	Mean	Std. Dev.
TK	Between Groups	4.194	1	9.556	.002	Female	116	3.32	0.58
	Within Groups	117.610	268			Male	154	3.57	0.72
	Total	121.804	269			Total	270	3.47	0.67
TCK	Between Groups	4.610	1	9.000	.003	Female	116	3.22	0.70
	Within Groups	137.276	268			Male	154	3.49	0.73
	Total	141.885	269			Total	270	3.37	0.73
TPK	Between Groups	1.389	1	4.213	.041	Female	116	3.77	0.60
	Within Groups	88.357	268			Male	154	3.92	0.56
	Total	89.746	269			Total	270	3.85	0.58
TPACK	Between Groups	6.956	1	12.499	.000	Female	116	3.15	0.73
	Within Groups	148.029	266			Male	154	3.48	0.76
	Total	154.984	267			Total	270	3.34	0.76

Table 5. Showing Descriptive results of scales segregated by qualification

	N	TK		TCK		TPK		TPACK	
		Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Master	21	3.52	0.69	3.26	0.80	4.03	0.48	3.48	0.70
Bachelor	203	3.50	0.65	3.43	0.68	3.89	0.55	3.37	0.76
Diploma	13	3.19	0.96	3.04	1.08	3.49	0.72	3.27	0.69
Certificate	34	3.32	0.63	3.26	0.77	3.68	0.65	3.09	0.83
Total	271	3.47	0.67	3.37	0.73	3.86	0.58	3.33	0.76

Table 6. Representing Participants' age and years of teaching experience

Age range/ Years of experience	1 to 5	6 to 10	11 to 15	16+	Total
18 to 25	20	1	0	0	21
26 to 30	56	19	1	0	76
31 to 35	6	59	11	0	76
36 to 40	1	9	30	18	58
41 +	0	1	0	36	37

A one-way MANOVA revealed a significant multivariate main effect for age, Wilkis' λ =.880, *F* (12, 693.47) = 2.861, p<.001, partial eta squared = 0.042. Power to detect the effect was .976. Thus, the hypothesis of the inverse relation of age and adoption of technology was confirmed. Given the significance of overall test, the univariate main effects for age were examined. Significant univariate main effects were obtained for the means of technology knowledge, F (4, 269) =6.987, p < 0.001, partial η^2 = 0.096, power =.994; and technological pedagogical knowledge, F (4, 269) = 3.873, p <.004, partial η^2 = .055, power = .896.

Significant age range pairwise differences were obtained in technology skills mean scores between teachers of more than 41 years of age and 18 to 25 years, 26 to 30 years, and 31 to 35 years. The mean technology skills scores were 3.00 for teachers of more than 41 years of age, 3.37 for teachers between 31 and 35 years, 3.60 for teachers' age ranging from 26 to 30, and 3.74 for teachers between 18 and 25 years of age. This suggests that younger teachers are more technologically competent in terms of technology skills than their senior counterparts. Similarly, a significant age range pairwise difference was obtained in technological pedagogical knowledge scale between teachers of age range within 26 to 30 and 36 to 40 years. The mean technological pedagogical knowledge scores were 4.00 for teachers of 26 to 30 years of age and 3.69 for 36 to 40 years of age.

3.1.4 Location

43.2 percent of the schools the teachers were serving in were rural school, 23.6 percent of the schools were located at semi-rural areas, 7.4 percent were in semi-urban schools, and 25.8 percent were located in urban areas.

According to the results in Table 7, teachers of Semi-urban schools reported the highest mean in TK, and TCK, while the teachers of Rural schools reported the highest means in TPK and TPACK. A one-way ANOVA revealed a significant difference in the TK scale at *F(3, 267) = 2.748, p =.043.* Post-hoc analysis revealed that teachers of rural schools (M = 3.57, SD = .061) were more proficient in TK compared to teachers of semi-rural (M=3.34, SD = .064) and teacher of urban schools (M=3.37, SD = .072).

3.1.4.1 H_0 There is no difference in the use of technology for teaching based on the location of the school

Contrary to common beliefs, teachers in remote schools reported the highest mean scores in TPK and TPACK. Furthermore, teachers in remote schools revealed significantly higher scores in technology knowledge compared to teachers of semi-rural and urban schools. This may be explained based on the implementation of teacher human resource policy [16]. Newly recruited teachers are placed in remote schools for a minimum duration, and hence they are younger with greater technology knowledge compared to their senior peers.

3.2 Teaching Experience

In terms of years of teaching experience, 30.6 % had one to 5 years of experience, 32.8 % had six to ten years of experience, 15.9 percent had eleven to fifteen years of experience, and 20.3 % had more than sixteen years of teaching experience. Results from Table 8 suggests that teachers with one to 5 years of teaching experience had the highest mean scores in all the scales.

One way ANOVA results obtained suggest that there are significant differences between the groups of participants in terms of TK , *F (3, 266) = 9.344, p<.000;* TCK, *F (3, 266) = 3.381, p = .019;* and TPK, *F (3, 266) = 3.430, p = .018.* There were significant differences between the scores of teachers with one to five years of teaching experience and the scores of teachers with six to ten years and more than sixteen years of teaching experience in terms of TK. Compared to six to ten and more than sixteen years of teaching experiences, teachers with one to five years of experiences reported a greater score in TK. There were also significant differences between the scores of teachers with six to ten years of experience and eleven to fifteen years of teaching experiences to the teachers with more than sixteen years of teaching experiences. Teachers who had more than sixteen years of experience had the lowest TK, compared to all other groups.

In terms of TCK, a significant difference was observed only between two groups of teachers, one to five years and more than sixteen years of teaching experiences. The former group reported a higher score compared to the teachers with more than sixteen years of teaching experience.

Table 7. Showing Descriptive results of the scales based on location

Location	TK			TCK		TPK		TPACK	
	N	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
Rural	117	3.57	0.61	3.45	0.66	3.95	0.53	3.39	0.71
Semi-Rural	64	3.34	0.64	3.27	0.71	3.78	0.48	3.23	0.82
Semi-Urban	20	3.64	0.82	3.46	0.85	3.79	0.62	3.33	0.69
Urban	70	3.37	0.72	3.32	0.80	3.78	0.69	3.33	0.81
Total	271	3.47	0.67	3.37	0.73	3.86	0.58	3.33	0.76

Table 8. Representing Descriptive results of all the scales against years of teaching experiences

	TK			TCK		TPK		TPACK	
	N	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
1 to 5 yrs	83	3.72	0.57	3.54	0.69	3.99	0.56	3.47	0.75
6 to 10 yrs	89	3.43	0.67	3.36	0.70	3.88	0.52	3.38	0.75
11 to 15 yrs	43	3.49	0.57	3.41	0.61	3.77	0.56	3.27	0.67
16+ yrs	55	3.14	0.75	3.15	0.80	3.70	0.64	3.14	0.78
Total	270	3.47	0.67	3.38	0.71	3.86	0.57	3.34	0.75

For TPK, there were significant differences in the scores of teachers with one to five years of teaching experience compared to teachers with eleven to fifteen years of experiences and teachers with more than sixteen years. Teachers with one to five years of teaching experiences reported higher scores compared to the other two groups of teachers.

3.2.1 H_0 There is no statistically significant differences between teachers' years of experience and technical skills

Literature on the relationship between teachers' years of experience and age to the use of ICT in teaching and learning, suggests that the relationship is inverse (Cabero & Barroso [17]; Šabić, et al. [13]). The findings of this research confirm the claims that younger teachers are more knowledgeable and more proficient in the use of technology. Out of the four scales, younger teachers with one to five years of teaching experience reported a higher and significant differences with the other groups of teachers (six to ten years, eleven to fifteen years, and more than sixteen years). Significant differences were obtained for technology knowledge, technological content knowledge, and technological pedagogical knowledge.

In a similar manner, younger teachers in terms of their age were found to significantly differ in the scores compared to other age groups. Younger teachers reported a higher knowledge and ICT competencies. Similar findings were obtained by Guillén-Gámez, Lugones, Mayorga-Fernández, [18].

4. RECOMMENDATIONS

In lieu of the findings of this research, the following recommendations are made;

- Teachers' professional capacities on ICT and specifically on the various components of TPACK needs to be built. Such a program should include the elements of effective professional development capacities synthesized by Darling-Hammond et al. [19] on behalf of the Learning Policy Institute.
- Teacher professional development programs could be focused more on female teachers and senior teachers since their reported competencies is lower compared to male and younger teachers.
- Teachers' with diploma and teaching certificate require more professional development programs on integrating technology in their classrooms.

5. CONCLUSION

Teachers of late have been compelled to use more and more of information and communications technology in their classrooms. TPACK offers a framework for integrating technology proficiently in the teaching and learning processes. However, achieving this feat is easier said than done. This research tested some long-held hypotheses about information and communication technologies based on the variables such as gender, age, location of the school placements, and teacher certification on technology knowledge, technological content knowledge, technological content knowledge and technological pedagogical content knowledge. While acknowledging the existence of other confounding factors, such as access and availability of ICT facilities, both in personal and professional lives, there is a gender gap in the knowledge and conceptions of proficiency in the use of ICT for teaching and learning process. Similarly, teachers' age which also corresponds to the number of years teachers have spent in the teaching profession has a significant bearing on their conceptions of proficiency and knowledge about technology. Teacher certification also plays a significant role in teachers' conceptions about proficiency and knowledge of ICT. Teachers with a certification equivalent to undergraduate degree or higher are much more comfortable in the knowledge and use of technology in their classrooms compared to those who do not have an undergraduate degree or an equivalent.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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