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Examining Cambodian high school science teachers' perception of Technological Pedagogical Content Knowledge (TPACK)

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Abstract: The purpose of this study is to assess Cambodian high school science teachers' perceptions of Technological Pedagogical Content Knowledge (TPACK) knowledge domains, including content knowledge (CK), pedagogical knowledge (PK), technological knowledge (TK), pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK) and TPACK and investigate the relationship between knowledge domains with some demographic variables such as gender, qualification, age, teaching experience, school type and school location. The study surveyed 240 Cambodian high school science teachers using a self-rating questionnaire. Data analyses employed independent samples t-test, One-Way ANOVA and Pearson's correlation statistics to produce findings. The results revealed that Cambodian high school science teachers responding to the survey rated their knowledge relatively high for the CK, PK, PCK and TK, but relatively low for TCK, TPK and TPACK. Difference analyses affirmed that only the school-type variable indicated the difference in the four technology-related knowledge domains of TPACK. Age and teaching experience had negative correlations solely with the four technology-related domains. In conclusion, Cambodian high school science teachers have enough knowledge in (1) subject contents, (2) teaching strategies of their subject matter, and (3) ICT for administrative works and to support subject-matter-related works. Cambodian high school science teachers need more knowledge of specialised ICT for education to improve their teaching and enhance students' learning on their subject.

Keywords: Cambodian education; educational technology; science education; science teacher; TPACK.

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INTRODUCTION

Technological pedagogical content knowledge was first postulated by Koehler and Mishra (2005), denoted as TPCK, and was changed to Technology, Pedagogy and Content Knowledge by Thompson and Mishra (2007), suggested as a Total PACKage (TPACK) for effective teaching with technology (Voogt, Fisser, Pareja Roblin, Tondeur, & van Braak, 2013). TPACK has emerged as a widely accepted framework for information and communication technology (ICT) integration in teaching (Graham, 2011) and become a much-discussed research topic (Chai, Koh, Tsai, & Tan, 2011). The framework of TPACK has been adopted in various settings (Pamuk, Ergun, Cakir, Yilmaz, & Ayas, 2015).

The Education for All National Plan 2003-2015 was an unprecedented official document of Cambodia that mentioned ICT policy in Cambodian education. Since then, significant strategic policies, plans, projects, and programs have been documented and implemented concerning ICT in education. One of the specific goals was to enhance the quality of teaching and learning through ICT integration.

Although much effort has been made over these last two decades, ICT usage in teaching and learning remains limited (MoEYS, 2019), as can be seen in the baseline statistics of the Education Strategic Plan (2019-2023) showing only five per cent of upper secondary schools used ICT as a supporting tool in teaching and learning. Fortunately, enormous efforts and investments in distance learning during the COVID-19 outbreak fostered digital transformation and proliferated ICT in education in Cambodia (Heng, 2021; Thy, Ly, & Ean, 2023). In this regard, there is a lack of empirical evidence about the integration of ICT in teaching and learning in Cambodia, especially through the TPACK lens. While TPACK internationally has been regarded as special knowledge to optimize or integrate ICT in teaching and learning (Chai, Koh, Tsai, et al., 2011; Graham, 2011), through a Google Scholar search with a broad keyword like "TPACK AND Cambodia", merely, a relevant publication was found. It was a study conducted by Chea, Bo, and Minami (2022) to assess Cambodian secondary school teachers' readiness to adopt distance teaching during the school closure due to the COVID-19 outbreak, with which the TPACK self-rating score indicates the readiness level. The study broadly investigated the secondary education level as a whole (i.e., grades 7 to 12) and teaching staff in social and hard science disciplines, aimed to compare secondary resource schools, which received technical and financial support to enhance ICT for teaching and learning through the Upper Secondary Education Sector Development Program (USESDP 2), with ordinary secondary schools. The study showed that Cambodian teachers indicated low confidence in technology in general (i.e., TK score was below media point). Surprisingly, teachers from the schools with better ICT and related resources and who received ICT training showed lower confidence in all technology-related domains of TPACK compared with teachers from ordinary schools. The authors questioned this finding and suggested further study to answer. The study excluded the New Generation Schools (NGS), another type of school in Cambodia. Therefore, the results did not capture all aspects of schools in Cambodia. The authors also suggested further study with different angles and approaches to triangulate the findings. Furthermore, the literature emphasised that TPACK constructs were developed from complex constructs of PCK, TCK, TPK and TPACK (Lin, Tsai, Chai, & Lee, 2013), and their relationships vary from one context to another (Brianza, Schmid, Tondeur, & Petko, 2022). Based on such a rationale, the current study incorporates NGS in the sample to extend the aspect of school, but in a more specific context, which focuses specifically on science teachers in senior high school, hereafter called high school. The current study aims to investigate how Cambodian high school science teachers perceive TPACK. This paper seeks to answer two research questions as follows:

1. How do Cambodian high school science teachers perceive TPACK knowledge domains? Do their perceptions differ among gender, qualification, school type and school location?
2. How do Cambodian high school science teachers' demographics (i.e., age, teaching experience) and TPACK knowledge domains correlate with each other?

Theoretical background

Based on Shulman (1986), teaching is a complex process that needs to emerge between specialized content knowledge, expertise in the instruction of specialized subjects and general pedagogy called Pedagogical Content Knowledge (PCK). The revolution of technology has reshaped the education systems. Mishra and Koehler (2006) introduced the inclusion of technology into the Shulman (1986) framework to understand the need for teacher knowledge for effective teaching with technology, namely Technological Pedagogical Content Knowledge (TPACK). According to Mishra and Koehler (2006), a teacher's knowledge consists of three main components: content knowledge (CK) (knowledge of the subject matter); pedagogy knowledge (PK) (knowledge of methods and processes of teaching and learning); and technology knowledge (TK) (the understanding of various technologies). The interaction between those components gives four more complex knowledge domains such as pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK) and technological pedagogical content knowledge (TPACK), as shown in Figure 1. While PCK deals with the teaching process with specific content, TCK refers to the knowledge of utilising technology to develop a representation of certain content. TPK is the knowledge of using technology to change the way of teaching, and TPACK refers to the knowledge of teachers to integrate technology into teaching their content subject. Introducing technology in the teaching and learning process was believed to enhance students' 21st-century skills and affect teaching methodology (Koehler et al., 2011).

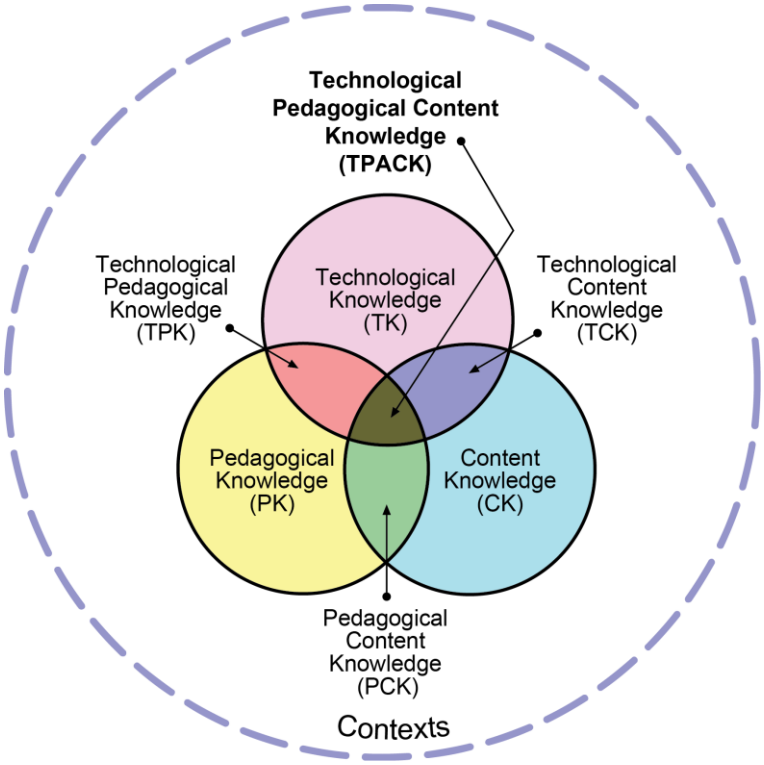

Figure 1. TPACK framework (source of image http://tpack.org)

However, integrating technology into the classroom is not a simple process. Teachers must be able to utilise technology to represent the specific concept differently and more meaningfully (Mishra & Koehler, 2006). OECD (2020) reported that many teachers feel uncomfortable using technology in instruction due to accessibility and ICT competency. The TPACK framework has been used for more than a decade to evaluate teachers' knowledge required for technology integration; this framework shows the relationship between the three bodies of knowledge and the transformation among the overlapping areas. A significant number of empirical studies have been contributing to the development of the theory of TPACK knowledge. Nonetheless, to date, how TPACK constructs were developed, especially in relation to complex constructs of PCK, TCK, TPK and TPACK, and these constructs related to each other remains debated (Lin et al., 2013). Context has been pointed out as a keyword to address the disagreement and proposed as the eighth component of TPACK (Brianza et al., 2022). Therefore, more empirical studies in different contexts must be conducted to contribute to a more comprehensive and precise TPACK framework.

Studies have explored the extent to which teachers have TPACK perception and the factor that predicts TPACK perception. Liu, Zhang, and Wang (2015) surveyed 6650 K12 teachers and reported that teachers rate themselves as high in PK and CK but relatively low in technology-related knowledge domains (i.e., TK, TPK, TCK and TPACK). Similarly, Koh, Chai, and Tsai (2014) studied 354 Singapore teachers and found that teachers were more confident in CK, PK and PCK but not very confident in the technology-related knowledge domains. Likewise, De Freitas (2018) examined 93 Junior High School Mathematics teachers in South Africa and reported that the teachers perceived relatively low scores in TK and even more for the other technology-related knowledge domains. Corresponding results were also reported in studies conducted by Chai, Chin, Koh, and Tan (2013), Jang and Tsai (2013), and Archambault and Crippen (2009) that teachers were more optimistic in non-related technology knowledge domains (i.e., CK, PK, and PCK).

The world today is in the Industrial Revolution 4.0 period, where the rapid advancement of ICT affects all aspects of society, and education is not an exception. Knowing the subject matter and general pedagogy would not be enough for a teacher. Teachers should know about ICT and relevant pedagogy and be able to utilise it to improve teaching and enhance student learning (Noor-Ul-Amin, 2013). Therefore, knowledge about ICT should also be considered an essential criterion for being a qualified science teacher in the current era and future. However, the above literature showed that most teachers are highly confident in subject matter and general pedagogy but need more improvement in technology-related knowledge. Since the level of satisfaction in each domain depends on some variables, including age, gender, and teaching experience, these variables will be discussed in the following sections.

Gender is an important factor in almost all aspects of educational study. Studying under the umbrella of the TPACK framework addressed gender gaps among knowledge domains (Chang, Tsai, & Jang, 2014; Chea et al., 2022; Gómez Trigueros & Yáñez de Aldecoa, 2021; Irwanto, Redhana, & Wahono, 2022; Jang & Tsai, 2013; Jordan, 2011; Koh & Chai, 2011; Lin et al., 2013). Lin et al. (2013) reported that female in-service

science teachers were higher in PK but lower in TK compared to their male counterparts. They addressed ICT was described as a masculine preference, and males had relatively rich experience with computers. However, such differences were not statistically evidenced for the pre-service teacher group. They further suggested that career environment might alter female science teachers' notions of ICTs. Jang and Tsai (2013) discovered that male teachers perceived higher than their female partners in TPACK and TK. Scherer, Tondeur, and Siddiq (2017) uncovered that female teachers indicated lower competencies than male teachers with regard to all technology-related domains (i.e., TK, TCK, TPK and TPACK). Nevertheless, there was no biological explanation for the differences rooted in the social context in which males and females were put (Castéra et al., 2020). Therefore, the relationship between gender and perceived TPACK knowledge domains is still vague and needs more research (Jordan, 2011).

Teaching experience (TE) seems to have a clearer direction of relationship with TPACK knowledge domains, especially for the four technology-related domains (i.e., TK, TCK, TPK and TPACK). Many studies indicated that TE had negative associations with teachers' perception of technology (Jang & Tsai, 2013; Koh et al., 2014; Lee & Tsai, 2010). Lee and Tsai (2010), for example, studied teachers' perception of TPACK knowledge domains regarding educational use of the World Wide Web and revealed that older teachers with more years of experience perceive less self-efficacy of Web-related TPACK. Likewise, Koh et al. (2014), in a study about teachers' perceptions of constructivist-oriented TPACK, found similar relationships that teaching experience was negatively correlated with technology-related knowledge domains. On the other hand, age was found to have inconsistent relationship with teachers' perception of technology. Some studies showed a negative relationship (Castéra et al., 2020; Koh et al., 2014; Lee & Tsai, 2010; Lin et al., 2013), whereas several studies indicated no relationship (Guo, Dobson, & Petrina, 2008; Hsu & Chen, 2018). Even though TE and age are strongly dependent (Castéra et al., 2020), their relationships with technology-related domains of TPACK are somehow different. More empirical examinations are needed.

Besides gender, age and teaching experience, other variables – teacher qualification, school type and location – are observed to see whether they are correlated with teachers' perception of TPACK knowledge domains. In this study, although all schools are public schools incorporating the same prototype, they practically have different conditions, e.g. receiving support differently, technically and financially, due to the school type and location. There are three types of public schools in Cambodia, including Ordinary High Schools (OHS), Secondary Resource Schools (SRS) and New Generation Schools (NGS). OHS and SRS are non-autonomous schools that fixedly follow the Cambodian national curriculum. Teachers and staff are assigned by the Ministry of Education, Youth and Sport (MoEYS). OHS have relatively poor infrastructure, which generally lacks science laboratories and computer labs. SRS have a better infrastructure with a resource building that consists of two science labs, two computer labs with internet services, an e-library and a large seminar room. In addition, SRS receive extra budget and technical support for teacher professional

development. Unlike the previous two, NGS are semi-autonomous and can generate some income in addition to government subsidy, modify the curriculum to suit their context and recruit teachers and staff as needed and wanted. NGS are richer in infrastructure, especially related to ICT. Each teacher receives a laptop computer, a monthly bonus on top of the state salary and technical support from a local non-government organization (NGO). As for teacher qualification in Cambodia, as principals, high school teachers hold a bachelor+1 (4-year bachelor's degree plus 1-year high education teacher training program). In this study, although the target participants were high school teachers, practically, in some schools, junior high school teachers holding secondary education certificates were teaching at high school due to the lack of teachers, especially in rural areas. Besides, some teachers upgraded their qualifications to master's degrees or higher through professional development programs and scholarships. Therefore, researchers hypothesize that these variables (qualification, school type, and school location) may shape different perceptions of TPACK knowledge domains of Cambodian teachers.

METHOD

Participants

The selection of participants followed three steps of the sampling process, as the following. Firstly, the researchers purposively selected one province from each of the four regions of Cambodia (Tonle Sap, coastal and sea, central plain, mountain) and the capital city. Due to the budget constraint, only one best province that represented the uniqueness of its region was selected. Therefore, the researcher decided to do it purposively. In addition, the capital city was in the central plain; however, its characteristics were far different from other provinces in the same region. Secondly, four high schools from each chosen province, with the criteria of being two urban schools and two rural schools, were purposively and conveniently selected, whereas, for the capital, two downtown and two suburban schools. Thirdly, the selection of teachers followed a convenient sampling method, where all approachable science teachers in each selected school, during administering the survey, were requested to participate in this study. It is worth noting that the procedure was trying to collectively cover the characteristics of the sample as much as possible, aiming to have a representative sample of the Cambodian high school science teacher population. When the sample size required was small, together with the complicated nature of Cambodia's geography, employing a random selection method cannot guarantee that all these characteristics are included proportionally in the current study.

The participants of this study were in total 240 science teachers, and 107 were females. The average age was 40.39 (SD = 8.15) and teaching experience was 11.79 years (SD = 8.99). Table 1 shows more details about the participants.

Table 1. Participants of the study by demographics

		Female (%)	Male (%)	Subtotal (%)
Qualification	12 + 2	8 (3.3)	3 (1.3)	11 (4.6)
	Bachelor	85 (35.4)	107 (44.6)	192 (80.0)
	Master or higher	12 (5.0)	23 (9.6)	35 (14.6)
	Other	2 (0.8)	0	2 (0.8)
Major	Physics	18 (7.5)	58 (24.2)	76 (31.7)
	Chemistry	35 (14.6)	43 (17.9)	78 (32.5)
	Biology	40 (16.7)	23 (9.6)	63 (26.3)
	Earth science	14 (5.8)	9 (3.8)	23 (9.6)
School Type	NGS	12 (5.0)	13 (5.4)	25 (10.4)
	SRS	50 (20.8)	66 (27.5)	116 (48.3)
	OHS	45 (18.8)	54 (22.5)	99 (41.3)
School Location	Capital	22 (9.2)	28 (11.7)	50 (20.8)
	Urban	76 (31.7)	78 (32.5)	154 (64.2)
	Rural	9 (3.8)	27 (11.3)	36 (15.0)
Total		**107 (44.6)**	**133 (55.4)**	**240 (100)**

Instrument

The study employed a survey research method. Developed by the researchers, the survey questionnaire, consisting of two sections, was used to collect data. The first section comprises 10 questions about the participants' demographic information. The second section consists of 29 Likert-type scale items, of which 22 items were adopted from the work of De Freitas (2018) and modified to suit the Cambodian context as well as science education, and another 7 items were developed by the researchers to increase the content validity of the instrument to assess participants' perception of TPACK. The work of De Freitas (2018), using a four-point Likert scale, fundamentally relied on the works of Schmidt et al. (2009) and Chai, Koh, and Tsai (2011) who employed a five-point scale. In this study, rather than using a four-point scale, the authors employed a five-point scale the same as the original scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree). For content validity, the instrument was reviewed and approved by a team of science teacher educators and members of the Commission of Research Development and Innovation of the National Institute of Education (NIE) in Cambodia.

Principal Component Analysis (PCA) with Varimax Rotation was performed to assess the internal structure of TPACK since the instrument incorporated adopted items that were contextualized to the Cambodian context and some newly developed items. The minimum factor loading criteria was set to 0.50. The results showed that all communalities were over 0.50. The Kaiser-Meyer-Olkin measure of sampling adequacy was 0.95, above 0.80, and Bartlett's test of sphericity was significant ($\chi 2(406) = 6640.85$, $p < .001$). With eigenvalues greater than one confirmed by parallel analysis (Hayton, Allen, & Scarpello, 2004), the factor solution derived from this analysis yielded three factors for the scale, which accounted for 70.17 per cent of the variation in the data. The reliability of the instrument was assessed on the overall and seven

subscales of TPACK. The internal consistency reliability (Cronbach's alpha) was 0.97 for the overall scale and ranged from 0.80 to 0.92 for the subscales (Table 2).

Data analysis

The raw data collected from the questionnaire were entered into a Microsoft Excel spreadsheet and cleaned. The data analyses were performed using the Statistical Package for the Social Sciences (SPSS v.25). The first research question was examined by analyzing the descriptive statistics of teachers' TPACK ratings, followed by analyses of independent samples t-test and One-Way ANOVA to test demographic differences of gender, qualification, type of school and school location. The second research question was answered by examining the relationship between the perception of TPACK knowledge domains and age and teaching experience using Pearson's correlation statistics.

RESULTS AND DISCUSSION

Research Question 1: How do Cambodian high school science teachers perceive TPACK knowledge domains? Do their perceptions differ among gender, qualification, school type and school location?

Cambodian high school science teachers responding to the survey rated their knowledge relatively high for the CK (Mean = 3.61), PK (Mean = 3.46), PCK (Mean = 3.51) and TK (Mean = 3.16), but relatively low for TCK (Mean = 2.91), TPACK (Mean = 2.47) and TPK (Mean = 2.59), compared to the median score of 3.00. These scores indicate that Cambodian high school science teachers seem to have enough subject content knowledge and teaching strategies on their specialized subject. They also show having basic knowledge and skills on how to use ICT to assist and facilitate their administration work and communication and to support and develop their subject matter; however, they do not seem to be able to utilize ICT to improve their teaching and enhance student's learning on their subject. This result suggests that Cambodian high school science teachers may be more comfortable with traditional teaching aspects, i.e., prefer a whiteboard-pencil/pen-paper-based classroom environment to an ICT-based environment. This trend contrasts with the study of Chea et al. (2022) which found that Cambodian secondary school teachers perceived relatively low in TK but higher in TCK, TPK and TPACK.

Table 2. Descriptive statistics of the seven TPACK knowledge domains

	Number of Items	Mean (N = 240)	Standard Deviation	Cronbach's Alpha
CK	3	3.61	0.82	0.85
PK	5	3.46	0.79	0.92
TK	5	3.16	0.90	0.90
PCK	3	3.51	0.79	0.80
TCK	4	2.91	0.89	0.86
TPK	4	2.59	0.95	0.89
TPACK	5	2.47	0.84	0.87

Independent-sample t-test was performed to test the difference in each TPACK knowledge domain among gender. The result showed no significant difference, meaning that male and female teachers perceived

the same level for all TPACK knowledge domains. In a similar vein, One-Way ANOVA was used for qualification, school type and school location variables. The ANOVA test revealed only school type variable was statistically significant differences in TK ($F(2, 237) = 8.645$, $p = .000$), TCK ($F(2, 237) = 9.074$, $p = .000$), TPK ($F(2, 237) = 7.474$, $p = .001$) and TPACK ($F(2, 237) = 13.906$, $p = .000$). Post-hoc tests (Tukey's HSD) for multiple comparisons were performed, with the results illustrated in Table 3. For all technology-related knowledge domains (i.e., TK, TCK, TPK and TPACK), science teachers from NGS perceived higher levels than SRS and OHS.

Table 3. Results of post-hoc tests for multiple comparisons among school types

			Mean Difference	Std. Error	95% Confidence Interval	
					Lower	Upper
TK	NGS	SRS	0.59**	0.19	0.13	1.05
		OHS	0.81***	0.20	0.35	1.27
	SRS	OHS	0.22	0.12	-0.06	0.5
TCK	NGS	SRS	0.71**	0.19	0.26	1.16
		OHS	0.82***	0.19	0.36	1.27
	SRS	OHS	0.11	0.12	-0.17	0.39
TPK	NGS	SRS	0.72**	0.20	0.24	1.2
		OHS	0.78**	0.21	0.29	1.27
	SRS	OHS	0.06	0.13	-0.24	0.36
TPACK	NGS	SRS	0.88***	0.18	0.46	1.29
		OHS	0.90***	0.18	0.48	1.32
	SRS	OHS	0.02	0.11	-0.23	0.28

*Note: ***p < .001, **p < .01, *p < .05*

The current study indicated consistent findings with Koh and Chai (2011), whose results showed no significant difference in gender in all knowledge domains. Irwanto et al. (2022) demonstrated similar findings, except for PK, that the females showed high than the males. On the other hand, Gómez Trigueros and Yáñez de Aldecoa (2021) spotted that males were perceived as superior to females in TCK, TPK and TPACK, and Jang and Tsai (2013) substantiated only TK and TPACK. Chang et al. (2014) studied two groups of teachers in which each group used a distinct ICT. The result showed a gender difference (i.e., males perceived higher) in one group but not in the other. Lin et al. (2013) discovered that female science teachers perceived higher self-confidence in PK but lower self-confidence in TK than males. Chea et al. (2022) found that male teachers rated higher than their female peers in all domains. Therefore, the position of gender remains contradictory in literature. It is needed to explore more, especially regarding TK and technology-related knowledge domains.

Research Question 2: How do Cambodian high school science teachers' demographics (i.e., age, teaching experience) and TPACK knowledge domains correlate with each other?

Table 4 shows age and teaching experience, although their coefficients are small, denoting a weak association, both significantly and negatively correlated only with the four technology-related domains of TPACK, suggesting that the older or more years of teaching experience, teachers possess less knowledge for integrating technology into their teaching. Regarding age, this result is consistent with Chea et al. (2022). Similar associations between age and technology-related domains were reported by Lin et al. (2013); however, such relationships merely existed among in-service teachers. Koh et al. (2014) found that age had negative correlations with TK, TPK and TPACK, not TCK (not statically significant). As for teaching experience, Koh et al. (2014) reported that teaching experience had negative correlations with the four technology-related. Lee and Tsai (2010) investigated teacher self-efficacy toward web-based TPACK (TPCK-W); they revealed that more experienced teachers perceived low self-efficacy concerning TPCK-W, but those with more experience with the web perceived higher self-efficacy. This discussion suggests that the knowledge teachers have today can be out-of-date tomorrow in this rapid technological development era. Teachers cannot know and master all technologies available, but paying attention to the most relevant ones and trying to utilize and constantly adapt to them in their teaching are necessary endeavours. Although teachers become older, they may still be confident to adopt recent technologies for teaching, as indicated in the study by Lee and Tsai (2010); Otherwise, as becoming older, teachers may lose their confidence and be demotivated to utilise technology.

Table 4. Correlations among seven TPACK knowledge domains, age and teaching experience (TE)

	CK	PK	TK	PCK	TCK	TPK	TPACK
Age	0.031	-0.005	-0.313**	0.011	-0.317**	-0.221**	-0.276**
TE	0.029	-0.011	-0.313**	0.015	-0.307**	-0.219**	-0.263**

*Note: ***p < .001, **p < .01, *p < .05*

CONCLUSION

Through their perceptual rating on TPACK knowledge domains, Cambodian high school science teachers showed evidence of having enough knowledge in (1) subject contents, (2) teaching strategies of their specialised subject, and (3) uses of ICT for administrative works and supporting subject-matter-related works. However, they did not seem to be able to use ICT to improve their teaching and enhance students' learning on their subject. Therefore, Cambodian high school science teachers need more knowledge of specialised ICT for education. Difference analysis revealed that only the school type variable indicated the difference in merely the four technology-related knowledge domains of TPACK (TK, TCK, TPK and TPACK). There was no difference among gender, qualification, and school location. Age and teaching experience have negative correlations with the four technology-related domains of TPACK (TK, TCK, TPK and TPACK).

There are some implications from this study. Teachers' capacity development programs or INSET should focus on ICT in general and on distinct ICTs for each subject and the pedagogical aspects possessed by those ICTs to enhance teaching and learning and, especially, take more care of the older or longer years of experienced teachers. Schools should support and motivate science teachers to integrate ICT into their teaching and learning. Ordinary and secondary resource schools should learn how the New Generation Schools have done with their science teachers concerning ICT. The role of gender concerning perceived TPACK knowledge domains remains unclear; however, that male teachers perceived higher than females in TK or technology-related knowledge domains of TPACK should be hypothesized and proposed for further examination.

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