Teachers' Knowledge and Competence in the Digital Age: Descriptive Research within the TPACK Framework

Liwei Hsu and Yen-Jung Chen

***Abstract*—The present study applied the technological, pedagogical, and content knowledge (TPACK) research model to examine proposed factors that may influence an individual teacher's knowledge on technology, pedagogy, and content at this digital age. These factors refer to background information including age, gender, seniority in teaching career, and qualifications they have as a teacher. Based on quota sampling technique, a total of 333 teachers at vocational high schools in Taiwan took part in this research. The revised TPACK scale was used in this study. Statistical analysis showed that the age and seniority factors produced a significant difference in pedagogical knowledge, while the rest of the factors did not produce a significant difference in the participants' technological, pedagogical, and content knowledge. The possible reasons for this and suggestions for future studies were discussed.**

***Index Terms*—Technological, pedagogical, and content knowledge (TPACK), age, gender, seniority, qualification.**

I. Introduction

Teaching is a highly complex and dynamic activity that involves various types of knowledge for uptake and influencing factors. Multi-knowledge systems are the basis of teaching [1], [2]. Shulman [3] suggested that teachers should have content knowledge, general pedagogical knowledge, curriculum knowledge, pedagogical content knowledge, knowledge of learners and their characteristics, knowledge of educational contexts, and knowledge of educational ends, purposes, and values and their philosophical and historical grounds. Mishra and Koehler [2] noted the increasing influence of technology in education and included technological knowledge as a core knowledge for teachers striving to teach properly. They further agreed with Shulman [3], [4] on the importance of pedagogical content knowledge and came up with the concept of technological, pedagogical, and content knowledge (TPACK).

As discussed above, TPACK covers the relationships between the three facets of knowledge and their interactions. This leads to seven constructs in total: technological knowledge, pedagogical knowledge, content knowledge, technological pedagogical knowledge, technological content knowledge, pedagogical content knowledge, and technological pedagogical content knowledge. According to Mishra and Koehler [2], TPACK can be conceptualized as shown in Fig. 1.

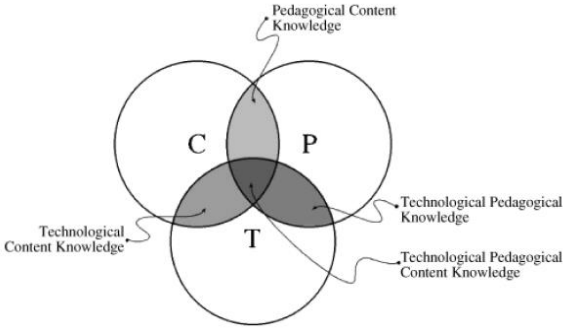

Fig. 1. Theoretical concept of TPACK.

Within the theoretical concept of TPACK, technological knowledge refers to knowledge on science and technology—from using the traditional blackboard, chalk, books, and other tools to applying computers for instruction. The teacher should be able to operate emerging technologies (e.g., networks), install hardware and software installation, and learn and adapt to new technologies for instruction. Content knowledge refers to the teacher's level of proficiency in the knowledge to be delivered. In other words, the teacher must understand the core facts, concepts, theoretical basis, and related evidence for the target content. Pedagogical knowledge refers to the teacher's knowledge about adopting a suitable process or method of teaching. This covers knowledge about students' learning strategies, classroom management, curriculum development and implementation, and other pertinent issues for effective teaching.

In terms of the interactions between the three major knowledges, technological pedagogical knowledge refers to the teacher's ability to apply various types of technologies in a teaching context. Teachers should understand changes that a specific technology will bring forth in teaching. Technological content knowledge refers to a teacher's ability to change the way the target content is presented through the application of science and technology and understand the relationship between technology and teaching content. Pedagogical content knowledge is the teacher's ability to understand the target content and kinds of teaching methods that enhance the effectiveness of teaching at the same time. It also involves the teacher's understanding about students' content schema for the target content and the teaching strategies that he or she will adopt.

TPACK is the teacher's realization of the need to understand how to use technology in constructive ways to present teaching materials and deliver teaching content. The teacher should also know how to use technology to help students solve problems during learning, develop new concepts, or help students understand their existing

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knowledge to learn new knowledge.

Based on this conceptual model for TPACK, scholars have come to various positions. For example, Hilton [5] argued that, although TPACK is described as a seven-oriented cycle, it is essentially the interaction of three essential constructs: the technological, pedagogical, and content knowledges. In practical terms, the intersection of these three basic knowledges indicates the effective use of educational technology to balance the other two facets at the same time. This statement is supported by Peng and Daud [6]. They posited that mutually integrated knowledges are derived from the three essential knowledges and hence have strong common characteristics and relevance.

Nevertheless, Ellis *et al*. [7] regarded all these interrelated knowledges (technological pedagogical knowledge, technological content knowledge, pedagogical content knowledge, and TPACK) as different unique forms of knowledge in the TPACK model. However, they still considered the three essential knowledges as the key elements of TPACK. Based on this background, the present study focused on the role of teachers' demographic variables on their perception of the three essential knowledges for success in the digital age.

II. Method

A. Research Hypotheses

To extend understanding about teachers' demographic backgrounds and the three essential knowledges regarding TPACK, the following hypotheses were proposed for this study:

- Hypothesis 1. Male and female teachers have the same technological knowledge .
- Hypothesis 2. Male and female teachers have the same pedagogical knowledge .
- Hypothesis 3. Male and female teachers have the same content knowledge .
- Hypothesis 4. Teachers of different ages haves the same technological knowledge.
- Hypothesis 5. Teachers of different ages have the same pedagogical knowledge.
- Hypothesis 6. Teachers of different ages have the same content knowledge.
- Hypothesis 7. Teachers with different qualifications have the same technological knowledge.
- Hypothesis 8. Teachers with different qualifications have the same pedagogical knowledge.
- Hypothesis 9. Teachers with different qualifications have the same content knowledge.
- Hypothesis 10. Teachers with different levels of seniority have the same technological knowledge.
- Hypothesis 11. Teachers with different levels of seniority have the same pedagogical knowledge.
- Hypothesis 12. Teachers with different levels of seniority have the same content knowledge.

B. Sampling and Participants

Quota sampling, which is also known as stratified quota sampling, is commonly used in large-scale research.

TABLE I: Demographic Data of Research Participants

Construct	Category	Frequency	Percentage
Gender	Male	109	33%
	Female	224	67%
Age	<25	25	8%
	26–35	169	51%
	36–45	99	30%
	>46	40	11%
Qualification	Fully Certified	205	62%
	Certified with	23	7%
	Provision	8	2%
	Substitute	97	29%
	Teacher		
	No Certificate		
Seniority	<1 year	26	8%
	1–3 years	62	19%
	3–5 years	63	19%
	5–7 years	47	14%
	7–9 years	26	8%
	>9 years	109	31%

TABLE II: Reliability and Validity of the Research Instrument

	Cronbach's α	CR	AVE	TK	PK	CK
TK	0.91	0.91	0.50	0.71		
PK	0.85	0.86	0.55	0.59	0.74	
CK	0.95	0.95	0.61	0.56	0.74	0.78

TK: Technological knowledge; PK: Pedagogical knowledge; CK: Content knowledge

Researchers invite participants based on the known stratification characteristics of the parent group and subjectively select the proportions for research. This sampling method has one advantage in that, if any participant turn down the invitation, the researchers may be able to invite another individual of the same group to fill the spot without affecting the sampling design [8].

Teachers in a hospitality program at vocational high schools of four major regions of Taiwan (northern, central, southern, and eastern) were invited to participate. In total, 333 copies (n = 333) of valid responses were collected for statistical analysis. Table I presents the participants' demographic data.

C. Instrumentation

The research instrument adopted in the present study was designed according to Shulman's [3] work. However, the suggestions of recent academic works [9]-[14] were also considered to revise the questionnaire to better fit in the research context. A panel of five experts was invited to review the questions after the first version of the instrument was finished followed by a pilot study. The results of the pilot study were statistically analyzed with Cronbach's alpha, exploratory factor analysis (EFA), and confirmatory factor analysis (CFA) and indicated that the research instrument was both reliable and valid [15], [16]. Table II details the examination of the reliability and validity.

III. Results

Based on the research hypotheses, the *t*-test and one-way analysis of variance (ANOVA) were performed. Table III presents the results of the hypothesis tests.

The first three research hypotheses (Hypotheses 1–3) were mainly about whether a participant's gender causes any

significant difference in technological, pedagogical, and/or content knowledge. The descriptive statistics indicated that the female teachers scored lower in technological and content knowledges but scored higher in pedagogical knowledge. Table IV presents details on the descriptive statistics.

TABLE III: RESULTS OF HYPOTHESIS TESTS

Construct	Category	F	P
Gender	Technological knowledge	0.12	0.73
	Pedagogical knowledge	60.70	0.01**
	Content knowledge	30.30	0.08
Age	Technological knowledge	0.81	0.49
	Pedagogical knowledge	10.29	0.28
	Content knowledge	20.06	0.11
Qualification	Technological knowledge	0.52	0.67
	Pedagogical knowledge	0.00	0.39
	Content knowledge	0.46	0.71
Seniority	Technological knowledge	10.73	0.13
	Pedagogical knowledge	20.30	0.01**
	Content knowledge	10.82	0.11

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

TABLE IV: DESCRIPTIVE STATISTICS OF GENDER AND THREE KNOWLEDGES

	Gender	Mean	Std. Deviation
Technological knowledge	M	3.75	0.62
	F	3.64	0.66
Pedagogical knowledge	M	3.84	0.73
	F	3.93	0.56
Content knowledge	M	3.79	0.71
	F	3.73	0.62

TABLE V: DESCRIPTIVE STATISTICS OF SENIORITY AND THREE KNOWLEDGES

Seniority		N	Mean	Std. Deviation
Technological knowledge	<1	26	3.82	0.68
	1–3	62	3.52	0.65
	3–5	63	3.71	0.63
	5–7	47	3.82	0.55
	7–9	26	3.54	0.61
	>9	109	3.69	0.66
Pedagogical knowledge	<1	26	3.75	0.58
	1–3	62	3.97	0.57
	3–5	63	3.67	0.74
	5–7	47	3.97	0.49
	7–9	26	3.83	0.56
	>9	109	4.01	0.61
Content knowledge	<1	26	3.64	0.79
	1–3	62	3.73	0.67
	3–5	63	3.65	0.68
	5–7	47	3.87	0.57
	7–9	26	3.52	0.46
	>9	109	3.84	0.65

The *t*-test results indicated that the gender was only a significant factor for the participants' pedagogical knowledge ($F = 6.70$, $p < .01$). Hypotheses 4–6 focused on if age caused significant differences in the three essential knowledges. The results did not show any significant difference. The teachers' qualifications also had no significant effect on TPACK.

Table V compares the teachers' essential knowledges regarding seniority.

The results of the one-way ANOVA indicated that an individual teacher's seniority did have a significant effect on their pedagogical knowledge ($F = 2.30$, $p < 0.01$). The post hoc analysis revealed that, if a teacher had more than 9 years of teaching experience, he or she tended to have more pedagogical knowledge than counterparts with 3–5 years of teaching experience. Such findings suggest that the teacher's teaching techniques, such as the teaching volume, speed, questioning skills, instruction time allocation, and teaching style of response, will improve with experience and thus become more mature.

IV. DISCUSSION

Nowadays, teaching is no longer a simple task. The impact of newly developed technology has raised expectations that teachers effectively integrate technologies in their instructional activities. The present research explored how teachers' demographic background, such as gender, age, qualifications, and seniority, affect their three basic knowledges according to TPACK. The findings indicated that the gender made a significant difference in pedagogical knowledge but not the other two knowledges. Such results are partially in line with the findings of Hsu *et al*. [17]. In other words, female teachers' pedagogical knowledge was significantly higher than male teachers in this study. This may be because females tend to be more attentive and thus more mindful of their interaction with students during instruction. Another reason may be the sampling bias [18] because more females (224 to 109 males) took part in this study. Future research may focus on balancing the gender issue.

Age made no significant difference to the participants' three knowledges. This result differs somewhat from the perception that the younger teachers will tend to have more technological knowledge. Most of the teachers in this present study were aged 26–35 (approximately 50%), and only 11% were over 45 years old. This age gap may not have caused a significant difference because the teachers had similar experiences with technology. Future studies may need to widen the age gap to diversify the participants' ages, which may produce different findings.

The qualifications did not seem to cause significant differences in the teachers' three knowledges. The sampling technique may account for this result: 60% of the participants were fully certified teachers, so their professional training was identical. This could result in insignificant differences in their three basic knowledges.

The last proposed factor was seniority. This factor only caused a significant difference in pedagogical knowledge. Teachers teaching for more than 9 years had the highest score for pedagogical knowledge, which implies that seniority does matter.

V. CONCLUSION

As we enter the digital age, technology has changed the landscape of education. More and more technology-based pedagogy has emerged, such as massive open online courses (MOOCs) and mobile learning. Teachers today need more knowledge to succeed in class. The conceptual model of TPACK was introduced to answer this call. TPACK consists of three essential knowledges—technological, pedagogical, and content—and four integrated knowledges from combining these three essential knowledges. Prior studies [5], [6] suggested that the essential knowledges should be examined before comprehensive research on TPACK. In the

present study, the technological, pedagogical, and content knowledges were investigated for high school teachers in Taiwan. Four factors (gender, age, qualification and seniority) were hypothesized to cause significant differences among participants in their three essential knowledges. The major findings were that age and seniority caused significant differences in pedagogical knowledge, while the other research hypotheses were not significant. The possible reasons for this and suggestions for future studies were discussed.

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