Studies in English Language Teaching
ISSN 2372-9740 (Print) ISSN 2329-311X (Online)
Vol. 8, No. 1, 2020
www.scholink.org/ojs/index.php/selt

Original Paper

The Impact of the Design Teams Approach on Preservice Teachers' TPACK in the Vietnamese Context

Tan, Choon Keong[1*], Nguyen, B.D.[1], Lee, Kean Wah[2] & Kang, Hwa Choo[3]

[1] Faculty of Psychology and Education, University Malaysia Sabah, Jalan UMS, 88999 Kota Kinabalu, Sabah, Malaysia

[2] School of Education, University of Nottingham Malaysia Campus, Jalan Broga, 43500 Semenyih, Selangor, Malaysia

[3] Teacher Training Institute, Kent Campus, Tuaran, Sabah, Malaysia

[*] Tan, Choon Keong, Faculty of Psychology and Education, University Malaysia Sabah, Jalan UMS, 88999 Kota Kinabalu, Sabah, Malaysia

Received: February 9, 2020 Accepted: February 19, 2020 Online Published: February 24, 2020
doi:10.22158/selt.v8n1p85 URL: http://dx.doi.org/10.22158/selt.v8n1p85

Abstract

This study aimed to examine the impact of the design teams approach on preservice teachers' technological pedagogical and content knowledge (TPACK). Using a mixed-method design, the researcher implemented the investigation among 62 teacher candidates whose major was Primary English Teaching at a university of foreign language studies in Central Vietnam. All of the participants attended a course named "Technology in Education", which was adapted based on Johnson's design teams approach model (2014). The data were collected using pre- and post-TPACK Survey, a TPACK Rubric (TIAI) and semi-structured interviews. The findings indicated that this design teams approach had a significant impact on the participants' TPACK, particularly its technology-related knowledge domains (TK, TPK, TCK, TPACK). The result was also confirmed by the teacher candidates' positive responses about their perceptions towards this instructional approach.

Keywords

TPACK (Technological Pedagogical and Content Knowledge), the design teams approach

1. Introduction

As advanced technology has become an integral part of society, technology has exerted a great impact on almost every aspect of life and education is no exception. As a matter of fact, the incorporation of technology as part of curricula has created challenges for educators and teachers, especially those who are about to embark on the journey of the teaching career (Kovalik, Kuo, & Karpinski, 2013). Although there is no denying that most teacher candidates are comfortable with using technology to support their personal lives, communication, entertainment and social networking (Bennett & Maton, 2010; FLuck & Dowden, 2013), their experience of planning and making use of technologies for educational purposes is still limited (Kovalik et al., 2013).

Meaningful technology integration in teaching practice is supposed to go beyond simply using technological tools, such as computers. To be prepared for their future teaching profession, preservice teachers must be trained to learn how to use technologies instructional settings. Some higher institutions have made attempts to address technology use and integration within subject-specific methodology courses with alternative approaches (Dexter, Doering, & Riedel, 2006; Kisicki, 2012). In spite of the fact that these approaches play a better role in fulfilling the need to teach about technology incorporation within the context of content specific curriculum, there are some limitations regarding the number of opportunities preservice teachers can have for teaching with technology in classrooms (p. 658). Obviously, there is no “one-size-fits-all” approach for preparing teacher candidates to teach with technology, yet, teacher educators and researchers are continuing their efforts to look for ways to transform them into successful integrators of technology in their teaching practice. Therefore, this current study sought to explore the effectiveness of a specific instructional approach suggested by Johnson (2014), *the design teams approach*, within the context of an existing teacher preparation program for preservice teachers. The significance of this research partly lies in the fact that the researcher hopes to make contribution to the types of technology integration instruction which can be promising to train teacher candidates who have sufficient knowledge, skills and experience needed to satisfy the technological demands of the 21-century classroom.

In order to measure the efficiency of the design teams approach on preservice teachers’ technology integration, TPACK (Technological Pedagogical and Content Knowledge) was employed as a framework for teacher knowledge as well as an instrument for the study. TPACK was founded on Shulman’s (1986) construct of pedagogical content knowledge (PCK), which is familiar and widely examined in the preparation of science teachers (Aydin & Boz, 2012; Nexvalová, 2011). According to Mishra and Koehler (2006), the basis of this framework is “the understanding that teaching is a highly complex activity that draws on many kinds of knowledge” (p. 1020), which means it is important to consider technology, pedagogy and content knowledge when planning learning activities. Since teachers in the digital age are required to own the ability to harness new technologies in a variety of contexts and for different purposes (Niess, 2008), TPACK allows them to conceptualize and deliver effective learning experiences informed by its seven knowledge subdomains (TK, CK, PK, TCK, TPK, PCK, TPACK) (Angeli & Valanides, 2005).

This study aims to address two research questions:

1. What impact did the integration of a design teams approach into an existing technology integration course have on preservice teachers’ TPACK?

2. What was the preservice teachers' perception of the design team approach-infused course?

The hypothesis for this study is:

H_0: the integration of a design teams approach had no impact on preservice teachers' TPACK.

H_1: the integration of a design teams approach had an impact on preservice teachers' TPACK.

2. Literature Review

2.1 The Design Teams Approach

The design teams approach is grounded in learning theories mainly focusing on such theories related to collaboration, social constructivism (Vygotsky, 1978), constructionism (Harel & Papert, 1990, Papert, 1991), constructivist learning (Jonassen, 1999) and generative learning (Grabowski, 2004). These theories suggest that learning is constructed through interactions with the context, the learners and learning communities.

The design teams approach was also mentioned by Kolodner and her colleagues in 2003 as part of their Learning by Design (LBD) approach. LBD approach has been impacted by numerous theoretical traditions including reciprocal teaching, case-based reasoning (Koehler & Mishra, 2005a); problem-based learning (Han & Bhattacharya, 2001; Koehler & Mishra, 2005a; Kolodner et al., 2003); goal-based scenarios, project-based inquiry science, anchored instruction, knowledge integration and cognitive flexibility theory (Kolodner et al., 2003). Another theory worth a mention is constructionism in which the potential of design-based learning activities was suggested. Other scholars have also highlighted the important role of complex, self-directed, personally motivated and meaningful design projects for students (Harel & Paper, 1990; Blumenfelt et al, 1991; Kafai, 1995). In addition, design-based approaches are supported by problem-based learning's research and theory. In such approaches, authentic learning opportunities are offered to engage students in meaningful tasks to thus help leverage their prior knowledge (Koehler & Mishra, 2005). Design-based approach required students to become a "cognitive, apprentice, exploring and learning about the problem in the presence of peers" and the teachers to become a facilitator managing the context and helping students to enhance an understanding of the material at hand (Blumendeld et al., 1991; Savery & Duffy, 1995).

This approach, as part of the LBD approach, has been used in a variety of contexts (Alayyar, 2011; Fessakis, Tatsis, & Dimitracopoulou, 2008; Pamuk, 2012). Although design teams approach was first employed in research related to science, its components have also been applied in the area of technology integration. For example, some research were implemented among participants who were required to deal with instructional technology tasks and they were asked to work in teams to identify possible promising solutions to deal with these problem (Alayyar et al., 2010; Jang & Chen, 2010; Koehler et al., 2007).

Moreover, as part of collaborative approaches, the design teams approach has been believed to have a positive impact on teacher candidates in authentic teaching environments than conventional instructional approaches (Korthagen & Kessels; Brush & Saye, 2009). According to Gibbons et al.

(2002) and Hughes (2005), this approach provides a contextualized learning environment in which preservice teachers have opportunities to become active participants in their own learning, particularly their meaningful activities in classrooms, to collaborate for problem solving and thus, build up their instructional knowledge. Moreover, this can lead to an increase in their abilities to apply their knowledge gained during their teacher training courses to their future teaching contexts.

According to Kolodner et al. (2003) and Koehler et al. (2004), there are two components constituting a design team. One of them is whole group (whole class/community) and small group (three to four members). While whole group's activities include mainly discussing readings, sharing experience, giving and receiving feedback and improving understanding from problem solving, small groups engage themselves in investigating, exploring, making predictions, justifying decisions, developing as well as present artefacts. Based on each type of group's functions and the principles related to collaboration of the design teams approach, Koehler et al. (2004) and Hawkes and Romiszowski (2001) suggested it is important to have an appropriate sequence of these components. Therefore, a sequence of such components synthesized from the approaches mentioned above was proposed by Johnson (2014), based on which the adapted course was developed for this current study (Figure 1).

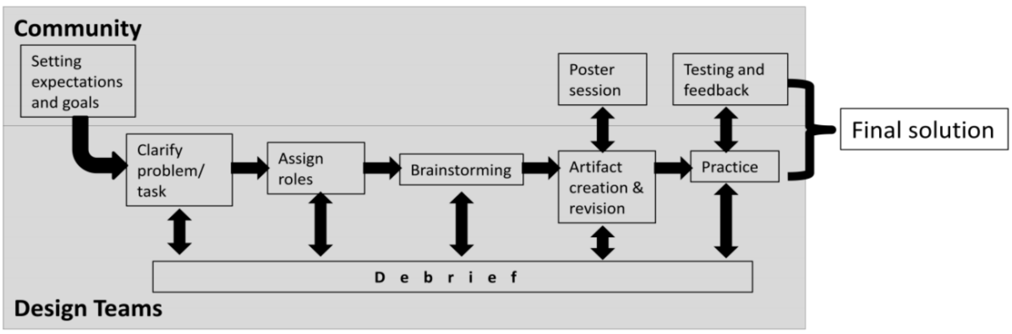

Figure 1. Sequence of Components in the Design Teams Approach (Johnson, 2014)

2.2 Technological Pedagogical and Content Knowledge (TPACK)

TPACK is built on the foundation of Shulman's (1986) pedagogical content knowledge (PCK) framework. PCK offer definitions of knowledge of subject matter (content) and instructional strategies and considerations (pedagogy) and give a description of how these components interact or combine to form a unique form of knowledge. After that, the notion of PCK has been extended and critiqued by researchers after Shulman. Howland, Jonassen and Marra (2012) claim that the TPACK framework has "fundamental problems" in its epistemological assumptions, the nature of knowledge and importance of learning (p. 13). This model suggests technological knowledge as a fourth domain to extend PCK, considering technological knowledge (TK), content knowledge (CK) and pedagogical knowledge (PK) as foundational facets. The framework is further anatomized into paired domains including pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), technological content knowledge (TCK) and technological pedagogical content knowledge as an extending conceptual knowledge package to understand the complex, situated knowledge necessary for teachers to effectively teach with technology (Koehler, Mishra, & Zellner, 2015) as illustrated in Figure 2.

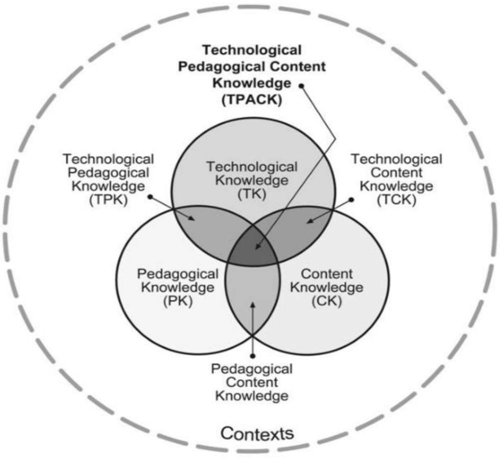

Figure 2. Graphic Presentation of Technological Pedagogical Content Knowledge Framework

The TPACK knowledge domains are described as follows:

- Content Knowledge (CK) refers the knowledge about the subject matter. It includes the knowledge of facts, procedures, principles and theories in ones' subject matter area (Mishra & Koehler, 2006)
- Pedagogical Knowledge (PK) refers to "general skills, beliefs and knowledge related to teaching including knowledge and beliefs about learners, basic principles of instruction, classroom management and the aims and purposes of education.
- Technological Knowledge (TK) refers to knowledge about generic uses of technologies consisting of knowledge about standard technologies, such as books, chalk, and blackboard and more advanced technologies, such as the Internet and digital video.
- Pedagogical Content Knowledge (PCK) refers the understanding of "the most useful forms of representation of content, the most powerful analogies, illustrations, examples, explanations, and demonstrations. In other word, the meaningful ways of representing and formulating the content to make it comprehensible to others" (Shulman, 1986b, p. 9).
- Technological Content Knowledge (TCK) is the knowledge of technologies specific to a content area including the knowledge of how technology represents content, how technology generates new content and how content transforms technology (Cox, 2008, p. 60)
- Technological Pedagogical Knowledge (TPK) is the knowledge of the pedagogical use of technologies independent of any content, including the knowledge of how those technologies' affordances and constraints affect or are affected by pedagogical choices of a teacher (Cox, 2008; Koehler & Mishra, 2009).

- Technological Pedagogical Content Knowledge (TPACK) is the knowledge of using technology, pedagogy and content at the same time in the same context. According to Cox (2008), some essential features of TPACK are the use of appropriate technology in a particular content area as part of a pedagogical strategy within a given educational context to develop students' knowledge of a particular topic or meet and educational objective or student need.

2.3 The Relationship between the Design Teams Approach and TPACK

Since the design teams approach has been mentioned above as part of LBD and that not much research has been conducted solely on design teams approach, this part aims to discuss the connection between this approach, as part of LBD, and TPACK. There have been several studies in examining the TPACK development through the approach. For instance, in 2005, Mishra and Koehler carried out a LBD seminar in which faculty members and students collaborated to develop online courses. In another similar study by Koehler et al. (2007), participants' discourses which they named it "design-talk" were investigated to understand the TPACK development. The similarities can be found between the two studies is the way faculty members and teachers engaged in discussing readings and issues and working together to prepare online courses. In another study by Agyei and Voogt (2012), four preservice mathematics teachers' TPACK development was examined as they worked in design teams to design spreadsheet-supported lesson plans. Kafyulio (2010) undertook an investigation into TPACK development among science and mathematics preservice teachers. The participants were required to conduct a short microteaching practice which they assessed after their TPACK trainings and then designed lesson plans incorporating TPACK. Overall, all of these studies demonstrate that the design teams approach helped increase participants' TPACK competency.

Unlike the pieces of research above, Fransson and Holmberg (2012) undertook a self-study research based on LBD approach. The participant teachers from schools of different levels and subject combinations attended a course which aimed to develop the pedagogical use of web 2.0 resources to support learning in schools in Sweden. Using a triangulation of data including observations, artefact analysis and survey at the start and end of the program, the researchers found that it was easier for teachers with more expertise in ICT teaching to combine theory and practice than those who were mostly academically oriented.

Some other LBD-based studies also reported problems in the development of TPACK for preservice teachers. Guzey and Roehrig (2009) carried out case studies among 4 in-service secondary science teachers who took a professional development program focusing on technology integration to support science as inquiry teaching. One of the findings of the study was that teachers' pedagogical reasoning was closely related to the development of TPACK, which could imply that the biggest obstacle to learners' TPACK development was found to be their pedagogical inexperience. Similarly, in 2012, implementing a LBD study in a course called Principles of Distance Education among 78 preservice teachers in Turkey, Pamuk (2012) also found that lack of teaching experience or pedagogical inexperience seemed to be the biggest barrier to the development of TPACK.

Some researchers have begun to examine the efficacy of design teams approach on preservice teachers' TPACK and other factors influencing technology integration. In 2011, Alayyar 545 conducted a study among 61 preservice teachers from Kuwait attending a science teacher preparation program which was organised in the form of Design Teams. Using ICT skills questionnaires, TPACK survey and interviews, the results were encouraging, indicating that there was an increase in preservice teachers' different knowledge components of TPACK as well as their understanding of ICT related to other aspects of teaching. Moreover, the design teams approach enabled them to gain better ICT skills and more positive attitudes towards both ICT and the design teams approach and that working in Design Teams to design and develop a solution for authentic problems fosters the TPACK development.

In 2014, Kafyulilo and his colleagues carried out a study at a secondary school in Tanzania to investigate the impact of design teams approach as a professional development arrangement on technology integration knowledge and skills among 12 teachers. The results showed that collaboration in design teams led to an increase in teachers' knowledge and skills in the incorporation of technology and had potentials for them to share knowledge, experience and difficulties regarding technology-enhanced teaching. In the same year, another investigation (Johnson, 2014) into the effect of the design teams approach was implemented at a medium-sized university in the northeast region of the United States. In this quasi-experimental study, the preservice teachers majoring in either early childhood or elementary education took part in three one-credit courses on technology integration in teaching. The findings revealed that although there was a considerable growth in preservice teachers' attitudes towards technology, technology skills and TPACK, no noticeable differences were found between groups.

In summary, most LBD research revealed a significant TPACK improvement for undergraduates, graduates and faculty members. Some of them identified pedagogical problems for example pedagogical inexperience and inadequate pedagogical reasoning skills of preservice and in-service teachers.

Despite a great deal of existing research proving the role of LBD approach designing teacher preparation programs in developing teachers' TPACK, it seems that this area requires more research work to improve the approach as regards the learning activities, instruction delivery and classroom management. More adjustments to the LBD-based environment should be explored to enrich the literature review on this approach.

Another point that deserves a mention is that preservice teachers are considered a generation who have grown up with digital technology and thus, educators have pointed out that digital natives exploit technology in many different ways. Therefore, it cannot be denied that their learning style, understanding of technology and experience of using technology must be different from their previous generations including their parents and teachers (DeDe, 2005; Powell, 2007; Prensky, 2001; 2006b). These factors can have an impact on the design team's environment and hence, it is vital to carry out more studies to help the researcher gain a deeper understanding of TPACK development among these digital native prospective teachers.

3. Methodology

3.1 Appropriateness of the Research Design

This research is a mixed-method study, more specifically, a sequential explanatory design aiming to explore the effects of a design teams approach on preservice teachers' TPACK. The rationale for using this method is that due to the incorporation of a combined quantitative and qualitative approach, the overall strength should be more beneficial than using each of them individually. As Rossman and Wilson (1985), Creswell (2003) claimed, the reason for using this two-phase model is that the statistical results and their subsequent analysis both contribute to bringing about a general understanding of the research issues and exploring participants' perceptions in greater depth.

3.2 Research Site, Sampling and Participants

The research was undertaken at a university of foreign language studies in Central Vietnam. The population of this current research included 62 preservice teachers who were in their third year pursuing a bachelor degree in Primary English Teacher Training program. The Technology in Education course was often taken during their third year once they already finished courses related to basic and advanced teaching methodologies and other subjects related to English language. During the time the research being carried out, there were only 62 participants attending this course, which were all invited and agreed to participate in the study. This helps reduce the limitations of convenience sampling because every member of the target population has a chance to take part in the research irrespective of the small sample size (Creswell, 2012).

3.3 Pilot Study and Instrument Validation

Before the implementation of the main study, in order to test the reliability of the TPACK Survey, a pilot study was undertaken among 30 preservice teachers whose major was Primary English Teaching. SPSS was used to determine Cronbach alpha for each TPACK domain and they were found to be in the acceptable range (>0.75). For the validity, two experts who were lecturers of Teaching Technology in Education were invited to evaluate this self-assessment instrument. Based on their feedback, the chosen 29 items for the questionnaire were sufficient and valid enough to proceed to the main study. As for the TPACK Rubric, interrater correlation was calculated at 0.813 and the scoring agreement was 84%, which were considered to be reliable.

3.4 Overview of the Adapted Design Teams Approach Course

The current research attempted to apply this Johnson's design teams approach model (2014) (Figure 1) to modify the existing course format for the two classes of 62 preservice teachers. In fact, this approach is easily integrated into any kinds of task while the compulsory content of the course remained basically unchanged. For the current study, the course was conducted mainly on a face-to-face basis allowing the preservice teachers to interact with one another for discussion and other collaborative activities in the most effective way. In addition, online discussion and email exchange were also common among the participants throughout the course.

In order to provide the preservice teachers with the necessary instruction of the design teams approach, the cycle of this approach was repeated for each topic. The fifteen-week course was divided into six sessions in which five main introductory technologies were covered including (1) Overview of Educational Technology and Technology Integration (two weeks); (2) Searching for Resources on the Web (two weeks); (3) Creating Interactive Exercises with Hot Potatoes (three weeks) (three weeks); (4) Creating Multimedia Presentation with Microsoft PowerPoint and Windows Movie Maker (three weeks) ; and (5) Podcasting (three weeks), leaving two last weeks for preservice teachers' final projects. The instruction for each session was comprised of several different components following the phases in the design teams approach suggested by Johnson (2014) (Figure 1). These components were arranged and modified in a way to accommodate the particular context of the course, the time allowance for each topic, the participants' limited experience and most importantly, to guide the preservice teachers through the process of the design teams approach.

3.5 Data Collection and Instrumentation

Since it is a mixed method design, both quantitative and qualitative data were employed in sequence, creating a triangulation of data.

For the first phase, preservice teachers were required to complete the TPACK pre and post survey (Schmidt, 2009) (Appendix A) at the beginning and at the end of the course. This self-assessment report has been found to have an internal consistency (using Cronbach's alpha) ranging from 0.75 to 0.92 for each of the TPACK constructs, which is considered to be acceptable to excellent (George & Mallery, 2001).

For the second phase, in order to have a complete picture of teachers' TPACK, at the end of the course, each preservice teacher was required to submit their final project which was a technology-integrated lesson plan as a requirement. A TPACK Rubric (Appendix B) was used to assess the participants' lesson plans. This rubric, named Technology Integration Assessment Instrument (TIAI) (Britten & Cassady, 2005, is commonly used to assess teaching artefacts based on four criteria: (1) Curriculum Goals and Technologies, (2) Instructional Strategies and Technologies, (3) Technology Selection(s) and (4) "Fit". Based on previous research, this instrument has been tested by expert technology educators and found to be reliable and valid and thus, it is sufficient robust to be used in this study to assess preservice teachers' lesson plans as part of instruction (Harris et al., 2010). Another qualitative data instrument is semi-structured interview conducted in the end aiming to understand the effectiveness of the technology course that they have attended and whether they wish to make any suggestions for more successful teacher preparation programs.

3.6 Data Analysis

For the quantitative data, SPSS version 20 was used to analyze the results from the TPACK pre and post surveys to explore whether there is any impact of the design teams approach on preservice teachers' TPACK. First, all data from the survey was entered into an SPSS file and then they were checked for errors to detect any “values that fall outside the range of possible values for a variable: (Pallant, 2011, p. 40). The analysis of the questionnaire findings started with descriptive statistics such as percentages, mean score and standard deviation.

For the qualitative data, the participants’ lesson plans were marked by the instructor and the second rater who were also a lecturer of this subject. This second rater was also provided with essential information about the research as well as was trained to mark the lesson plans according to the criteria in the rubric through several face-to-face meetings with the researcher. The scores of the artefacts were collected from the two raters and they were calculated to determine the interrater coefficient, the scoring agreement and the mean value for each criterium. As regards the interview data, they were recorded and analyzed using thematic analysis to explore the main theme which reflected the preservice teachers’ perceptions towards the design teams approach.

4. Findings

4.1 TPACK Survey

Table 1. Descriptive Findings about Preservice Teachers’ TPACK and its Domains before and after Taking the Course

	pre_post	N	Mean	Std. Deviation	Std. Error Mean	t	df	Sig.
PCK	pre	62	3.7258	.81320	.10328	-.219	122	.827
	post	62	3.7581	.82354	.10459			
TCK	pre	62	3.2097	.65630	.08335	-4.219	122	.000
	post	62	3.7258	.70523	.08956			
TPK	pre	62	3.2290	.60038	.07625	-6.722	96.987	.000
	post	62	3.8194	.34300	.04356			
TPACK	pre	62	3.0927	.62926	.07992	-5.144	122	.000
	post	62	3.6411	.55556	.07056			
TK	pre	62	3.5065	.57113	.07253	-2.185	109.902	.031
	post	62	3.7806	.80629	.10240			
CK	pre	62	3.0108	.70120	.08905	.041	122	.967
	post	62	3.0054	.75263	.09558			
PK	pre	62	3.1903	.52533	.06672	.768	108.299	.444
	post	62	3.1000	.76201	.09678			

As can be seen from Table 1, there was a difference in every technology-related TPACK domains (TK, TCK, TPK, TPACK) with sig = 0.000 < 0.05. More specifically, as for TCK, mean (post) was higher than mean (pre) (3.7258 > 3.2097). Similar patterns were found in the domain of TPK (3.8194 > 3.2290) and TPACK (3.6411 > 3.0297) and TK (4.0323 > 3.5065). This means that, for these TPACK components, the null hypothesis was rejected and there was certainly an impact of the design teams approach on the preservice teachers' TK, TCK, TPK and TPACK.

Among the technology-related TPACK domains, TK was found to have the slightest increase (5.482%) compared to TPK (11.808%), TCK (10.322%) and TPACK (10.968%) prior to and after the course.

With regard to CK, no difference was found in this domain because its sig = 0.967 > 0.05. The same occurs with the two remaining domains PK and PCK (with sig = 0.444 and 0.827 respectively). This means that, there was not sufficient evidence to show that the design teams approach could lead to an improvement in these TPACK components.

4.2 Preservice Teachers' Lesson Plans

For this study, the scores given by both raters showed that the interrater coefficient was 0.824 and the scoring agreement was calculated at 83%, which were considered to be reliable. The results of 124 lesson plans scored by both raters were demonstrated in Table 2.

Table 2. Descriptive Findings about TPACK Rubric

	N	Minimum	Maximum	Mean	Std. Deviation
Curriculum Goals & Technologies (TCK)	124	2.00	4.00	3.2823	.69330
Instructional Strategies & Technologies (TPK)	124	1.00	4.00	3.1290	.70961
Technology Selection(s) (TPACK)	124	1.00	4.00	3.2500	.82270
"Fit" (TPACK)	124	1.00	4.00	3.1532	.80692
Valid N (listwise)	124				

It can be evident from Table 2, the preservice teachers' lesson plans were assessed on three domains addressing TCK, TPK and TPACK. All these components with the mean value ranging from 3.1 to 3.28 demonstrated the fact that the preservice teachers' TCK, TPK and TPACK developed after the course. Among them, TCK showed the highest means score of all (3.2823) followed by TPACK (3.25) and TPK (3.1290).

4.3 Preservice Teachers' Perception towards the Team Designs Approach

This question is addressed through the preservice teachers' semi-structured interviews mainly about whether they thought the course was helpful for their technology integration into their teaching practice.

Overall, it is clear from the data that most participants gained more confidence and experience of using technology in teaching.

"I'm not saying that I am not good at technology, actually, I use computer, Internet almost every day. I have also used it for my presentations for my different subjects in class. However, incorporating technology in classroom teaching is a different story, which was what I drawn from this course. I now feel kinda more comfortable than before and believe I can do an effective teaching with technology”.

The course helped boost the preservice teachers’ confidence as they gained better knowledge and experience of what technology integration really meant in teaching practice. Nevertheless, at the end the course, most participants changed their minds and started to realize the value the course for their future career.

“The course itself is not as easy as I used to think. Technology is one thing and integrating it into lesson plans is another. I realized that being good at using technology doesn’t mean that I can use it well in my teaching. However, I now feel comfortable using it to make my lectures more interesting and effective”.

Moreover, their confidence also came from having plenty of opportunities to practice incorporating technology into teaching and their belief that they could certainly put what they learnt from the course into future teaching practice.

“I absolutely enjoy the course activities, especially the task and the project at the end of the course. Working in group had never been that exciting, each of us had to consider very carefully which technologies are suited for different activities. We had to be very creative and some of my mates’ ideas were really original and brilliant. I was better prepared and benefited a lot from my classmates”.

The significant effect of the course on the participants’ TPACK was also clear in every stage of the design teams approach. More specifically, the stage of goal setting and task clarification gave them chances to implement research to collect materials and theories about the problem before designing artefacts. The second stage of braining storming and artifact creation not only helped the participants explore what technological tools or resources were available for them but also improve their knowledge and experience about how to use them. In the third stage of artifact creation and revision, most of the preservice teachers said that they found it stimulating to tackle the instructional problem at hand in team and cooperating with other members and exchanging feedback could enable them to deal with the complexity in planning technology-enhanced lessons. The construction of technological artefacts also enhanced the teacher candidates’ technological knowledge as well as the awareness of the complexity in technology integration in teaching. The stages of poster session and testing and feedback allowed the participants to interview other teams about how they would use technology to teach the lesson. Most of them considered this step important because this communication helped clarify their team’s ideas through presenting their ideas to other teams.

5. Discussion

5.1 Research Question 1: What Impact Did the Integration of a Design Teams Approach into an Existing Technology Integration Course Have on Preservice Teachers’ TPACK?

In order to address this question, both TPACK Survey and TPACK Rubric were used and the semi-structured also played a part in discussing the findings related to the preservice teachers’ TPACK development.

As regards the findings about the different domains of TPACK, the preservice teachers reported a significant increase in three main technology-related components including TCK, TPK and TPACK at post-survey. The finding is in line with previous numerous research (Durdu & Dag, 2017; Thomas & Edson & Abebe, 2018; Adams & Rojas, 2018; Lu et al., 2011) in which an intervention was implemented throughout a course led to TPACK growth. This is also supported and overlaps with the participants' achievement in lesson plans in which these TPACK components were also found to be good. Moreover, based on the reponses of the preservice teachers in the semi-structured interviews, they generally agreed that the course was helpful for them to learn about how to integrate technology into teaching. The teacher candidates showed that contrary to their belief prior to the course, they were then aware of the complexity of technology incorporation for instruction, which can be viewed as evidence of their TPACK growth. Obviously, not only did they realize the factors influencing their decisions in instructional planning but their understanding and experiences about problem solving in authentic environment were also enriched.

Moreover, although there was sufficient evidence for the fact that the design teams approach also had an effect the participants' TK, this effect did not seem significant. Similar results can be found in Lowder's study (2013) in which there was a slight increase in pre to post TK scores (from 3.7 to 3.97). This can be explained by the fact that all of the participants are Digital Natives (Prensky, 2001), which made them feel confident of their computer literacy before the course started. Therefore, after the course, they did not think this domain of knowledge would improve considerably.

PK was also found to remain unchanged, which is quite a contrast to Valtonen's study (2018) and Chai et al. (2010) in which PK received the highest score, showing that today's teacher candidates' confidence in technology use for educational purposes should not be taken for granted. As regards the current study, the participants' perceptions of their PK were already strong before attending the course due to the fact that they were well-prepared pedagogically in the previous curriculum course they completed. Similarly, the design teams approach did seem to have any impact on the preservice teachers' CK probably because most of them had learnt English subject for at least ten years, which was why they responded they had no difficulty dealing with issues related to this subject matter itself.

In short, both TPACK self-assessment survey and TPACK performance-based assessment instrument (TPACK Rubric) were used together over a course period supported each other and offered a firm and reliable indication of teachers' TPACK growth thanks to the infusion of the design teams approach into the course.

5.2 Research Question 2: What Was the Preservice Teachers' Perception of the Design Teams Approach's Impact on Their TPACK?

As can be evident from the finding, the qualitative data strongly support the quantitative data in terms of the impact of the design teams approach on their technology integration.

The design teams approach helped the preservice teachers gain more confidence in several ways. First, their confidence came from their rich opportunities to design activities on their own, which is agreed by Koehler and Mishra (2005b) that designing authentic teaching situations is one of the best methods for TPACK enhancement. Second, the participants' TPACK developed from the interactions among members in design teams as they work together to seek the optimal solutions for problems/tasks. This is in agreement with Baran and Uygun (2016)'s idea that cooperation can allow learners to engage in "a joint discourse on effective technology integration" (p. 50). Moreover, design teams enabled the preservice teachers to no longer become passive users but also designers of technology (Koehler & Mishra, 2005) through a series of design activities from the brainstorming of design ideas offering them opportunities to see varied solutions to technology integration problems, the engagement of theoretical knowledge and then investigation of technological tools and finally to the examination of artefacts. The preservice teachers' perceptions towards the design teams approach are align with previous literature, for example, Lu et al. (2011); Fransson and Holmberg (2012) and Johnson (2014) in which the design teams environment created favourable conditions for the development of preservice teachers' TPACK.

6. Conclusion and Implication

This study addresses key gaps in the corpus of research on the implementation of the design teams approach for the development of technology integration knowledge measured through the lens of TPACK. The findings from both TPACK measurement instruments firmly confirmed the positive influence of this approach on preservice teachers' technology integration, especially their technological-related domains (TPK, TCK, TPACK, TK). The interview data also greatly supported the survey results indicating that the teacher candidates developed the awareness of the benefits of the design teams approach via the course they took part in.

The findings of the current study support the application of the design teams approach. Nevertheless, the results can be explained only within the contextual boundaries of this case study and thus, this approach should be further investigated to gain a profound insight into how the findings of this case can transfer to other contexts and how adaptations of this approach could make a contribution to the TPACK growth of not only preservice teachers but also in-service teachers and teachers educators.

Moreover, as the findings of the current study indicated that the adapted course based on the design teams approach suggested by Johnson (2014) had positive impact on preservice teachers' TPACK, at faculty level, learning modules adapted with this approach in technology integration courses should be widely implemented.

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