Examining the Use of Learning Communities to Improve Pre-service Teachers' Technological Pedagogical Content Knowledge

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***Abstract*—In this study, we organized and implemented learning communities in an introductory technology course for pre-service secondary teachers. There were 49 participants enrolled in the course "Instructional Media and Applications" in the fall semester of 2015. To measure the participants' technological pedagogical content knowledge (TPACK), a questionnaire was administered at the beginning and end of the course. To understand the participants' perceptions on learning communities, another questionnaire was administered at the end of the course. The results indicate that all the TPACK constructs were significantly improved except the content knowledge construct. Furthermore, the participants expressed a favorable perception on joining in learning communities. There was also an enhancement of interpersonal relations, human skills, practical knowledge, and quality of artifacts. However, two problems were identified in the process of learning communities, namely availability of time and degree of participation. Based on the research findings, relevant suggestions are provided at the end.**

***Index Terms*—learning communities, teacher preparation, technology integration, technological pedagogical content knowledge**

I. Introduction

It is widely accepted that future teachers must know how to use Information and Communication Technologies (ICT) effectively to help students learn. To meet such technology standard, pr-eservice teachers are commonly required to take ICT courses offered by teacher preparation programs. However, these ICT courses have long been criticized for being skill-focused, and seldom focusing on specific content area [1], [2]. That might explain why many pre-service teachers feel inadequately prepared to use ICT in classrooms. Grounded in Schulman's idea of pedagogical content knowledge [3], the Technological Pedagogical Content Knowledge (TPACK) framework addresses the problem arising from overemphasis on technological knowledge in many ICT courses, and emphasizes the dynamic and interconnected nature of the three primary components: technology knowledge, pedagogy knowledge, and content knowledge. These are the three core bases of knowledge required by teachers for successful technology integration into instruction [1].

The TPACK framework has been widely employed in the research and development of pre-service teachers' competencies for technology integration [4], [5]. One of the problems that the TPACK framework highlights is that most pre-service teachers enrolled in introductory ICT courses are just beginning their teacher preparation study and have not yet taken any subject teaching courses. Furthermore, some of them are still in their sophomore or junior year of undergraduate study and might not have sufficient knowledge in their teaching subjects. In addition, most students do not have any practical teaching experience in K-12 schools. Accordingly, deficiency in one of the core bases (content knowledge, pedagogical knowledge, and pedagogical content knowledge) may result in failure of effective technology use [6].

Seeing that the students in our teacher preparation program had multiple backgrounds, we decided to take advantage of one's strengths and make up for one's deficiencies so as to achieve the best professional development for everyone. For example, Master's or Ph. D. students may be more knowledgeable in content area; The students having the experience of substitute teachers may be more familiar with the teaching practice; Young college students have less fear of learning and using emerging technologies. Therefore, if we build learning communities based on specific content area, the students with the same teaching subjects could collaborate with each other and have professional dialogues or discussion on technology integration into instruction. This would improve the students' technological, pedagogical and content knowledge, and hence increase the effectiveness of technology integration.

Many studies have reported the use of learning communities in teacher preparation, and revealed the following benefits: (1) Enhancing pre-service teachers'

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attitudes towards collaboration [7], (2) Strengthening the links between theory and practice [8], and (3) Encouraging the building of professional communities in the future [9]. Considering the characteristics of learning communities and the challenges faced by development of pre-service teachers' technology competence, we organized and implemented learning communities in an introductory ICT course for pre-service teachers, and examined their TPACK perceptions as well as other learning effects at the end of the course.

II. Literature Review

A. Teachers' Technology Competence

It is generally agreed that teaching with new and emerging ICT is a complex task. It is much more than simply using computers for instruction. Building on the notion of pedagogical content knowledge [3], Mishra and Koehler (2006) developed the TPACK framework which includes technology as an additional knowledge construct. The framework emphasizes that effective teaching with technology must focus on the connections and interactions among subject content, pedagogy, and technology [1]. As illustrated in Fig. 1, the TPACK framework includes three core knowledge constructs: pedagogical knowledge (PK), content knowledge (CK), and technological knowledge (TK); with four intersected knowledge constructs: pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and technological pedagogical content knowledge (TPACK).

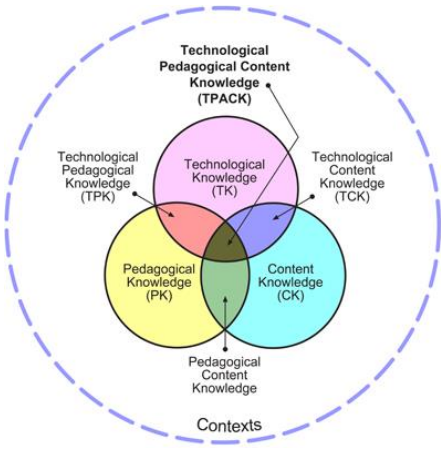

Figure 1. The TPACK framework.

Mishra and Koehler (2006) further described the seven constructs in the TPACK framework as follows [1]. Pedagogical Knowledge (PK): Knowledge of nature of teaching and learning, including teaching methods, classroom management, instructional planning, assessment of student learning, etc. Content knowledge (CK): Knowledge of the subject matter to be taught. Technological knowledge (TK): Knowledge of technology for information processing, communications, and problem solving, and focuses on the productive applications of technology in both work and daily life. Pedagogical content knowledge (PCK): Knowledge of the pedagogies, teaching practices, and planning processes that are applicable and appropriate to teaching a given subject matter. Technological content knowledge (TCK): Knowledge of the relationship between subject matter and technology, including knowledge of technology that has influenced and is used in exploring a given subject matter. Technological pedagogical knowledge (TPK): Knowledge of the influence of technology on teaching and learning as well as the affordances and constraints of technology with regard to pedagogical designs and strategies. Technological pedagogical content knowledge (TPACK): Knowledge of the complex interaction among the principle knowledge domains (content, pedagogy, technology).

The TPACK framework has been widely used in research to assess pre-service teachers' capabilities of ICT integration [10], [11]. For example, Schmidt et al. (2009) developed a 58-item Survey of Pre-service Teachers' Knowledge of Teaching and Technology to measure TPACK perceptions for the subjects of mathematics, social studies, science and literacy [11]. TPACK surveys were also developed in specific subject matters such as science or mathematics [12]. Compared to the qualitative method, TPACK survey instruments are more easily replicated and administered across different contexts [13]. Chang and Hsu (2013) developed a questionnaire for Taiwanese secondary student teachers based on the TPACK framework [14]. As reported by Chang et al. (2014), the reliability coefficients for each construct of the questionnaire were 0.92, 0.89, 0.88, 0.90, 0.89, 0.92, and 0.91, respectively [15]. All of the constructs had reliability coefficients higher than 0.85, indicating that the instrument was valid and reliable. We then adopted this questionnaire as a basis to measure the pre-service teachers' TPACK perceptions in this study.

ICT Education for Pre-Service Teachers.

It is widely accepted that future teachers must know how to use technology effectively to help students learn. The offering of ICT courses seems to be the most straight and easiest way to meet such technology standard. Strudler and Wetzel (1999) reported that 70% of the teacher preparation programs in America required their students to take at least one 3-cridt ICT course [16]. Studies have reported that ICT courses significantly improve computer attitudes of pre-service teachers and enhanced their self-efficacy beliefs for computer use [17], [18]. Despite these positive results, research continuesly reveals that teachers feel inadequately prepared in using technology for instructional purposes [19], [20].

Graham, Borup, and Smith (2012) adopted the TPACK framework to understand elementary teacher candidates' technology integration decisions in three content teaching design tasks. They found that teacher candidates' rationales seemed to be more closely related to general pedagogical practices than to content-specific pedagogical practices. They explained that this could be that the participating teacher candidates were simultaneously developing their understanding of content-specific strategies in language arts and math methods courses and had yet to take their science and

social studies methods courses. Without the foundation of the science and social studies content methods, teacher candidates may have had more difficulty developing TPACK in those content areas [6].

Pamuk (2012) discussed pre-service teachers' achievement barriers to technology integration, using principles of TPACK as an evaluative framework. The participants were all junior college students. He concluded that lack of direct teaching experience limited these pre-service teachers in effectively using or integrating technology into teaching. Knowing about technology or the content did not produce effective technology use. Although pre-service teachers may have technology, pedagogy, and content knowledge, TPACK development from interactions among these constructs remained problematic to a certain degree. He also claimed that developing Pedagogical Content Knowledge (PCK) is an important factor in overall technology integration, and PCK development must be supported with actual teaching experience. He further suggested that pre-service teachers should receive guidance about how to achieve effective technology integration into their teaching, and carefully designed case studies or exercises could help pre-service teachers gain some teaching experience before doing actual teaching in the real classroom [21].

Koh and Divaharan (2011) proposed an ICT instructional model for developing pre-service teachers' TPACK [2]. This model included three phases: (1) Fostering teachers' acceptance and technical proficiency through faculty modeling and a combination of tutor demonstration and student self-paced exploration; (2) Pedagogical modeling to help teachers foster some level of technological pedagogical knowledge; and (3) Pedagogical application to formulate TPACK by designing ICT-integrated lesson for a selected lesson topic. Their empirical study revealed a challenge for ICT instructors to model content-based integration examples. Therefore, they suggested pre-service teachers be grouped by related subject specializations so as to critique and improve ICT-integrated lesson plans related to that area. Creating a community of practice among pre-service teachers thus helps them form connections between technological, pedagogical, and content knowledge. To sum up, learning communities with a focus on sharing, discussion, collaboration, and innovation plays an important role in enhancing and integrating pre-service teachers' technological, pedagogical, and content knowledge for effective technology integration.

B. Learning Communities and Teacher Preparation

A learning community is a group of people who share common academic interests and goals. Its aim is to continuously improve each other's knowledge, skills, and attitudes through idea exchange, participative learning, and mutual encouragement [22]. Learning communities for teacher preparation have also been called "communities of practice." The term "communities of practice" refers to groups of people who engage in a process of collective learning in a shared domain of human endeavor [23]. They share a concern or a passion for something they do and learn how to do it better as they interact regularly. Wenger and Snyder (2015) further identified three critical characteristics of communities of practice: (1) The domain: A shared domain of interest that creates identity; (2) The community: Members engaging in joint activities and discussions, helping each other, and sharing information in pursuing their interest in their domain; (3) The practice: A shared repertoire of resources including experiences, stories, tools, ways of addressing recurring problems [23]. Dinsmore and Wenger (2006) claimed that a sense of community encouraged in cohort structures adopted by some teacher preparation programs can foster learning and discourage the intellectual and professional isolation of teachers. Furthermore, through the operation of communities, more ideas can be inspired, theory can be linked with practice, and such community experience can continue at a later stage of practicum or first-year teaching [8].

Wang (2008) suggested the use of multiple strategies for successful operation of pre-service teachers' communities [24]. In the aspect of interaction, he proposed to encourage participations in community activities, provide collaborative experience and skills, and teach interpersonal and communication skills. In the aspect of implementation, he proposed to increase practical experiences, provide exhibition opportunities, adopt numerous practical cases in the field, and ask pre-service teachers to keep a record of the process of communities. Furthermore, he identified four stages in the development of pre-service teachers' communities. Each stage has its own tasks. For instance, at the entry stage, teacher educators explain the rationale and functions of learning communities and help the building of communities. Pre-service teachers get acquainted with each other in the same community. At the development stage, teacher educators arrange community inquiry in educational practices and foster pre-service teachers' identity. Pre-service teachers actively participate in community activities, abide by group regulations and norms, respect peer's opinions and endure differences among community members. At the mature stage, teacher educators are able to deal with conflicts with fairness. Pre-service teachers can trust with each other, have group identity, and help peer grow. At the evaluation stage, teacher educators need to evaluate professional learning effects of pre-service teachers. Pre-service teachers need to reflect if their professional identity increases, and critical thinking skills grow.

Bond (2013) examined the development of a professional Learning Community (PLC) among 20 pre-service secondary teachers during a semester-long, field-based education course to share artifacts of learning from their professional portfolios [25]. He found that the participants enjoyed meeting with classmates, offering emotional support, and sharing their experiences from the university course and cooperating teachers' classes. At the same time, the participants were facing the following challenges including focusing attention on their high school students' learning, selecting a PLC leader,

managing their time, and offering constructive feedback to other group members. Cavanagh and Garvey (2012) studied the development and implementation of a professional learning community for a group of pre-service secondary mathematics teachers. They found that participation in the learning community helped pre-service teachers make stronger links between theory and practice, learn from each other, and become more reflective about problem-solving teaching approaches [26].

Wang (2011) explored the process and effects of communities of practice among the pre-service teachers enrolled in a course, "Curriculum Design for Young Children" [27]. His research revealed a number of benefits of communities including increasing an understanding about this course, developing collaborative and interactive strategies, improving articulation and communication skills, enhancing integrative and reflective abilities, alleviating academic stress and load, integrating theory and practice, and constructing as well as modifying knowledge of practice. Two problems were also identified, that is, difficulty in arrangement of common time and different engagement of community members. To sum up, learning communities benefit the development of pre-service teachers' higher level abilities such as reflection and critical thinking. Therefore, they would be helpful to stimulate the growth of more complex and integrated constructs of TPACK.

III. Method

This study aims to examine the effects of learning communities created for pre-service secondary teachers in an introductory ICT course. The participants, the course, and the instruments of this study are described as follows.

A. Participants

There were 49 pre-service teachers participating in the learning communities built for the course "Instructional Media and Applications" in the fall semester of 2015. As indicated in Table I, 73.5% of the participants were females, and only 26.5% were males. Although more than 70% were college students, near 30% were graduate students, including two Ph. D. students. Because this course was offered for the first-year study, most participants (67.4%) were just beginning their education for secondary teachers. However, there were 32.6% in their second or third year study of our program. Most participants' teaching subjects were English (36.7%) and Chinese (26.5%), and only one participant taught business. Furthermore, more than 30% of the participants had practical experience either in remedial teaching or in cram or K-12 schools. To sum up, the participants had a very diverse background which could complement each other in terms of content knowledge, pedagogical knowledge, and technological knowledge. Under such favorable conditions, we thus promoted the use of learning communities for "Instructional Media and Applications." In addition, because the course focused on technology integration into certain content areas, learning communities created for this course were based on specific subject matter or content area. This course ended up with a total of seven communities. There were two for Chinese, two for English, two for social studies, and one for Japanese. Each community consisted of six to nine members or participants.

TABLE I. Demographic Data of the Study (N=49)

Variable	Category	No.	%
Gender	Male	13	26.5
	Female	36	73.5
Status at our university	Sophomore	11	22.4
	Junior	16	32.7
	Senior	8	16.3
	Master	12	24.5
	Ph. D.	2	4.1
Years of study in our program	First year	33	67.4
	Second year	10	20.4
	Third year	6	12.2
Subject specification	Chinese	13	26.5
	English	18	36.7
	History	7	14.3
	Civics	4	8.2
	Japanese	6	12.3
	Business	1	2.0
Experience in remedial teaching	Yes	15	30.6
	No	34	69.4
Teaching in cram or K-12 school	Yes	17	34.7
	No	32	65.3

B. The Course

It was an introductory ICT course called "Instructional Media and Applications," offered regularly in the fall semester for the first-year students in our secondary teacher preparation program. It was also one of the two ICT courses that our pre-service teachers were required to take. Its goal was to familiarize pre-service teachers with various kinds of instructional media so that they were able to collect, select, and produce suitable instructional materials for the subject matter they are going to teach. Because technology played an important role nowadays, we expected students to obtain high motivation and competences to implement technology integration in their future classrooms. However, in addition to technological knowledge, students need content knowledge and pedagogical knowledge for meaningful technology integration. As mentioned earlier, our students had very diverse backgrounds. Some students had practical teaching experience, most graduate students were good at certain content area, and almost all young students were accustomed to using technology. It would be a great benefit if students with different specialty could collaborate with each other. Learning communities were thus adopted for this course as a platform for idea exchange and sharing. Furthermore, to enhance the

interior cohesion of communities and to establish a favorable condition for implementing learning communities, about fifteen minutes were reserved in every class session so that members of a community could interact and communicate with each other. The topics and assignments designed for this course were listed in Table II.

TABLE II. SYLLABUS FOR INSTRUCTIONAL MEDIA AND APPLICATIONS

Week	Topics and Assignments
1	Course overview and introduction of learning communities
2	Media and instruction; Assignment: A file to introduce yourself to the class
3	Visual design and evaluation
4	Traditional media and applications
5	Characteristics and applications of computer technology Assignment: Video case analysis of technology integration in a teaching subject
6	Design and development of electronic presentations Assignment: Case analysis of using an electronic presentation in a teaching subject
7	Guest Speech: Using mobile technology in teaching
8-9	Group project presentation: Applications of distinctive media in a teaching subject; Assignment: Reflection reports
10-11	Project presentation: Development of electronic presentations for a teaching subject; Assignment: Reflection reports
12	Effective use of instructional media: ASSURE model Assignment: Lesson plan design in technology integration
13	Characteristics and applications of video in instruction
14	Digital camera operation and video editing
15	Future of instructional media; Final project presentation: Teaching demonstrations of applying instructional media
16	Final project presentation; Assignment: Reflection reports

C. Instruments

To measure the participants' TPACK, we adopted a 38-item questionnaire developed by Chang and Hsu (2013) based on the TPACK framework for Taiwanese secondary student teachers. Each item was measured using a 7-point Likert scale (1 = strongly disagree; 2 = moderately disagree; 3 = slightly disagree; 4 = neutral; 5 = slightly agree; 6 = moderately agree; and 7 = strongly agree). Considering that some participants in our study just entered the teacher preparation program and might have difficulty understanding the statement in the questionnaire, we added the "0" option for each item. The new version of the TPACK questionnaire was tested in the same course "Instructional Media and Applications" but offered in the previous year. All together, we received 51valid responses, and its reliability coefficients for each construct were .91, .92, .89, .88, .89, .88, and .89, respectively. All of the constructs had reliability coefficients higher than 0.85, indicating that the instrument was valid and reliable. In the fall semester of 2015, we adopted this new version of the TPACK questionnaire at the beginning and end of the course "Instructional Media and Applications," and paired-sample *t* -tests were conducted to examine if there were significant differences between the pretest and posttest.

To measure the participants' perception about learning communities, we developed another questionnaire as shown in Table IV. The questionnaire contained 10 items using a 5-point Likert scale (1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree). In addition, there were two open-ended questions asking students to write down their experience in participating in learning communities as well as suggestions or opinions related to learning communities. The questionnaire was administered at the end of the course, and the mean score and standard deviation were calculated for each item. As for the open-ended questions, the first step of analysis was to examine all the responses so that certain themes or categories might emerge, followed by classifying the responses based on the categories.

IV. RESULTS AND DISCUSSION

A. Perceptions of TPACK

Table III shows the mean score and standard deviation for each TPACK construct in the pretest and posttest. In the pretest, the TPACK construct received the lowest rating (M=4.10) with the highest standard deviation (SD=1.84), and TPK received the second lowest rating (M=4.25); whereas CK received the highest rating (M=5.07), and TK received the second highest rating (M=4.67). This indicates that before taking this course, the participants were more confident about their subject specification. In contrast, they had a lower confidence especially in a more complex construct such as TPK and TPACK. In the posttest, the mean scores of all the constructs increased, with TPACK receiving the largest increase and TPK the second largest increase. Although CK still received the highest rating (M=5.21), its increase was not significant at the .05 level. The remaining six constructs received a significant increase in the posttest, with TK, TPK, and TPACK significant at the .001level, and PK, PCK, and TCK significant at the .05 level.

TABLE III. SUMMARY TABLE OF PAIRED-SAMPLE T TEST

	Pre-test		Post-test			
Constructs	Mean	SD	Mean	SD	*t* value	Probability
TK	4.67	1.41	5.09	1.14	3.77[b]	.000
CK	5.07	1.64	5.21	1.11	1.83	.073
PK	4.65	1.79	5.17	1.07	2.67[a]	.010
PCK	4.56	1.64	5.10	1.06	2.54[a]	.014
TCK	4.52	1.71	4.96	1.08	2.31[a]	.026
TPK	4.25	1.82	5.04	1.10	3.94[b]	.000
TPACK	4.10	1.84	5.10	1.11	4.64[b]	.000

[a] $p < .05$; [b] $p < .001$

This indicates that learning activities designed for this course did benefit the development of pre-service

teachers' TPACK for meaningful technology integration. It was probably because this course required pre-service teachers to design ICT-integrated lesson for a selected topic. As indicated by many studies, such hands-on design projects help pre-service teachers develop TPACK [2]. In particular, their TPK and TPACK were greatly improved although these two constructs, considered to be more complicated and integrated, were practically difficult to deal with. This might be due to the actual teaching experience with the use of technology required by this course to increase pre-service teachers' TPK as suggested by Graham, *et al*., 2012 [6]. Moreover, learning communities played a significant role in this course. This is consistent with the recommendations provided by Koh and Divaharan (2011) that through peer collaboration, sharing, or even critics of subject-focused ICT integration ideas and lesson design, pre-service teachers' TPACK would be greatly enhanced [2]. In summary, the use of learning communities in an introductory ICT course did help pre-service teachers develop more complex constructs of TPACK.

B. Perceptions of Learning Communities

As indicated in Table IV, the mean score for each item was more than 3.50. This indicates that the participants had a fairly positive and favorable perception regarding learning communities. It was probably the peer-support atmosphere that the participants value (Item 8). After all, most participants were just beginning their study in teacher education. More information could be obtained from interacting with other members in a learning community so as to reduce the academic stress resulting from uncertainty. Furthermore, the participants indicated an increase in human skills (Item 7). These findings are consistent with previous studies that learning communities benefit pre-service teachers' discussion and communication skills [25], [27].

TABLE IV. DESCRIPTIVE STATISTICS FOR THE QUESTIONNAIRE ON LEARNING COMMUNITIES

Statement	Mean	SD
1. Participating in learning communities makes me feel more professional.	3.86	0.84
2. Through learning communities, I become more familiar with the content area I am going to teach.	3.96	0.50
3. Through learning communities, I understand more about the realities in the teaching field.	3.86	0.65
4. Through learning communities, I obtain more about technological knowledge and skills.	3.73	0.84
5. Through learning communities, the quality of my course work increases.	3.88	0.73
6. Due to learning communities, I put more effort into the course activities.	3.78	0.77
7. Through learning communities, my human skills improve.	4.14	0.65
8. I like the peer-support atmosphere in learning communities.	4.12	0.67
9. I hope the learning communities created for this course continue to operate in the future.	3.67	0.72
10. I will participate in the teacher learning community built by the school where I am teaching in the future.	3.88	0.78

Because the learning communities were organized based on the teaching subjects, the members in a learning community would teach the same subject matter in the future classroom. Therefore, the participants also indicated an increase in their familiarity with certain content area (Item 2). In addition, they expressed an increase in the quality of their assigments completed for this course (Item 5) as well as an expansion in their understanding about the realities in the teaching field (Item 3) as some participants had years of practical teaching experiences. Most importantly, the participants reported a moderately high willingness to join in teacher learning communities in the future (Item 10). This finding is consistent to the declaration of many scholars [9], [28]. However, they expressed with reservations to sustain the learning communities built for this course (Item 9). This was probably because the participants had various backgrounds and their daily schedules were not the same. In reality, it was very difficult to find a convenient time to meet with other members except the class time. Wang's study revealed a similar problem [27]. Therefore, the participants did not have high expectations for sustaining their learning communities after the course ended. As pointed out by Sim (2006), strong institutional support from the teacher preparation program is critical to successfully sustain the operation of learning communities [29].

C. Reflections and Suggestions

Various ideas and opinions were collected based on the participants' responses to the open-ended questions. In the first place, there were a lot of statements related to the benefits of learning communities. For example, the participant could get to know others with the same subject majors and obtain a lot of assistance from senior brothers and sisters. Furthermore, different points of view were stimulated through communicating and discussing with each other. In addition, everyone had his own viewpoints and could learn from each other to improve his own weakness. Finally, by sharing one's works with others and observing others' works, one was able to identify and made up one's deficiencies as well as to push oneself further to complete the required works on time. Above all, young undergraduates with less knowledge and experience tended to express a high recognition of learning communities. Below is the statement from a sophomore student majoring in Chinese Literature.

"Originally, my impression was that teaching Chinese was mainly relying on blackboard and textbook; so I'm a little confused about how to apply instructional media. However, after observing senior classmates' presentations, I got some ideas, had a clear direction, and felt much easier to start a lesson design. Through the discussions in our community, I found myself a lot of deficiencies that I had to make up. Such community experience also made me have deep reflection on the area of teacher education."

Secondly, there were three problems identified by the participants regarding the operation of learning communities. First of all, time is a key issue as mentioned by other studies [25], [27]. Insufficient time made it impossible for communities to have adequate and in-depth discussion. As planned in the course schedule, 15

minutes of the class time were reserved for learning communities. However, in many cases, no more than 10 minutes were left, and most communities could not find a more suitable time other than the class time. Another problem was related to the topics designed for discussion. Some participants stated that certain topics were not so clear or understandable. Some pointed out that the scope of some topics was too rigid. It seemed unnecessary to spend time discussing such topics. The last problem was about the degrees of community participation. Some participants expressed that their communities did not have heated discussion. Instead, every member just took turns delivering his or her own ideas. The issue of degrees of participation was also mentioned in the previous research [27].

Finally, relevant suggestions provided by the participants include: (1) Increasing the length of community time and allocating a period of time for discussion; (2) Expanding the scope of discussion topics and making these topics more understandable and interesting; (3) If possible, providing the topics one week ahead of time so that students might have enough time to collect relevant information before joining in a discussion; (4) Implementing simulation games or activities to strengthen the internal cohesion of a learning community for achieving a higher degree of participation; and (5) Inviting the course instructor to take turns joining in the discussion of a community, and providing opportunities for one community to interact with another.

V. Conclusion

In this study, we built and implemented learning communities based on teaching subjects in an introductory ICT course for pre-service secondary teachers. We conclude that the use of learning communities significantly benefits the development of pre-service teachers' technological pedagogical content knowledge, especially in favor of more complex TPACK constructs. Furthermore, the participants have a fairly positive and favorable perception on participating in learning communities. Other benefits include an enhancement of interpersonal relations, human skills, practical knowledge, and quality of artifacts. However, two problems that commonly occur in learning communities are availability of time and degree of participation.

Accordingly, we suggest the use of professional learning communities to effectively develop pre-service teachers' more complex constructs of TPACK. Furthermore, teacher educators or course instructors' timely support and active involvement in per-service learning communities are crucial to achieve a higher degree of participation. Finally, we can take advantage of social media technology to increase interactions of community members. In addition, the whole institution may build learning communities based on teaching subjects the moment when pre-service teachers enter teacher preparation programs. Accordingly, learning communities are more likely to continue even when a course is over. Further investigation may focus on the operation process of learning communities and its effects on TPACK development as well as the performance and perception of pre-service teachers with different backgrounds on learning communities.

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