Collaborative Professional Development of Mentor Teachers and Pre-Service Teachers in Relation to Technology Integration

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ABSTRACT

This study examines the collaborative professional development (CPD) of three pairs of mentor teachers and pre-service teachers in a junior high school. Of particular focus is the integration of technology into instruction, by using technological pedagogical and content knowledge (TPACK) to evaluate professional development. A qualitative research method based on classroom observations and focus group interviews (FGIs) is adopted. Additionally, data obtained from instructional plans, video-recorded classroom observations and FGIs are analyzed using a constant-comparison analysis method. Analysis results indicate that mentor teachers adjust their instruction methods when they receive the support of pre-service teachers specifically by moving from presenting technological content knowledge (TCK) to constructing various TCK bases. The pre-service teachers constantly apply TCK and technological pedagogical knowledge (TPK) to develop professionally, especially in TPACK-related technology integration concepts. Notably, the CPD program benefits pre-service teachers more than mentor teachers because the former actively seek more opportunities to apply TPACK than the latter, who simply exchange digital instructional materials.

Keywords

Collaborative learning, Learning communities, Teacher professional development, Technology integration

Introduction

Integrating technology into classroom instruction can increase student motivation, learning efficacy, curiosity and creativity (Carle, Jaffee & Miller, 2009; Idris & Nor, 2010; Molins-Ruano, Sevilla, Santini, Haya, Rodríguez & Sacha, 2014). However, teachers frequently use technology to perform non-instructional tasks such as grading and monitoring attendance (Gray, Thomas, & Lewis, 2010; Russell, Bebell, O'Dwyer & O'Connor, 2003). According to Govender and Govender (2014), most teachers with access to technology and computer competency skills fail to incorporate technology in their teaching. Unsuccessful experiences in technology adoption in the classroom may inhibit teacher motivation (Slaouti & Barton, 2007), explaining the need to create successful classroom experiences of technology integration.

Akbaba-Altun (2006) verified that in-service training courses lack hands-on activities, and fail to prepare teachers adequately to integrate technology. Enabling teachers to integrate technology is more complex than simply delivering instructions and technology-related skills (Ferdig, 2006). Despite possessing valuable teaching experiences or proficiency in technological skills, in-service teachers may still fail to successfully apply technology in the classroom. Related studies have demonstrated that observing successful teachers enhances the professional development of teachers, increases the likelihood that they will adopt new technologies in their classrooms, and also improve their teaching methods and contents (Anderson, Barksdale, & Hite, 2005; Powell & Napoliello, 2005). Successfully collaborating with colleagues is essential to effectively integrating technology in the classroom (Tondeur, Kershaw, Vanderlinde & van Braak, 2013).

Although extremely familiar with related technologies, pre-service teachers tend to lack sufficient pedagogical skills. Although teacher education programs include various courses that provide pre-service teachers with technology integration-related knowledge, pre-service teachers lack opportunities to apply such knowledge. Related studies have shown that the design of teacher education courses varies considerably (Lee & Lee, 2014). Such courses also fail to help teachers to integrate technology into the classroom (Goktas, Yildirim & Yildirim, 2008).

According to Russell et al. (2003), pre-service teachers express more confidence and proficiency in computer use than experienced teachers do. In-service teachers with sufficient teaching experience tend to have fixed teaching philosophies, yet lack technological skills. However, effectively integrating technology with teaching involves both technological skills and teaching experience. Ideally, the ability of in-service and pre-service teachers to learn collaboratively would allow them to effectively integrate technology with classroom instruction.

Related studies have suggested that the professional development of pre-service teachers in technology integration depends on knowledgeable mentors and sufficient technology access for practice and curriculum development (Grove, Strudler & Odell, 2004). While demonstrating the effectiveness of pre-service and in-service teachers collaborating with each other (Chen, 2012), other studies have identified the advantages of collaboration as including mutual learning and providing professional support (Goodnough, Osmond, Dibbon, Glassman & Stevens, 2009; Spilková, 2001). However, the collaborative professional development (CPD) of mentor teachers and pre-service teachers in a specific school in relation to technology integration has seldom been examined. Based on a case study involving a teaching team consisting of three mentor teachers and three pre-service teachers, this study examines the CPD of mentors and pre-service teachers in terms of their ability to integrate technology with classroom instruction.

Literature review

Technology integration by TPACK constructs

Teachers often fail to successfully apply technology in the classroom owing to factors such as lessons and objectives, classroom strategies for implementing technology, as well as hardware and software use (Liu, 2011). Mishra and Koehler (2006) expanded the concept of pedagogical content knowledge (PCK), as developed by Shulman (1986), to develop the technological, pedagogical and content knowledge (TPACK) framework, which involves a complex interaction among content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK). The interaction of these three basic forms of knowledge gives rise to pedagogical content knowledge (PCK), which closely resembles Shulman's idea of knowledge of pedagogy, which is applicable to the teaching of specific contents. Meanwhile, technological content knowledge (TCK): refers to knowledge of how to use technology in order to develop innovative ways of teaching content (Niess, 2005). Moreover, technological pedagogical knowledge (TPK) attempts to understand how teaching and learning can change in impact when technologies are used in specific ways. Furthermore, TPACK describes knowledge required by teachers to integrate technology in the classroom for specific content areas (Koehler & Mishra, 2009). According to Koehler and Mishra (2009), TPACK provides the foundation for effective teaching by using technology. Cox and Graham (2009) asserted that TPACK has inspired teachers, teacher educators, and educational technologists to re-evaluate their technological knowledge and classroom application of technology. Some TPACK-related studies have also attempted to improve the ability of in-service teachers to integrate technologies into teaching (Niess, 2011; Wetzel & Marshell, 2012). In sum, TPACK provides the foundation for effective technology-based instruction.

Other investigations also examined how to improve the integration of technology by pre-service teachers using TPACK (Koh, Chai, & Tsai, 2010; Koh, & Divaharan, 2011). A few studies have developed TPACK applications for pre-service teachers. Koh and Divaharan (2011) found that pre-service teachers focus mainly on TK independent of ICT training. As they subsequently incorporate technology into their classroom instruction, those teachers began to address TPK-related issues. When allowed to consider the connections between technology-related skills and subject content, pre-service teachers present their TCK in course design (Koh, & Chai, 2014). However, pedagogical planning is essential to facilitate the transformation of subject content knowledge for learners (Pamuk, 2012). The lack of teaching experience among pre-service teachers significantly impedes their ability to apply technology in the classroom.

Several TPACK surveys have identified the pedagogical approaches of in-service teachers (e.g., Archambault & Barnett, 2010). Some studies have established that the PK of in-service teachers drives their integration of ICT (Harris, Grandgenett & Hofer, 2010; Liu, 2013). Moreover, other studies have suggested that in-service teachers emphasize subject content when they integrate technology into their classroom instruction (Koh & Divaharan, 2013; Koh & Chai, 2014). In Liu (2013), in-service teachers applied a PK basis, combined PK with subject content and

technology during a professional development program, and devised TPACK-related concepts. Most in-service teachers with PK and CK that exceeded their TK can consider various instructional strategies or subject content and adopt a technology that matches their own notions regarding technological integration.

In-service teachers and pre-service teachers may have expertise in various TPACK constructs. Based on the relationships between the two, mentors and mentees can exchange technology integration-related expertise.

Collaboration among mentor teachers and pre-service teachers

While generally more experienced than mentees, mentor teachers possess knowledge skills desired by the mentee (Ambrosetti & Dekkers, 2010). In an internship, mentor teachers are considered as a sample model for teaching by pre-service teachers. Teacher education has long adopted the apprenticeship model in mentoring, which reflects a hierarchical relationship between mentor and pre-service teachers.

Fairbanks, Freedman and Kahn (2000) defined mentoring in teacher education as complex social interactions in which mentor teachers and pre-service teachers construct and negotiate for various professional purposes and in response to contextual factors. Mentors and pre-service teachers can develop teaching expertise collaboratively while doing so in a school environment (Nilsson & van Driel, 2010). Unlike a traditional apprenticeship, the new relationship between mentors and interns deepens their interactions.

In the collaborative mentoring approach of van Velzen, Volman, Brekelmans and White (2012), mentors and pre-service teachers cooperate by sharing knowledge expertise, discussing subject contents and reflecting on teaching practices. Pre-service teachers and mentors learn from each other, subsequently improving their ability to identify and explain their teaching practices. Meaningful and collaborative relationships between pre-service teachers and mentors facilitate a focused dialogue on teaching and learning. The willingness of mentor teachers to discuss their individual challenges is important to conversing with pre-service teachers (Eller, Lev & Feure, 2014).

In terms of professional development, in-service teachers can also benefit from collaboration. Individually and collectively, teachers adopt new concepts in their classrooms and monitor the success of their efforts by jointly reviewing their work, considering outcomes, and reflecting upon their teaching efforts (Lau, 2013). However, even when teachers schedule regular meetings, the lack of effective cooperation procedures may impede collaboration (Pawan & Ortlof, 2011; San Martín-Rodríguez, Beaulieu, D'Amour, & Ferrada-Videla, 2005). Consequently, collaboration focuses solely on information exchanges rather than instructional observation, deep discussion and reflection (Pawan & Ortlof, 2011).

School-based teacher education involves more than just collaboration among in-service teachers, or between mentor teachers and pre-service teachers, as described above. Pre-service teachers can participate in peer mentoring, in which they play the mentor role during the activity (Le Cornu, 2005; Sundli, 2007). Pre-service teachers must openly share and support each other. The questioning of the ideas of a pre-service teacher by a peer fundamentally differs from that peer having their ideas questioned by an experienced mentor teacher (Nokes, Bullough Jr., Egan, Birrell & Hansen, 2008). Peer-mentoring programs enable pre-service teachers to serve as critical friends and provide constructive feedback following lessons so they do not need to depend entirely on feedback from their mentor teacher (Le Cornu & Ewing, 2008).

Theoretically, collaboration between mentors with sufficient teaching experience and pre-service teachers with technological skills can facilitate technology integration for professional development purposes. Notably, a school-based mentoring team that comprises both mentor teachers and pre-service teachers creates extensive opportunities for mutual learning.

Based on the study purposes and the literature review, this study addresses the following research questions.

- How do pre-service teachers and mentor teachers change in TPACK-related applications while participating in the CPD program?
- What collaborative experiences motivate pre-service teachers and mentors to adopt TPACK in practice?

Research methodology

This study examines the collaborative professional development of mentor teachers and pre-service teachers in relation to technology integration. As mentioned earlier, TPACK provides the foundation for applying technology to teaching effectively. Based on TPACK constructs, this study assesses the CPD of both mentor teachers and pre-service teachers with respect to their ability to integrate technology into their classroom instruction, with a particular focus on changes in TPACK. Therefore, this study adopts qualitative research methods, including classroom observations and focus groups.

Participants

In Taiwan, roughly 6,000 pre-service teachers participate in school-based field practice annually, located in about 1,800 accredited K-12 schools nationwide by local governments for teaching practice purposes. Each pre-service teacher is partnered with at least one experienced teacher for mentoring based on the Teacher Education Act legislated by the Taiwanese government. To obtain transferability, an accredited junior high school was invited to participate in this study. After the rights and obligations of the participants were announced, three mentor-teachers (i.e., one special education teacher, a mathematics teacher and a biology teacher, with 15, 14 and 18 years of teaching experiences, respectively) and their pre-service teachers from different universities of teacher education voluntarily participated in the CPD program from October 2013 to January 2014. No participants had graduated from a technology-related university department. Three mentors occasionally implemented teaching activities with PowerPoint presentations and a video projector.

Collaborative professional development program

The CPD program was implemented via four cycles, with each one involving practical teaching with technology/classroom observations and participation in FGI. Before teaching, instructors were asked to design teaching activities that used technology. While teaching, observers had to write observation records. Meanwhile, following teaching instruction, all participants attended a FGI.

In the first and the third cycles, each mentor demonstrated teaching activities that used technology. In the second and fourth cycles, each pre-service teacher taught a lesson using technology. After each cycle was completed, the instructional plans and recorded videotapes of the instructors were collected for analysis to design interview questions for FGI. During FGI, teachers could discuss their teaching practices and identify how their work changed between cycles. The FGIs enabled participants to learn from the experiences of others and share ideas on technology integration. Analytical data obtained from classroom observation were triangulated, based on perspectives of technology integration obtained from FGI records.

Besides interacting regularly with students, parents and school activities, each mentor teacher and pre-service teacher pair were encouraged to collaboratively develop technology integration-related ideas. During their interactions, the pre-service teachers helped their mentors to design digital instructional materials; otherwise, the pair collaborated with each other. A pre-service teacher in Taiwan can usually obtain teaching guidance from their mentors before teaching practice. After teaching practice, the mentor often identifies his or her related strengths and weaknesses and also offers recommendations to pre-service teachers. In this study, the interactions were extended to facilitate collaborative professional development in the area of technology integration in order to include interactions with other mentors and pre-service teachers. Accordingly, each mentor teacher or pre-service teacher contacted other participants regarding their technology integration activities. Notably, besides the relationships with mentors, pre-service teachers can learn of TPACK-related applications from peer mentoring and the mentors of other pre-service teachers. These interactions were not recorded yet encouraged to promote self-reflection and the development of new perspectives that could then be expressed during FGI meetings.

Instruments

This study also attempted to achieve dependability in qualitative research (as demonstrated by the use of overlapping methods) and validate the analytical results. Therefore, primary research data were obtained from instructional plans, classroom observations and FGI records.

Classroom observations

Classroom observations allowed all participants to share ideas and stimulate dialogue and reflection on technological integration activities. In addition to benefitting the pre-service teachers, the teaching demonstration of each mentor also benefitted other mentors involved in the CPD program. A model of CPD for mutual learning was constructed, based on observations of and by mentor teachers and pre-service teachers. All teaching activities were video-recorded. Moreover, all participants other than the instructor were asked to either observe the lessons or view the video records.

Particular emphasis was placed on classroom observations, in which an observation sheet was created to describe teaching activities that use technology by using the basic constructs of the TPACK (including PCK, TCK, and TPK), based on the evaluative framework of Pamuk (2012). The observation sheet consists of four columns, i.e., TCK TPK, PCK and TPACK descriptions. All participants were instructed to fill in the sheet. For example, the TCK column in an observation sheet appeared in which the instructional material was designed as animated pictures.

Focus group interviews

According to Krueger (1988), focus groups evaluate programs and the generation of insights that can contribute to efforts to develop strategies. Accordingly, by using FGIs, this study evaluated changes in how participants integrate technology into their work and also formed related perspectives collectively. The interview questions were based on the analysis results of instructional plans, recorded videotapes, and records based on classroom observations. Although certain questions were based on an analysis of instructional plans, videotapes, and classroom observation sheets to facilitate data triangulation, most FGI topics involved technology integration because this study deals with collaborative professional development as reflected by changes between the initial and final perspectives regarding this topic, based on practical experiences. Sample questions are as follows.

- Please briefly state your (mentors and pre-service teachers) instructional plan and its proposed rationale. How are technology, teaching strategies, and content knowledge related to each other.
- Did you encounter challenges in designing and conducting activities that integrated technology? If so, how did you overcome such challenges?
- Did you discuss technology integration activities with other participants, including the participant with whom you were paired? If so, what did you discuss?
- How did interacting with other participants help you to reflect on your perspectives on technology integration, if at all?

Data analysis

Data obtained from instructional plans, video-recorded classroom observations and FGIs were analyzed using a constant-comparison analysis method. To obtain confirmability, three trained researchers independently reviewed the instructional plans of each participant, developed analytic headings and codes based on TPACK constructs, and compared video-recorded classroom observations with the analytical results of instructional plans. The researchers subsequently formed a consensus on the technology integration performance of instructors. When a pattern of relative clues emerged, the researchers again reviewed the analytical results to confirm any trends among the various data. The extent to which instructors adopt TPACK provides a contrast with classroom observation records in terms of indicating similarities and differences between the opinions of instructors regarding technological integration activities. These differences may reflect the ability of instructors or creative technology integration-related ideas. Comparing instructional plans and video-recorded classroom observations revealed specific events of interest,

subsequently revealing patterns in the data on technology integration activities, which were attributed to collective professional development. Above results were confirmed through FGIs. The above analysis was conducted during each of the four CPD cycles.

To ensure achieve credible qualitative research, the performance of each participant, in relation to their instructional plan, actual teaching, observation sheet and communication in FGIs, was triangulated across the four cycles to clarify the changes in technology integration based on TPACK. Positive changes reflect professional development in technology integration.

Results

Above results demonstrate the effectiveness of three aspects of the CPD program in technology integration. These aspects involved the change in the teaching activities of mentor teachers, from presenting a TCK to building various TCK bases, the change in the focus of the pre-service teachers from TK to TCK and PCK, as well as the fact that the CPD program improved the professional development of pre-service teachers more than that of mentor teachers in TPACK utilization.

Changes in the ways in which mentors integrate technology in their teaching practices

When designing instructional plans, three mentor teachers initially used PowerPoint presentations to introduce instructional materials. During the first FGI, two mentor teachers considered the effectiveness of presenting abstract concepts using PowerPoint slides because the combination of pictures and words can support comprehension. Although mentor teachers recognized that technology-based teaching improves learning comprehension and facilitates teacher-student interaction during teaching, they did not integrate technology integration into every lesson. A mentor expressed the following during the first FGI:

> *Students must occasionally perform a science experiment… I do not think* technology-based teaching *is appropriate in all science lessons, unless abstract concepts are taught. I am accustomed to presenting pictures with descriptive text. (Mentor A, 1st FGI)*

As for the use of TPACK constructs, the mentor teachers presented TCK concepts during lectures. At the beginning of this CPD program, mentor teachers mastered the subject contents and used simple technological skills to lecture using a digital presentation. The digital material attracts student interests, based on an observation sheet provided by a pre-service teacher.

Based on observation of the teaching activities of pre-service teachers, the mentor teachers admitted that the pre-service teachers had superior technology skills. For example, the pre-service teachers made animated pictures, and were more proficient at performing Internet searches. A mentor teacher thus asked her pre-service teacher for assistance during the second and third cycles.

> *After class, I asked her if she could send me the animated pictures. Maybe I should make similar materials with her guidance. I'll use animated pictures to teach students in the future. (Mentor A, 2nd FGI)*

Besides presenting additional materials obtained online, mentor teachers slightly adjusted their presentations, such as by using animated pictures in PowerPoint slides; whereas, previously, they had only used static pictures. Analysis of observations of student responses to teacher questions revealed that teachers enhance student motivation and comprehension of course contents. Two mentor teachers stated the following:

> *I raised some questions on slides to encourage the students to think independently. My questions and answers were immediately displayed as animation effects, explaining why no time was wasted in writing on a blackboard. Students felt excited when they answered correctly. (Mentor B, 3rd FGI*)

My technological skills are improving. After viewing the slides made by the pre-service teachers, I realized that PowerPoint has many functions that I had never used previously. I have now learned creative ways to display contents and will try to use them in the future. (Mentor A, 4th FGI)

Mentor teachers recognized that the pre-service teachers outperformed them in terms of technological skills, subsequently motivating them to actively learn technological skills from those pre-service teachers, as reflected in the following comment:

I want to use software other than PowerPoint, such as Cyberlink PowerDirector, and Photoshop. I can use software to edit or produce videos for students. (Mentor C, 4th FGI)

Once having improved their technological skills by collaborating with and learning from pre-service teachers, the mentors began to add animated pictures to their PowerPoint slides in order to improve the concentration and motivation of their students. Mentors increasingly adopt various technologies to assist students in comprehending abstract concepts and increasing their learning motivation. Therefore, mentor teachers changed the way in which they went from using a single TCK to utilizing various TCK approaches in teaching activities.

Development of the ability of pre-service teachers to integrate technology

Initially, the teaching activities of the pre-service teachers using technology corresponded to the models of technological integration used by their mentors, which involved using digital presentations to support their lectures, as reflected in the following comment:

Using slides reminds me to slow down while teaching. Additionally, the animated pictures ensured that my lecture went more smoothly. (Intern C, 1st FGI)

However, the pre-service teachers admitted that they taught more poorly than their mentors when they used technology because they concentrated too much on how to use it. Following observation and reflection, they began to recognize how to improve their teaching skills. An observation sheet from a mentor teacher noted how the pre-service teacher with whom they were paired presented digital material together with their lecture, yet spent too much time standing in front of their computer, and did not interact much with their students. The pre-service teacher also reflected upon their teaching experience in the second FGI:

Comparing my teaching with that of my mentor made me realize that I simply stood by the podium when using slides. I failed to interact with the students, explaining the ineffectiveness of my approach. (Intern B, 2nd FGI)

I observed that my mentor did not use the computer continuously throughout the class and also that his teaching was more flexible than before. Using slides to introduce mathematical steps is occasionally difficult. I saw that my mentor used the blackboard whenever deemed necessary, such as when questioning students. I plan to make this approach a model for my own teaching method. (Intern C, 2nd FGI)

The instructional plans of pre-service teachers in the third cycle included more technological material, such as films. However, as they had previously wanted, the pre-service teachers began to perform multiple teaching activities, and also became concerned with technologies such as animated pictures, which were most appropriate for specific subject content.

Biology as a subject includes varied content knowledge. I cannot adopt the same method to teach all chapters of the textbook. My mentor thus recommended that I combine questions with animated pictures to more closely interact with the students. (Intern C, 3rd FGI)

Mentor C identified changes in the instructional strategies of pre-service teachers using technology that was related to TPK when using the observation sheets. *Mentor A* also confirmed changes in the instructional strategies of pre-service teachers when discussing instructional plans with two pre-service teachers. Throughout the CPD program, the

pre-service teachers considered student characteristics when designing activities that involved technology, as expressed in the following comments:

> *During course design, I ignored the prior knowledge of students and did not consider how appropriate they were for my course design. I must therefore be more aware of the ability of my students (Intern C, 3rd FGI)*

> *A teaching activity that uses only one teaching method is incomplete. Teaching methods should therefore be revised to match student learning styles. (Intern A, 4th FGI)*

During the initial stage of the CPD program, pre-service teachers relied on the technology integration model of their mentors. Pre-service teachers focused on TK applications, and their lectures were based on slide presentations. Classroom observations and FGI discussions facilitated reflection by the pre-service teachers on their use of technology. After the third FGI, pre-service teachers began to combine subject contents with animated pictures and considered multiple teaching methods that suited the learning abilities of their students.

Benefits of the CPD program for mentors and pre-service teachers

During the CPD program, including the after class period, collaboration among mentor teachers was insufficient to develop TPACK, although they observed each other's teaching and recorded several descriptions of teaching activities in the observation sheets. Their interactions were also limited to technological skills rather than subject contents or instructional strategy. One mentor teacher made the following comment.

> *We exchanged digital multimedia by e-mail…. With our different office locations and busy schedules, we rarely discussed among each other. (Mentor A, 3rd FGI)*

The frequency of mentor-mentor interactions remained unchanged during the CPD program, while that of mentor-intern interactions increased. Before the program, mentor teachers assisted pre-service teachers in their classroom performance. In response to problems, pre-service teachers could approach any mentor teacher for assistance. The program increased the frequency of mentor-intern interactions, and especially increased the frequency of interactions concerning technology integration. Notably, besides enabling regular discussions on subject content, interactions between mentors and interns helped both parties to develop new interests. The pre-service teachers focused on developing pedagogical knowledge, while the mentors focused on using various technological functions to present knowledge, as reflected by the following comments:

> *I would often wonder about the effectiveness of my instructional strategies, explaining why I often called on my mentor. My mentor also suggested how I could lecture more effectively. (Intern B, 2nd FGI)*

> *Given my hectic schedule, I have no spare time to design digital materials using PowerPoint software. My pre-service teacher offered assistance after we discussed the subject contents. Afterward, we often discussed how to present effective digital materials in order to improve learning. (Mentor C, 2nd FGI)*

Pre-service teachers recognized that cooperation encouraged and strengthened peer-mentorship, as reflected by the following comments:

> *Despite my fear of teaching poorly, I seldom sought my mentor for assistance. Pre-service teacher C always encouraged me and helped whenever I ran into difficulties in the classroom, especially in relation to software utilization. I am happy to learn from other pre-service teachers. (Intern A, 4th FGI)*

> *Before teaching, I asked pre-service teacher C about lesson design. We discussed the program requirements and shared ideas. I found this discussion helpful in integrating technology in my classroom. (Intern B, 2nd FGI)*

Analytical results indicate that both mentor teachers and pre-service teachers developed professionally. However, mentors collaborated only on exchanging digital material. Notably, pre-service teachers were critical to the CPD program. The pre-service teachers, especially *Intern C*, were superior to their mentors in technological skills. Like

video clips, these technological skills not only motivated mentor teachers to apply technology in teaching, but also enabled them to help their mentors and other pre-service teachers design technological applications for teaching. Additionally, the pre-service teachers actively sought further instruction from mentor teachers and seized additional opportunities than previously to discuss technology-integrating activities with other pre-service teachers. By increasing learning opportunities and peer-mentoring opportunities, pre-service teachers recognized their own professional development in integrating technology.

In summary, pre-service teachers benefit from the CPD program more than the mentors. In particular, the pre-service teachers benefited from various opportunities to learn technology integration-related applications, while the mentors lacked sufficient peer collaboration in technology integration during the CPD program.

Discussion

This study examines the collaborative professional development of a group of mentors and pre-service teachers in technology integration. During the CPD program, the findings regarding poor collaborations of mentor teachers in technology integration differ from those of Tondeur et al. (2013). According to their results, collaborating with colleagues improves technology integration ability. The poor collaboration is owing to that the mentor teachers had limited motivation to work with other mentor teachers, as mentioned elsewhere (Pawan & Ortlof, 2011; San Martín-Rodríguez, et al., 2005), thereby limiting the exchange of ideas regarding technology application. In Taiwan, in-service teachers are accustomed to working alone, thereby limiting their willingness to discuss teaching practices with each other. Technological skills are also insufficient for mentors to integrate technology into their classroom instruction. In this study, the technological skills of pre-service teachers can fulfill the requirements of mentor teachers. This study identifies the benefits of collaboration between mentor teachers and pre-service teachers (Chen, 2012; Goodnough, et al., 2009). When supported by pre-service teachers in using technology and designing digital materials, mentor teachers can easily combine various technological applications and subject contents. Since pre-service teachers support the use of technology in ways related to subject contents, the technology integration activities of mentor teachers tend to construct the TCK base. Therefore, during this study, mentor teachers went from using a single TCK to constructing various TCK bases.

Our results further indicate that the technology-based teaching activities of pre-service teachers shifted the focus from TK to TCK and TPK, despite the difficulty of identifying overall TPACK development. Similar to a study of Koh and Divaharan (2011), the pre-service teachers focused on TK at the start of the CPD program. The program extended the opportunities enjoyed by pre-service teachers to observe the teaching activities of mentors and other pre-service teachers. Those activities were discussed as well. In particular, pre-service teachers became mentors for each other, which is consistent with previous findings (Le Cornu, 2005; Sundli, 2007), and acted as critical friends and providers of feedback. These pre-service teachers easily form collaborative relationships and obtain more support and feedback from their peers than from their mentors. Guidance from mentors with respect to pedagogy knowledge and interactions with skilled peers enabled pre-service teachers to constantly practice the application of TCK and TPK, subsequently developing professionally in technology integration concepts related to TPACK.

Pre-service teachers undoubtedly strive to obtain practical experiences and adopt various instructional strategies to prepare for their future careers. Highly motivated, the pre-service teachers in the CPD program actively engaged with all mentor teachers and other pre-service teachers at school and shifted the focus of technology integration activities from TK to TCK and TPK. The mentor teachers examined in this study were motivated only to apply technology. With the assistance of pre-service teachers, experienced mentors with sufficient PCK can develop technology integration ideas faster than ever. Although mentor teachers did not implement sufficient technology integration activities, pre-service teachers learned about the methods of technology integration through discussion with their mentors. Since action is superior to knowledge, the CPD program enhanced the professional development of pre-service teachers in relation to technology integration more than it did for the mentor teachers.

Based on the TPACK constructs, technology integration activities involve more pedagogical activities than simply lecturing. Insufficient in-service training limits the effectiveness of teachers in integrating technology in their classroom. As a school-based teacher education program, the CPD program benefits both mentor teachers and pre-service teachers by extending collaborative opportunities, thus enabling all teachers to acquire knowledge skills from each other. Observing the instruction and discussions of pre-service teachers motivated mentors to integrate

technology in their teaching practices. The above perspective regarding the extent to which the active learning performance of pre-service teachers affects mentors appears to facilitate the professional development of in-service teachers in relation to technology integration.

Although previous investigations have demonstrated the effectiveness of collaboration between a pair of pre-service and mentor teacher (e.g., van Velzen et al., 2012), this study uniquely identifies that pre-service teachers gain more from the CPD program than mentor teachers do. Conversely, the collaborations among mentors were poor, slightly limiting applications to a school-based mentoring team.

In this study, several mentor-intern relationships provide numerous opportunities for mutual learning by mentors and interns. Pre-service teachers were also involved in peer mentoring and were willing to provide mutual support. The CPD program is based on collaboration between mentor teachers and pre-service teachers in a school. Undoubtedly, the program can be applied for traditional school-based teacher education, which provides few opportunities for meaningful collaboration with other educators. When the CPD program is implemented in a school-based teacher education situation, pre-service teachers skilled in using computers could facilitate the implementation of the mentors' ideas on TPACK application and further obtain the guidance from mentors for integrating technology in the classroom. Both mentors and pre-service teachers develop professionally during the collaboration in technology integration.

Conclusions and future research

This study demonstrates that both pre-service teachers and mentor teachers developed professionally in relation to technology integration through the program implemented here. In particular, the mentor teachers changed their teaching activities when they had the support of pre-service teachers: from presenting knowledge of technological contents to constructing various TPK approaches. The pre-service teachers shifted to using TCK and PCK, having originally focused on TK applications and the application of slide presentations to teaching. Moreover, the mentors developed technology integration ideas with the assistance of their pre-service teachers faster than previously. Afterwards, the pre-service teachers learned more about the methods of TPACK applications through discussion with all mentors as well as interactions with skilled peers in a school-based mentoring team.

Notably, the CPD program benefited pre-service teachers more than mentor teachers since the former sought more opportunities for the practical application of TPACK than the mentor teachers did, who only exchanged technological applications.

This study developed a strategy in which pre-service teachers seemed to be an initiator for CPD in a mentoring team. We recommend that future research efforts identify the feasibility of the strategic perspective in school-based teacher education. Future research should also investigate the factors resulting in poor collaborations of the mentors in a school-based mentoring team.

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