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Multimedia case-based learning to enhance pre-service teachers' knowledge integration for teaching with technologies

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HIGHLIGHTS

- We investigated the effects of multimedia case-based learning in teacher education.
- Video cases helped pre-service teachers' individual knowledge acquisition.
- Video cases helped pre-service teachers integrate knowledge for TPACK.
- Teacher preparation programs need to be reconstructed to incorporate TPACK.

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ABSTRACT

This study investigates the effects of case-based learning on pre-service teachers' knowledge integration related to teaching with technologies. 78 pre-service teachers were provided with interventions that included either video cases or no cases. ANCOVAs were performed to compare two groups' TPACK scores representing technological, pedagogical and content knowledge, and their integration. The results showed that video cases improved pre-service teachers' perceived learning of technological and pedagogical knowledge, and knowledge integration of these knowledge areas. However, content-relevant knowledge for technology integration was not developed through case-based learning. The results were discussed in the context of current teacher preparation programs.

1. Introduction

Nowadays, new generations are immensely familiar with emerging technologies, and pre-service teacher education has even more strongly emphasized the use of such technologies in a meaningful way in education (Ertmer, 2005; Lawless & Pellegrino, 2007). With this increasing importance of using technologies in teaching, in the United States, one survey shows that, among 1439 institutions with teacher education programs, 85 percent provide an educational technology course (Kleiner, Thomas, & Lewis, 2007). However, doubts have been raised as to whether pre-service teachers are adequately educated to use these technologies in a way that goes beyond standard daily use that could be incorporated within instructional practice to enhance education. Researchers have criticized university teacher preparation courses for putting more emphasis on a mastery of basic computer skills, such as using a particular software program, rather than on teaching students to integrate technology into their classroom teaching (Lee, Shin, Yoo, & Lee, 2000; Llorens, Salanova, & Grau, 2002; Russell, Bebell, O'Dwyer, & O'Connor, 2003). This criticism seems universal and many studies conducted in various countries reported the needs for improvement of university teacher preparation programs. For example, in Singapore, pre-service teachers perceive that finding and integrating ICT tools and resources relevant for the target students and learning activities is particularly challenging (So & Kim, 2009). Also, the limitations of current teacher preparation programs have been reported in South Korea (Eom, Shin, & Han, 2011), in Turkey (Goktas, Yildirim, & Yildirim, 2009). By comparing the use of technologies between new teachers and more experienced teachers in the United States, one study also reported that pre-service teachers are not educated to use technologies when delivering instruction or having students engage in learning

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activities (Russell et al., 2003). Along with this criticism, pre-service teachers also perceive their teacher preparation programs do not adequately address their needs for technology integration, because educational technology courses are disconnected from methods courses (Friedman & Kajder, 2006; Kay, 2006) and lack content-area relevance (Sutton, 2011).

Recently, academic interest in these deficiencies in teacher preparation programs has increased and technological, pedagogical, content knowledge (TPACK) has been proposed as a framework to examine what knowledge teachers should have in order to effectively integrate technology in teaching (Koehler & Mishra, 2008, 2009; Koehler, Mishra, & Yahya, 2007; Mishra & Koehler, 2006). According to TPACK, content, pedagogy, and technology should be considered as a whole, not separately, with TPACK being explained as the outcome of interactions among the three parts of the model, which includes effective teaching and learning activities and strategies using technology. Also, given that there is no 'one-size-fits-all' teaching and learning strategy for using technology, these three parts of TPACK should be flexibly amalgamated in content-specific ways (Mishra & Koehler, 2006). Within this framework, many studies argue that teachers should be educated to integrate knowledge of technology, pedagogy, and content in teacher preparation programs (Niess, 2005; Polly, McGee, & Sullivan, 2010). However, we are not aware of any research that particularly focuses on how to educate pre-service teachers to construct integrative knowledge for technology integration. Prior studies have identified teachers' belief as a critical factor that influences teachers' use of technology (Ertmer, 2005; Hew & Brush, 2007; Kim, Kim, Lee, Spector, & DeMeester, 2013) and various strategies for changing teachers' belief have been suggested (Ertmer, 2005; Kim & Baylor, 2008). However, these studies do not provide a guideline of how to improve teachers' integrative knowledge that is a prerequisite for effective technology integration. Thus, in this study, we examine the effect of multimedia case-based learning as an instructional method for pre-service teachers' construction of TPACK that is necessary for using technology in future practice.

2. Relevant literature

2.1. Case-based learning for teacher education

The construction of integrative knowledge can be realized with case-based learning approaches, which provide pre-service teachers with contextual understanding of how complex teaching and learning can be, and when and how to apply instructional principles at critical decision points (Doyle, 1990; Sykes & Bird, 1992). This instructional method is theoretically based on situated cognition and cognitive flexibility, and also related to anchored instruction (Fang, Lee, & Yang, 2011; Schulman, 1992; Williams, 1992). According to a theory of situated cognition (Brown, Collins, & Duguid, 1989), learning can be meaningful and effective when instruction is based on specific situations rather than presented in decontextualized activities. Since classrooms are dynamic and changing environments, in order to successfully plan and implement lessons, teachers have to endeavor to integrate their knowledge in a way that reflects content-specific contexts. Thus, teaching and learning should not be addressed theoretically as distinct constructs, but occur simultaneously and in an integrative way, which is more difficult to achieve from a lecture and textbook model (Schulman, 1992).

Given that cases capture and provide dynamic interactions in teaching practice, case-based learning has been researched and reported as a possible method for enhancing teacher education by providing opportunities to combine content knowledge and pedagogical theories learned in different teacher preparation courses (Baker, 2009; Kim, 2011; Kim & Hannafin, 2008, 2009; Koc, Peker, & Osmanoglu, 2009). Specifically, case-based learning has proven effective in developing various thinking skills, such as critical thinking skills (Mayo, 2004), reasoning abilities and meta-cognitive skills (Lundeberg, 1999), and also in other aspects of teacher education, such multicultural education (Noordhoff & Kleinfeld, 1991), motivation (Richardson, 1994), and classroom management (Stoiber, 1991). Overall, cases in teacher education provide opportunities to pre-service teachers to apply theoretical knowledge to analyzing real classrooms (Lundeberg, 1999) and to prepare for realities of teaching (Butler, Lee, & Tippins, 2006; Masingila & Doerr, 2002).

2.2. Multimedia case-based learning for knowledge integration

Multimedia cases appear to better capture a classroom's complexity compared to print-based cases that often present a single viewpoint and present events in a linear format (Kinzer, Cammack, Labbo, Teale, & Sanny, 2006; Kinzer, Kapur, et al., 2006) and visualize dynamic processes, which present learners with a fuller picture of complexity (Goldman, Pea, Barron, & Derry, 2007). In a study comparing classroom exemplars in video, animation or text formats, Moreno and Ortegano-Layne (2008) found that the video and animation groups were better able to apply principles learned in the course than the text and no case groups. With this advantage of multimedia cases, multimedia case-based learning has shown to enhance pre-service teachers' understanding about real classroom environments (Han & Shin, 2011; Koc et al., 2009; Kurz & Batarelo, 2010; Zhang, Lundeberg, Koehler, & Eberhardt, 2011). For example, Baker (2005, 2009) examined teachers' perceptions of their growth as literacy teachers, and multimedia case-based instruction was perceived as a useful tool to advance this pedagogical development. Also, Case Technologies to Enhance Literacy Learning (CTELL) proved a potential vehicle to broaden pre-service teachers' understanding. This project showed that teachers became more aware of the centrality of concepts related to the principles of effective reading instruction than did a control group taught using traditional methods (Kinzer, Cammack, et al., 2006; Kinzer, Kapur, et al., 2006). Furthermore, teachers used what they learned from multimedia cases when they designed their own activities (Van den Berg, Jansen, & Blijleven, 2004).

Regarding knowledge integration for using technology in teaching, multimedia cases also have potential to improve pre-service teachers' technology uses by developing their situated understanding of theories as applied in real classroom situations (Kim, 2011). Moreover, multimedia case-based learning and discussions positively affected pre-service teachers' perceptions of the diffusion of information and communications technologies (Sahin, 2012) and their lesson planning for using technologies (Han & Shin, 2011). Despite these positive influences of multimedia cases on technology integration, these studies did not further examine whether multimedia cases affected knowledge integration of technology, pedagogy and content knowledge that was proposed as a framework for effective integration of technology in teaching.

3. Research questions

In order to successfully educate pre-service teachers to effectively use technologies in teaching, their knowledge acquisition in technological, pedagogical and content aspects is necessary. Further, how to integrate those three elements is critical for enabling the knowledge to be used to solve authentic problems in real teaching practice. Thus, this study examines how multimedia case-based learning affect pre-service teachers' perceived learning of individual knowledge acquisition regarding technology, pedagogy and content knowledge, and integration of these three for

using technologies. To do this, learning with video cases and learning without cases are compared. Our research questions are: (1) Are there any differences in enhancing pre-service teachers' perceived learning of individual knowledge acquisition in the use of technology between learning with video cases and learning without cases? (2) Are there any differences in enhancing pre-service teachers' perceived learning of knowledge integration between learning with video cases and learning without cases?

4. Methods

4.1. Research context

This research was conducted in the context of teacher preparation program in South Korea. South Korea has implemented government-driven action plans in every critical stage of ICT (Information and Communication Technology) development. From 1996 to 2000, in order to build infrastructure for ICT education in K-12 settings, the Korean government implemented a nationwide plan that provided computer labs in schools and a computer with an Internet connection for every teacher. This dramatic increase in the physical infrastructure led to the implementation of successive actions plans for technology integration to subject-matter education and improvement of the quality of education for K-12 students and professional competencies of teachers by providing a diverse range of high-quality educational digital contents.

Resulting from these action plans, in last decade, physical infrastructure and digital learning contents for teaching and learning in subject-matter education has been formed (MEST & KERIS, 2010). However, supports for principal agents who in fact use digital technologies in education have been limited. Thus, recent research still reports that the university curriculum for technologies and ICT education has a drawback of not adequately reflecting the needs in reality (Han, Lee, & Lee, 2006). Even though the infrastructure for digital technologies differs depending on countries, the problem in teacher preparation program seems universal. As discussed earlier, many studies have criticized teacher preparation courses for putting more emphasis on a mastery of basic computer skills rather than on training pre-service teachers to effectively use technologies in practice (Lee et al., 2000; Llorens et al., 2002; Russell et al., 2003).

4.2. Participants

The participants comprised 78 students who were enrolled in a teacher preparation course, 'Educational Methods and Educational Technology', in a private university located in Seoul, South Korea in Spring 2011. 'Educational Methods and Educational Technology' is an education methods course that is offered for undergraduate students who are interested in becoming teachers. Since these students are from different majors, methods courses do not intend to enhance content specific knowledge and instead, mainly focus on teaching and learning theories, models and methods. In addition, the use of technology has become a required component of teaching methods courses in most programs and education methods courses are offered under the name of 'Educational Methods and Educational Technology' in most universities in South Korea. These emphasize the effective use of technology based on teaching and learning theories, models, and methods. Therefore, pre-service teachers in methods courses are expected to acquire pedagogical and technological knowledge.

There were two sections of the course, led by different instructors. Section 1 involved 38 students (15 males and 23 female) and section 2 had 40 students (20 males and 20 females). Data from 57 students (26 students from section 1 and 31 students from section 2) who had completed pre and post surveys were analyzed. Most participants were in their third or fourth year of college, who either had completed student teaching practicum before this experiment was conducted or would complete it as a requirement in a teacher education program.

All participants voluntarily participated in this experiment. Since this study was conducted as a field experiment, learning activities and interventions were provided within the regular course. However, surveys as experimental measurements were not included in the grading so that participants could choose whether they wanted to participate. At the end of the semester, participants were given feedback about what they had done in the class as a part of the experiment and debriefed about the result of the study. In the debrief, participants who were in the no-case group were given an opportunity to view two video cases and to observe in-service teachers' practices, which was intended to mitigate the intervention effect in learning for those who had received a treatment that had been assumed less effective in the study.

4.3. Video cases

The video cases used for this study were video clips showing classroom practice. These had won awards for showing the best practices of using digital technologies at The Competition for ICT Teaching and Learning Practices in South Korea. Two selected video clips introduced ICT preparation stages, such as subject, topic, target group, the teaching-learning model used, classroom layout, and technologies needed. After the introduction, the clip showed real classroom teaching with technology. Pre-service teachers could learn how to use technologies appropriately in different phases of a lesson and reflect on various aspects of technology use. At the end of each video clip, interviews from children who had taken part in the lesson were provided. These three elements (explanation of the ICT module, classroom teaching, and student interviews) within the video cases offered a rich context for learners, while providing access to information about learning goals, content areas, student information, and information about the classroom environment. This additional information allowed reflection and analysis leading to a deeper understanding of why technology was used in certain specific ways. General information about each case is provided below (Table 1). The running time of the Case 1 video clip was around 21 min and that of the Case 2 clip was around 18 min.

4.4. Research design

This study was field-based and quasi-experimental. The course, 'Educational Methods and Educational Technology' was a required teacher preparation course that dealt with various learning theories, instructional models, strategies, and the use of educational technologies. Students in this course were required not only to understand these theories and models but also to ideally build integrative knowledge so as to use them in practice. Even though

Table 1
Case information.

	Case 1	Case 2
Subject	Social studies	Science
Topic	Geography and human life	Water cycle and weather
Target group	10th grade	9th grade
Teaching-learning model	Brain storming	Project-based
Classroom environment	Computer lab	Computer lab
Technologies used	Computer, CD, projector	Computer, projector

different instructors taught different sections of the course, learning contents and activities that were delivered before conducting the experiment were designed identical in order to mitigate the instructor effects. For six weeks before the study was conducted, students learned about lesson planning, instructional models (lecture, discussion, discovery learning, inquiry-based learning, cooperative learning, and project-based learning), behaviorism, cognitive learning theories, and educational technology. While the first part of the course focused on acquiring basic knowledge about individual topics, the latter half considered integrating this with practical knowledge that could be used in educational practice. In the latter half, this study was implemented using two different approaches, the learning with video cases and learning without any cases.

Participants in the video case group watched two video clips, one per class, for two weeks (once a week), as a group of four or five. Each group, after watching a clip, discussed what they had watched and wrote a group reflection paper based on reflection questions provided.

Participants in learning without cases group were not provided video cases as a clip but offered syllabi and *MS Power Point* presentation files that were prepared and used by model teachers shown in the video cases. Syllabi and presentation files were blueprints for teaching and learning activities shown in the video clips. In the syllabus, basic information about the subject, topic, target group, teaching–learning model used, and classroom environment was described in text. More detailed information was also provided about teaching–learning activities, content delivered, technologies used, phases of using technologies, materials used. *MS Power Point* files that model teachers created and used in video cases included guidelines for learning activities. Participants in the no-case group read and reviewed these two syllabi and presentation files, one per class, for two weeks as a group of four or five. Each group, after reading the materials, had a discussion and wrote a group reflection paper, as the video case group did.

4.5. Measures

4.5.1. Prior content knowledge

In order to control participants' prior knowledge, two instructors used the same syllabus for the first half of the course before conducting the experiment. To examine whether there were any differences in understanding of the contents between two groups before starting case-based learning, a prior content knowledge test was administered. 10 multiple-choice questions included the contents of teaching–learning theories, educational technologies, and technology use in education. These questions were chosen from two instructors' test banks for this particular course that have accumulated all midterm test items for two years and validated with over three hundred students in a real testing situation.

4.5.2. Individual knowledge acquisition and knowledge integration

Pre-service teachers' individual knowledge acquisition and knowledge integration were evaluated with selected items of the Technology, Pedagogy, and Content Knowledge (TPACK) survey, developed based on the model suggested by Mishra and Koehler (2006). The original TPACK survey instrument was developed with the purpose of measuring teachers' perceived understanding of technology in relation to pedagogical and content knowledge (Schmidt et al., 2009). This original instrument consisted of seven categories, three for each Technology (TK), Pedagogical (PK) and Content (CK) knowledge set, three for each two combination of TPK, TCK, and CPK, and one for three combination of TPACK. This instrument has been translated and used in the context of various countries such as Singapore (Koh, Chai, & Tsai, 2010). To conduct research with Korean pre-service teachers, it was revised and translated to Korean and used in a study conducted by Shin, Han, and Eom (2012). In this study, 28 items in seven categories were used and the reliability was .925.

The current study's main purpose was to examine pre-service teachers' individual knowledge acquisition and knowledge integration for technology use. Thus, 24 items in five categories that were relevant to technology use were selected. Given the study focus, the four categories that were explicitly related to technology were included. These were TK, TPK, TCK, and TPACK. Since the provided cases delivered contents related to teaching–learning models, methods and strategies, the category of PK was also included. Two categories, CK and CPK, were excluded, since the course was not designed for specific content knowledge acquisition and students in the course were from various different majors. Items used for this study are presented in Table 2.

4.6. Procedures

The pretest of individual knowledge acquisition and knowledge integration was conducted with the TPACK survey instrument in the second week of the course. Based on studies reporting the superior effect of combination of case-based learning and lectures to a

Table 2
Survey items used for pre and posttests.

Categories	Items
TK	I know how to solve my own technical problems. I can learn about technology easily. I keep up with important new technologies. I frequently explore technology. I know about a lot of different technologies. I have the technical skills I need to use technology.
PK	I know how to assess student performance in a classroom. I can adapt my teaching based upon what students currently understand or do not understand. I can adapt my teaching style to different learners. I can assess student learning in multiple ways. I can use a wide range of teaching approaches in a classroom setting. I am familiar with common student understandings and misconceptions. I know how to organize and maintain classroom management.
TCK	I know about the technologies that I can use for understanding and conducting my subject.
TPK	I can choose technologies that enhance the teaching approaches within a lesson. I can choose technologies that enhance students' learning for a lesson. My teacher education program has caused me to think more deeply about how technology could influence the teaching approaches I use in my classroom. I am thinking critically about how to use technology in my classroom. I can adapt the use of the technologies that I am learning about to different teaching activities. I can select technologies to use in my classroom that enhance what I teach, how I teach and what students learn. I can use strategies that combine content, technologies and the teaching approaches that I learned about in my coursework in my classroom. I can provide leadership by helping others to coordinate the use of content, technologies and teaching approaches at my school and/or district. I can choose technologies that enhance the content for a lesson.
TPACK	I can teach lessons that appropriately combine my subject, technologies and teaching approaches.

complete case-based setting (Baeten, Dochy, & Struyven, 2011a, 2011b; Han & Shin, 2011), lectures were conducted before case-based learning. From the second to the seventh week, participants learned through instructors' lectures. Then, in the eighth week, a prior content knowledge test was administered as part of the midterm test. After this, the experiment took place over two weeks. In the first week, each group either watched the first case or read the first syllabus and presentation file and analyzed it by discussing it for about 20 min with group members. After discussion, they wrote a reflection paper based on the reflection questions. Discussion and reflection activities are key components of case-based learning designed to enhance pre-service teachers' understanding of cases and improve their knowledge acquisition (Whittaker & van Garderen, 2009). To help pre-service teachers' reflection, prompt questions were provided. They could re-watch the video clips or reread the learning materials as many times as were necessary to recall what they had seen or read so as to answer the questions. These questions led them to reflect critically in order to evaluate other teachers' teaching in terms of technology use. Questions contained the four aspects shown in Table 3. By writing reflections based on prompts within the above four areas, we expected that pre-service teachers would reinforce their understanding of technology use in practice, build up a framework that they could use to evaluate others' technology use, critically examine the areas to be improved, and eventually use this knowledge in their own teaching by integrating their individual knowledge learned from the methods course.

In the second week, participants also analyzed cases or read learning materials as a group and wrote a reflection paper. After the experiment, the survey instrument on individual knowledge acquisition and knowledge integration was administered as a posttest.

5. Results

To investigate the effects of multimedia case-based learning on pre-service teachers' individual knowledge acquisition and knowledge integration of technology uses in education, an analysis of variance was conducted with a dependent variable of intervention types and independent variables of five knowledge categories. Participants in both groups showed no differences in their prior content knowledge level with mean scores of 6.50 (SD = 2.06) for video case group and 6.36 (SD = 1.58) for no-case group ($t = .271$, $p = .787$). In order to control the effect of participants' perceived understanding before the intervention, ANCOVA was administered with a covariate of pretest scores.

5.1. The effects of multimedia case-based learning on individual knowledge acquisition

Firstly, we tested whether learning with video cases and learning without cases differed in enhancing pre-service teachers' perceived learning of individual knowledge with the dependent variables of Technological Knowledge and Pedagogical Knowledge. The estimated marginal means for post survey scores are provided in Table 4. As shown in the descriptive statistics results, the video case group showed more enhanced perception of their Technological Knowledge and Pedagogical Knowledge acquisition. In order to investigate whether this difference was statistically meaningful, two separate ANCOVAs with covariates of pretest were conducted. According to the ANCOVA results, the main effect of intervention type for both Technological Knowledge, $F(1, 54) = 5.548$, $p < .05$, partial $\eta^2 = .09$, and Pedagogical Knowledge, $F(1, 54) = 7.831$, $p < .01$, partial $\eta^2 = .13$, was statistically significant.

Table 3
Categories of reflection questions used for case-based learning activity.

Understanding of the respective teaching–learning module as linked to ICT.
Analysis of general teaching experience based on the ICT Skill Standards for Teachers.
Analysis of specific activities using ICT in terms of learning objective, motivation, interactivity, assessment.
Rationale for improving teaching experience by using ICT.

Table 4
Estimated marginal means for post survey scores.

	Video case group ($n = 26$)		No-case group ($n = 31$)	
	M	SD	*M*	SD
TK[a]	20.00	.56	18.22	.51
PK[b]	24.47	.54	22.41	.49

[a] Maximum score: 30.
[b] Maximum score: 35.

5.2. The effects of multimedia case-based learning on knowledge integration

5.2.1. Integration of technological and pedagogical knowledge (TPK)

In order to successfully use technology in education, pre-service teachers need to learn how to incorporate technologies in accordance with learning models and strategies. To examine the effects of video cases on how pre-service teachers integrated Technological and Pedagogical Knowledge, the video case group and the no-case group were compared. The independent variable was intervention type and the dependent variable was participants' Technological and Pedagogical Knowledge scores. The descriptive statistics results showed in Table 5 indicated that the video case group scored better than did the no-case group in the category of Technological and Pedagogical Knowledge. An ANCOVA with a covariate of pretest was conducted for statistical analysis. A main effect of intervention type for Technological and Pedagogical Knowledge was significant, $F(1, 54) = 8.399$, $p < .01$, partial $\eta^2 = .135$.

5.2.2. Integration of Technological and Content Knowledge (TCK)

Technologies should be used in a content-specific way so as to reflect the uniqueness of subject and learning topics. In order to examine whether pre-service teachers could integrate their Technological and Content Knowledge, statistical analysis was performed. The video case group showed higher scores than the no-case group in the category of Technological and Content Knowledge in the post survey (see Table 5). An ANCOVA with a covariate of pretest was conducted to further investigate whether this difference in scores was meaningful. The result revealed that the main

Table 5
Estimated marginal means for the post survey scores of Technological and Pedagogical Knowledge, Technological and Content Knowledge, and Technology, Pedagogy and Content Knowledge.

	Video case group ($n = 26$)		No-case group ($n = 31$)	
	M	SD	*M*	SD
TPK[a]	32.66	.79	29.55	.72
TCK[b]	3.67	.16	3.31	.15
TPCK[c]	3.59	.14	3.41	.13

[a] Maximum score: 45.
[b] Maximum score: 5.
[c] Maximum score: 5.

effect of intervention type for Technological and Content Knowledge was not statistically significant, $F(1, 54) = 1.877$, $p < .113$, partial $\eta^2 = .046$.

5.2.3. Integration of Technology, Pedagogy and Content Knowledge (TPACK)

Finally, it was proposed that in order to practice a successful technology-integrated lesson, technology knowledge, pedagogical knowledge, and content knowledge should be integrated. The effect of video cases on the knowledge integration of these three elements was examined using an ANCOVA with a covariate of pretest. The video case group showed a slightly higher score in the post survey than did the no-case group for Technology, Pedagogy and Content Knowledge (see Table 5). However, this difference was statistically insignificant, $F(1, 54) = .902$, $p = .346$, partial $\eta^2 = .016$.

6. Discussion

The purpose of this study was to investigate the effects of multimedia case-based learning on pre-service teachers' knowledge integration related to using technologies in practice. To serve this purpose, we assessed pre-service teachers' perceived understanding of individual knowledge acquisition and knowledge integration related to technology, pedagogy and content, depending on instructional intervention. The study results address two main ideas on: (1) How we educate pre-service teachers to construct an integrative perspective for using technologies, and (2) How we can reconstruct methods courses in university teacher preparation programs.

6.1. Video cases for knowledge integration

In this study, in order to provide pre-service teachers with the opportunity to learn how to integrate technological, pedagogical and content knowledge for effective technology use, we adopted multimedia case-based approach in an educational methods course. Topics of methods courses usually include theoretical aspects of instructional models for using technology in education. Thus, pre-service teachers can learn about the effects of using technologies and specific learning models or methods. However, this knowledge is decontextualized since they develop individual knowledge through the textbook but do not have opportunities to build integrative knowledge about when and how to apply the theories in different educational situations (Sahin, 2012; Sutton, 2011).

To learn how to use technology as embedded in particular learning models, viewing and analyzing the experiences that in-service teachers have as they try to integrate technology into their practice is crucial. Multimedia cases, in particular, have been proven to effectively embed such analysis by providing richer contexts (Koc et al., 2009; Kurz & Batarelo, 2010; Zhang et al., 2011). Thus, video cases we provided were expected to offer pre-service teachers opportunities to learn pedagogical and technological knowledge based on various classroom contexts, and to reflect on how to integrate those two knowledge areas in real teaching practice. The results of our study support the hypothesis by showing that learning with video cases was beneficial to both individual knowledge acquisition and knowledge integration. The students who were provided with video cases reported more enhanced perceived understanding of both technological knowledge and pedagogical knowledge. Also, they reported better perceived understanding of technological pedagogical knowledge than did the students who were provided with learning without cases. Since video cases included contextual information that becomes the base for the case teachers' pedagogical decision-making when they use technology, pre-service teachers could observe and analyze these decision-making processes and model expert teachers' successful teaching practices. Through these observing and analyzing opportunities, pre-service teachers could integrate their individual knowledge about technology and pedagogy within specific contexts.

6.2. Teacher preparation programs for knowledge integration

Unlike the results discussed above, there were also hypotheses that were not supported. In the categories of technological content knowledge and technological, pedagogical content knowledge, the video case group and the no-case group did not show any differences in their understanding. These results imply that even though students have content knowledge of their subject, they cannot integrate that knowledge effectively with technology knowledge and pedagogical knowledge, if they are not provided with opportunities to see technology use modeled in content-specific contexts. The cases provided in this study were related to geography and earth science content, but participants comprised very few geography education majors and no earth science majors. The few geography education students might have improved their integrative understanding of technological, pedagogical, and content knowledge, since the video cases showed the best practice of using technology in teaching geography. However, a majority of the students who participated in the study were not provided content-specific cases and could not integrate these three knowledge elements regardless of the type of intervention provided.

This result could be due to the limitation of current teacher preparation programs that provide disconnected learning experiences among technological, pedagogical, and content knowledge (Friedman & Kajder, 2006; Kay, 2006; Sutton, 2011). The segregation of content knowledge learning and educational methods learning in teacher preparation programs potentially prevents knowledge from being integrated in a way that can reflect context-specific uses of educational methods. As discussed earlier, in current teacher education programs, pre-service teachers learn content relevant to subject from their major department programs but learn theories and models from a teacher preparation program that is commonly offered to all pre-service teachers irrespective of major. Thus, in the educational methods courses, it is a challenge to provide subject-specific pedagogical approaches or technology uses.

The disconnection between technological and pedagogical knowledge could be overcome by applying multimedia case-based approach within the methods courses as discussed above. However, the problem of lacking of content-area relevance cannot be solved by applying a certain instructional intervention within current methods courses but might be overcome by reforming teacher preparation program in a way that can incorporate all three aspects of technological, pedagogical and content knowledge (Eom et al., 2011).

7. Implications and limitations

Multimedia case-based learning is unique in that it provides knowledge integration opportunities in pre-service teacher education. In the teacher preparation system, pre-service teachers have limited opportunity to practice teaching and receive little chance to observe experienced teachers' practice (Sahin, 2012). Thus, a multimedia case-based approach can benefit pre-service teachers in terms of integrating their knowledge by observing and analyzing other teachers' use of technologies. Also, this study has implications for the teacher preparation curriculum, which currently separates subject matter learning and educational methods learning. Since pre-service teachers need integrative knowledge about technology

uses that is pedagogically appropriate and can work in subject-specific contexts, educational methods courses should be integrated into the curriculum of each subject.

This study has some limitations. Firstly, we used a Convenience sampling method since the study was conducted with a quasi-experimental design in the real classroom settings. The Convenience sampling might have caused the possible inclusion of potential extraneous variables, such as participants' prior experiences and instructor effects. In terms of participants' prior experiences, participants who had already completed a student teaching practicum might have responded differently to multimedia case-based methods compared to those who had not been practiced classroom teaching. This difference could not be considered in the research design and thus not controlled. Also, we had two different instructors in two different sections, each of which served as an experimental group in the study. Even though learning contents and activities that were delivered before conducting the experiment were designed identical in order to mitigate the instructor effects, instructors' teaching styles, gender, and interaction pattern with students might have affected study results. Thus, further research using a better design involving randomization to better control variables is needed to examine findings in more depth. Also, self-reporting measurements for perceived understanding was not able to measure the actual knowledge improvement in terms of TPACK, which might lose objectivity of measurement. Since there is not yet other subjective quantitative measurement developed, we might use research methods, such as interview or observation, from a qualitative approach and find more evidence to support our quantitative results. Due to these limitations, the current results should be interpreted cautiously to avoid over-generalization.

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