Using Live Dual Modeling to Help Preservice Teachers Develop TPACK

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Abstract

To help preservice teachers learn about teaching with technology—specifically, technological pedagogical content knowledge (TPACK)—the researchers designed and implemented a Live Dual Modeling strategy involving both live behavior modeling and cognitive modeling in this study. Using qualitative research methods, the researchers investigated whether Live Dual Modeling was effective in helping preservice teachers develop TPACK in a technology integration course. The findings showed that the preservice teachers demonstrated the initial ability to transfer what they learned in the modeling to classroom teaching. When Live Dual Modeling is used, attention should be paid to the conditions that influence the effectiveness of the strategy due to the preservice teachers' limitation in their overall knowledge base, practical experience, and ability to transfer learning to other contexts. (Keywords: Live Dual Modeling, preservice teachers, TPACK)

Many instructional strategies used to help preservice teachers develop technological pedagogical content knowledge (TPACK) involve using technology to practice teaching in real-world settings (e.g., Koh & Divaharan, 2011; Niess, 2005). However, the ability for a teacher to solve authentic instructional problems is mediated by their prior knowledge and experience (Hughes, 2005). When these strategies are used, special attention must be paid to the challenges that preservice teachers face.

The first challenge is that preservice teachers have little or minimal real-world teaching experience. The level of teaching experience is a crucial factor influencing a teacher's classroom practices (Lederman, 1999). When making instructional decisions, compared to expert teachers, novice teachers pay less attention to classroom constraints and are less likely to base their teaching on a comprehensive view of the classroom (Westerman, 1991). Similarly, when making technology integration decisions, preservice teachers consider a narrower range of school- and classroom-level factors than inservice teachers (Greenhow, Dexter, & Hughes, 2008). Therefore, preservice teachers' lack of teaching experience presents challenges to them when they use technology to solve instructional problems in authentic settings.

The second challenge is that preservice teachers have limited opportunities to observe effective technology-use models in K–12 schools (West & Graham, 2007). Although technology is used regularly at school for administrative tasks, substantially less technology is used for instructional tasks (NEA, 2008). When technology is used for instruction-related activities, instead of integrating it into the curriculum, many teachers use it to assist teaching in a supplemental way (Graham, Tripp, & Wentworth, 2007). Teacher modeling during preservice teachers' school years has a strong influence on their attitudes toward teaching (Virta, 2002). Lacking the experience of seeing effective technology integration in classrooms, preservice teachers may perceive their K–12 teachers' supplemental use of technology as the norm, without realizing that the most productive and meaningful use of technology engages students in knowledge construction, conversation, articulation, collaboration, and reflection (Jonassen, 1995).

To resolve these challenges, modeling has been proposed as an effective strategy to help preservice teachers prepare for technology integration in teaching (e.g., Brush & Saye, 2009). For example, West and Graham (2007) designed and implemented a live modeling strategy in which instructors demonstrated live examples of effective technology use for teaching, while preservice teachers acted as K–12 students in the demonstration. Most preservice teachers perceived the live modeling strategy as effective.

However, the live modeling strategy in current literature (e.g., Brush et al., 2003; Doering, Hughes, & Huffman, 2003; West & Graham, 2007) includes only behavior modeling but does not have a cognitive modeling component. Cognitive modeling, a strategy to make the covert mental process perceivable, has been used to help preservice teachers solve complex teaching problems (e.g., Gorrell & Capron, 1989, 1990). Cognitive modeling can be a critical component to preservice teachers' technology preparation. Effective teaching with technology requires teachers to have a sound understanding of the complex and dynamic relationships among content, pedagogy, and technology. Understanding the relationship and making instructional decisions accordingly is a covert process. When showing preservice teachers how to integrate technology into teaching, it is also important to demonstrate the decision-making process behind the how-to's.

According to Koehler and Mishra's suggestions about how to teach TPACK (Koehler & Mishra, 2005a, 2005b), teachers should learn about teaching with technology by designing technological artifacts to solve instructional problems. To help preservice teachers

develop TPACK in a learner-centered, project-based learning environment, we propose to integrate into this environment a Live Dual Modeling (LDM) strategy, which involves both live behavior modeling and cognitive modeling. In this study, we designed LDM as an integral component in a Learning By Design (LBD) environment (Lu, Johnson, Tolley, Gillard-Cook, & Lei, 2011) and implemented it in a technology integration course for preservice teachers. In this study, we investigated whether LDM was effective in helping preservice teachers learn how to teach with technology and discussed the conditions that influenced the effectiveness of LDM.

Why Live Dual Modeling?

Modeling, especially live modeling, can provide a more authentic teaching experience to preservice teachers, thus compensating for their lack of real-world teaching experience. People learn from observing others' behaviors (Bandura, 1977). In the acquisition of social behaviors, imitation of models is "an indispensable aspect of learning" (Bandura, 1977, p. 3). Therefore, the provision of social models is necessary in learning. The mode of modeling affects the rate and level of learning (Bandura & Walters, 1963). Compared to live modeling, other modes of modeling, such as text-based and video modeling, present more challenges to learners due to the situated nature of knowledge. "[K]nowledge is situated, being in part a product of the activity, context and culture in which it is developed and used" (Brown, Collins, & Duguid, 1989, p. 32). Text-based modeling requires learners to exert extra cognitive load to visualize the situation described in the text (West & Graham, 2007). Although video modeling provides the visuals necessary for understanding, preservice teachers are still detached from the authenticity of the problem and their own empirical experience (West & Graham, 2007). In contrast, a live performance can provide "substantially more relevant cues with greater clarity than are conveyed by a verbal description" (Bandura & Walters, 1963, p. 50). When a master teacher models teaching in an authentic setting, observers not only see the particulars of the teaching process, but also understand the appropriate context in which a strategy or a teaching behavior is executed. With more contextual cues, preservice teachers also learn how to teach by being immersed in the interactions between the teacher and the students.

Live modeling also enables preservice teachers to think from both a student's perspective and a teacher's perspective. When Brush et al. (2003) implemented their version of live modeling, the preservice teachers first acted as K–12 students in the model lessons. Then they were required to critique whether the lesson was effective, discuss issues related to the lesson implementation, and propose possible changes to make it more effective. In live modeling, preservice teachers' being active participants and their dual roles not only enable them to experience learning and observe the learning results from a K–12 student's angle, but also push them to consider a teacher's point of view during and after the observation.

Cognitive modeling can further help preservice teachers identify the complexity inherent in teaching. Teaching is an "ill-structured" profession and is further complicated by the integration of technology (Koehler & Mishra, 2009). Reasoning and decision-making are the hidden key components of the teaching process. When covert cognitive skills are heavily involved in a skill set, cognitive modeling is an alternative instructional strategy to use (Harmon & Evans, 1984). Teacher educators have always used cognitive modeling in their practices. For example, to show student teachers how to reflect on teaching, Loughran (1997) went through the process of reflecting on his own teaching. He "thought aloud" (p. 23) about what he was doing, the decisions he was making, and the reasons for making those decisions. A model can do cognitive modeling by verbally delineating the cognitive process. Sarason (1973) found that a model's verbalizing of the cognitive tactics to reach a solution while solving difficult problems had positive effects on students' performance and helped students reduce their test anxiety.

Live behavior modeling, coupled with cognitive modeling, can be a viable way to teach preservice teachers how to teach. In the next section, we will discuss why LDM can help preservice teachers develop TPACK.

Using Live Dual Modeling to Teach TPACK

"[T]houghtful pedagogical uses of technology require the development of a complex, situated form of knowledge," which Mishra and Koehler (2006) called "technological pedagogical content knowledge (TPACK)" (p. 1017). TPACK describes teacher knowledge for technology integration by adding knowledge about technology into the construct of pedagogical content knowledge (PCK, Shulman, 1987). The interplay of the three components—content, pedagogy, and technology—forms four additional types of knowledge: pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPACK) (Mishra & Koehler, 2006). Because of its clear articulation of the types of teacher knowledge essential for effective technology integration and their complex, dynamic nature, TPACK provides a guide for designing teacher technology training programs. For teachers to develop TPACK, Koehler and Mishra (2005b) suggested that teachers be trained by designing technological artifacts to solve real-world instructional problems in an LBD environment, which honors the complex and dynamic relationships of the three components in TPACK. LDM situates technology use in rich teaching and learning contexts, which is consistent with the essence of an LBD environment. LDM can be an effective strategy for preservice teachers to develop TPACK.

On one hand, the live behavior modeling of effective technology use provides the initial experience necessary for preservice teachers to understand what it means to integrate technology into teaching. When experienced teachers use technology

Table 1. Live Dual Modeling

	1. Preparation	2. Behavior Modeling	3. Cognitive Modeling
Instructor(s)	Present a cognitive tool to help preservice teachers identify key TPACK elements Discuss the contents to be taught and state the desired student learning outcomes	Model appropriate pedagogical practices that integrate a chosen technology to teach a K–12 lesson	Verbally reflect on instructional decisions and their reasoning
Preservice Teachers	Know lesson content and what student learning outcomes to expect	Take on the role of K–12 students and learn the lesson with technology	Reflect on the modeling activities from a teacher's perspective

to solve instructional problems in a LBD environment, they often encounter "contradictions and tensions" (Koehler & Mishra, 2005a, p. 97) among content, pedagogy, and technology. As novice teachers still struggle to pedagogically transform and represent subject matter (Feiman-Nemser & Parker, 1990), adding one more variable—technology—into the teaching context can be challenging. Preservice teachers, especially those in their initial training stages, have little or no full-time classroom teaching experience. They also have limited experience observing meaningful and productive technology use in classrooms. For preservice teachers to wrestle with the complex nature of those instructional problems, some previous experience of technology integration is necessary (Kolodner, Gray, & Fasse, 2003). Instead of isolating technology use from content and pedagogy, the live modeling of how a teacher uses technology to tackle complex instructional problems is a viable way to compensate for their lack of experience in teaching with technology.

On the other hand, the cognitive component helps preservice teachers further articulate the complex relationships among content, pedagogy, and technology in TPACK development. Articulating the complex relationship in TPACK requires preservice teachers to be "reasoners" when using technology to teach, reasoning their instructional choices and predicting the possible outcomes (Kolodner et al., 2003, p. 502). The modeling of overt teaching behaviors does not necessarily direct the observers' attention to the complex decision-making process behind the acts. The demonstration of how-to's does not unfold how an effective instructor tactfully analyzes the content to represent it using technology, how he chooses one or a few technologies to teach the content in constructive ways, and how he understands students' prior knowledge and uses technology to develop students' new knowledge by building on the old, etc. (Mishra & Koehler, 2006). When a master teacher verbalizes her reasoning and decision making, preservice teachers "index" (Kolodner et al., 2003, p. 502) their experience by interpreting the instructional problem using the TPACK framework, recognizing the relevant technology and instructional strategy suitable for the situation, and evaluating the effects of the solution according to the students' learning results. The master teacher also clarifies the causal relationship between the use of technology and its results so that preservice teachers learn how to predict the students' learning outcomes and explain how to use technology to achieve those ends.

Design of Live Dual Modeling in a Preservice Teacher Technology Integration Course

We designed LDM in this study by adding a cognitive modeling component to West and Graham's live modeling strategy (2007) (see Table 1). It consists of three components: preparation, behavior modeling, and cognitive modeling. In preparation, instructors give preservice teachers a cognitive tool designed to help them identify key TPACK elements in the modeling. Instructors then discuss the contents to be taught and state the desired student learning outcomes so that preservice teachers know the lesson content and what learning outcomes to expect. In the behavior modeling that follows, instructors demonstrate live examples of effective technology use in a K–12 classroom while preservice teachers act as K-12 students. Following the behavior modeling, instructors conduct the cognitive modeling by verbally explaining the instructional decision-making process behind the live example, while preservice teachers reflect on their observations from a teacher's perspective.

Research Methods

Research Setting

This LDM strategy was implemented in a mandatory entry-level technology integration course at a large northeastern university in spring 2010. As the first in a series of three technology integration courses, this course is designed for preservice teachers who are in the initial stage of teacher training and have little practical teaching experience, especially with integrating technology into teaching. The course covers basic information technologies for teaching purposes, including educational websites, Microsoft Word, Microsoft PowerPoint, Microsoft Excel, electronic communication tools, and assistive technologies. The course consists of six classes. Designed as an LBD environment, the first five classes include four routine instructional components: reading discussions, model lessons, mini-projects, and reflections. In the final class, the preservice teachers conduct the group course project, in which they teach their fellow preservice teachers a 15-minute lesson. Instructors implemented the LDM strategy this article discusses in the model lesson section of the first five classes.

"[I]nability of faculty to provide meaningful and effective technology examples" and "preservice teachers not being given the opportunity to construct their own technology-based lessons" (Kay 2006, p. 389) are found to be two disadvantages of modeling. To overcome the first disadvantage, in the modeling

section, the technology integration examples were implemented in elementary schools and proved to be effective. In these examples, teachers use technologies as learning tools to engage students in knowledge construction, conversation, articulation, collaboration, and reflection (Jonassen, 1995). To overcome the second disadvantage, after the modeling in the first five classes, students are required to construct technological artifacts or design technological solutions for their class projects. Students also conduct a group course project, which requires them to use technology to teach their fellow preservice teachers a 15-minute lesson in class while their fellow classmates act as K–12 students. In the projects, they are required to use the accumulated skills from previous classes, including what they have learned in the LDM; analyze the instructional problems; identify useful technology resources; select appropriate instructional strategies; and use technology effectively to enhance learning.

To explore whether LDM was effective in helping the preservice teachers learn how to teach with technology, we investigated the following two questions:

1. Can the preservice teachers transfer what they learned in the LDM to their own teaching projects?
2. What were the conditions that influenced the effectiveness of LDM?

Data Collection

Thirty-nine preservice teachers, who enrolled in three sections of the technology integration course in spring 2010, participated in this study. A majority of them (92%) were female, and all were enrolled in teacher education programs as freshmen (82%) or sophomores (18%). Most of them had little to no teaching experience.

The data sources included observation on the preservice teachers' in-class implementation of their final projects, the project reports, and student interviews. One of the researchers observed the implementation of all group projects and made detailed field notes. We collected 12 reports yielded by the project groups. In the reports, the preservice teachers recapped the analysis, design, development, implementation, and evaluation of their projects. In the interview, the researcher first helped the preservice teachers review the model lesson activities and then asked whether the model lessons were helpful for them to understand teaching with technology and the reasons behind their thoughts. We conducted interviews with all participants individually. Most interviews lasted 20–35 minutes, with five interviews that were longer than 35 minutes and seven interviews that were fewer than 20 minutes. We recorded all interviews, but one recording file was corrupted due to technical problems. The analyses of the interviews were based on the 38 successfully recorded ones.

Data Analysis

We examined whether LDM was effective by investigating whether the preservice teachers could transfer what they learned in the modeling to their course projects. We used NVivo 8, a data analysis software program, to conduct the qualitative analysis. From the observation field notes and the project reports, we identified strategies and pedagogical practices in the course projects that had been modeled in the LDM. From the interview transcripts, using constant comparative method, we identified themes about what the preservice teachers learned from the LDM and the issues associated with the use of this strategy.

TPACK offers an analytical lens for us to understand teachers' practices in teaching with technology. We reviewed their experience from three major angles—the three main components of TPACK: content, pedagogy, and technology. Although we could not precisely isolate the preservice teachers' experiences by fitting them into the seven TPACK components, we were able to discern some themes around how they process content knowledge to be taught, what teaching strategies they used, what technologies they used to teach, and how they used them. The following section presents results of the analyses.

Results and Discussions

This section describes what this group of preservice teachers learned about teaching with technology from the LDM. In general, the preservice teachers were able to imitate the pedagogical strategies and technology integration examples in the LDM. Although their imitation of the models was superficial and rigid, the preservice teachers were more aware of the key factors—content, pedagogy, and technology—that would influence the decision making in a classroom regarding technology use. Using the TPACK framework, we identified themes about how the LDM influenced the preservice teachers' understanding of the content knowledge, pedagogical knowledge, and technological knowledge, and the complex relationships among them. We also discuss the conditions that influenced the effectiveness of this strategy.

Bridging CK and PK

Learning from the LDM, the preservice teachers began to bridge their content knowledge and pedagogical knowledge. The preservice teachers did not raise issues about their content knowledge at the beginning of the projects. However, they had difficulty understanding what lessons were appropriate for grade level. As one preservice teacher put it, "We didn't really know what we were doing at first just in terms of it being too hard or too easy." For example, one team proposed to teach Ellis Island in their second grade social studies lesson, but the instructor deemed this to be too difficult for second graders.

To overcome this problem, the preservice teachers adopted the strategy their instructors used in the LDM. In the model lessons, their instructors discussed the state standards that a lesson addressed prior to teaching. This gave the preservice teachers an opportunity to see how expert teachers interpreted the lesson content and represented it at an age-appropriate level for their students. When beginning their projects, the preservice teachers started by recalling what they had learned in a certain grade. They used their prior knowledge of being a student to "imagine" or "guess" what content

Table 2. Instructional Strategies Learned from Live Dual Modeling by a Project Team

Instructional Strategies in the Model Lesson	Instructional Strategies in a Project
Setting expectations	Show the lesson agenda on a PowerPoint slide.
Note taking	Have students research the ancient Egyptian tools on a website and take notes of the information.
Using graphic organizers	Ask students to distinguish ancient and modern tools on a Venn diagram.
Providing clear instructions	Give step-by-step explanation of each activity. Post activity directions on the screen.
Group collaborative learning	Divide students into small groups for activities.
Controlling the pace of a lesson	Check whether every student was on the same page before going to the next step of an activity.
Providing immediate feedback and assistance	Go around the classroom to make sure the students who needed help were receiving assistance.
Whole-class discussion	Use whole-group discussion to summarize the lesson.

Note: The lesson described in this table is a sixth grade social studies lesson about ancient Egyptian tools.

may be appropriate for their students. However, they relied on the state and local school district curriculum standards to help them narrow down or identify content appropriate to their students' developmental levels. As one preservice teacher said:

> It was kind of hard 'cause we had to think back. So like, "Okay, what do we do in sixth grade and what kind of stuff did we learn?" And all of us had read *Holes* that year. So we took that book and went through the standards that were set up for the City School District. One of them was vocabulary. So we actually just focused our lesson around that.

Inexperienced teachers are often found to have an "incomplete and superficial" level of pedagogical content knowledge (Cochran, DeRuiter & King, 1993). Choosing appropriate content for their projects requires the preservice teachers to link their content knowledge with their understanding of the learners' abilities (Shulman, 1986). Learning from LDM, the preservice teachers began to think about content knowledge from the learners' perspective, which may indicate that the preservice teachers were developing the initial sense of pedagogical content knowledge.

Expanding Understanding of PK

The LDM also helped the preservice teachers expand their understanding of pedagogical knowledge. The instructors' modeling of using a variety of instructional strategies enriched the preservice teachers' repertoire in instructional strategies, which is especially important because novice teachers know fewer instructional strategies or alternatives compared to expert teachers (Westerman, 1991). In their course projects, the preservice teachers imitated many of the pedagogical strategies they observed. Table 2 shows the instructional strategies one project team imitated in a sixth grade social studies lesson about ancient Egyptian tools. The team imitated eight instructional strategies from their instructors' modeling, from posting an agenda at the beginning of the lesson to using whole-class discussion to summarize the lesson.

During the interviews, several of the preservice teachers mentioned many instructional strategies that instructors had demonstrated in the modeling, especially classroom management strategies. The organization and management of instruction are often challenging for new teachers (Lederman, 1999). When the preservice teachers closely observed and reflected on the modeling from a teacher's perspective, the instructors' purposeful use of various classroom management strategies had an impact on them. One preservice teacher said:

> I think it was kind of interesting to see how sometimes they'd give us some of the instructions at the beginning, sometimes they would give us a handout with the instructions, sometimes they would give us some and then wait for us and then give us the next set. So I thought it was really interesting to see how many different ways you can just ask someone to do something.

The instructors' cognitive modeling helped the preservice teachers further understand why such strategies can help their students learn. In the interviews, they tried to articulate what they had learned from those instructional strategies modeled in class. One preservice teacher talked about the "learning center" strategy:

> I like the centers a lot. Moving around is something more for younger kids than people our age because we are used to sitting in lectures, but it's definitely something I think kids like in a classroom because they need to be stimulated all the time.

Imitating Technology Integration Ideas

In their course projects, the preservice teachers were able to imitate the technology integration ideas in the modeling, especially when they found similarities between their own teaching contexts and those in the LDM. The technologies that the preservice teachers chose in their course projects included Microsoft Word, Microsoft PowerPoint, Kidspiration, websites, online video clips, and online games. The instructors had previously integrated all of these into the model lessons. All the technology used in their projects can be traced back to the examples in the model lessons. Table 3 lists two examples of how the preservice teachers used technologies in their lessons and the corresponding model-lesson examples that they transferred their ideas from.

From Table 3, we can see the preservice teachers used technologies

Table 3. Technology Integration Ideas in Preservice Teachers' Projects and their Sources in the Live Dual Modeling

Team #	Technology Use Ideas	Examples in Projects	Examples in Model Lessons
1	Microsoft Word or PowerPoint as sorting tools	In a fifth grade math class about the order of operations, Microsoft Word was used to create a worksheet with math problems and steps to solve the problems in individual textboxes. Students arranged the textboxes in the order that the problem should be solved.	In a kindergarten class about the life cycle of a pumpkin, teachers created a Microsoft PowerPoint file with pictures of different stages in a pumpkin's life cycle in the wrong order. Students rearranged the slides in the order of a pumpkin's life cycle by dragging each slide into a correct place.
2	Kidspiration for concept map	In a second grade science class about phases of matter, students used Kidspiration to create a concept map of phases of matter.	In a first grade English language arts class, students used Kidspiration to create an idea map before writing a short essay.

as cognitive tools for their students to learn with, as demonstrated in the model lessons. For example, Microsoft PowerPoint is often used as a teacher's presentation tool. In one model lesson, the preservice teachers acted as kindergarteners and rearranged the PowerPoint slides in the order of a pumpkin's life cycle by dragging each slide into a correct place. Thus, PowerPoint was used as a sorting tool for kindergarteners to actively learn about a pumpkin's life cycle. Team One transferred this idea to their fifth grade math lesson about the order of operation. They used Microsoft Word to create a worksheet with a math problem and steps to solve the problem in individual textboxes. They asked their students to arrange the textboxes in the order that the problem should be solved. In Team One's project, Microsoft Word was not used as a text editing tool, but as a cognitive tool to manipulate thinking about the order of operation.

From the interviews, the preservice teachers described how they learned from the modeling by identifying similarities between the problems in their projects and what they had experienced in the modeling. When designing their lessons, the preservice teachers often referred back to similar situations in the live modeling, picked up technology integration ideas, and modified the activity for their own lessons. One preservice teacher said, "[F]or our projects, we really took what they did in the classroom and kind of did it on our own the same way." For instance, one member from Team One, which did the order of operations lesson, said: "So then I remember back to the pumpkin lesson, where they had them put the life cycle in order. So we would [be] doing all of the operations, so why don't we have them to put the problem in order?" After referring back to the pumpkin model lesson, the team decided to have their students practice doing order of operations by putting the problem-solving steps in order.

Although the preservice teachers were able to teach with technology in their projects, we noticed that they directly transferred many of their technology uses from the examples in the LDM. West and Graham (2007) found that when the preservice teachers' teaching context matched that in the modeling, transfer was easy for them. In our study, the instructors purposely designed examples in the LDM to represent the teaching contexts in elementary classrooms, which also matched those of the course projects. From the interviews, the preservice teachers' successful imitation of the examples seemed to be based on their superficial understanding of the high similarities between the contexts, not on a thorough analysis of the influencing factors in their own teaching context. While the LDM did provide the inexperienced teachers with the initial technology integration experience, more help is probably needed to transfer such experience into more substantial TPACK development.

Influencing Conditions

Although the LDM was generally effective in helping the preservice teachers develop the initial awareness of TPACK, we noticed some conditions that may influence the effective use of LDM due to limitations in the preservice teachers' overall knowledge base, practical experience, and ability to transfer learning to other contexts:

In LDM, instructors should help preservice teachers develop awareness of the school- and classroom-level factors related to technology integration decisions. As Zhao and Frank (2003) point out, teachers' use of technology in classrooms is a complicated process that involves factors at different levels. However, when making technology integration decisions, new teachers often attend to fewer classroom- and school-level factors that influence teaching compared to expert teachers (Greenhow, Dexter, & Hughes, 2008). The brief demonstration and explanation in LDM cannot fully compensate for preservice teachers' lack of a big picture about teaching or cover all factors that a teacher should consider in a classroom. In the interviews, when the preservice teachers were asked why they chose to use the technology in the lesson, responses such as, "We knew right from the start that we wanted to use PowerPoint," or "The first thing that came to our heads was getting a slide on each community," were common. Their rush decision-making without performing careful instructional analysis seemed to reflect their less comprehensive view of these factors.

A more comprehensive view of influencing factors in a classroom has to come from other education courses or experience in their program, especially their field teaching practice (Greenhow, Dexter, & Hughes, 2008). For example, in the lesson about assistive technology, those preservice teachers who had learned about assistive technologies in their special education courses or who had experience working with students with disabilities had a better understanding of why and how assistive technology should be used in a classroom. Therefore, the role of LDM in a

technology integration course is to connect preservice teachers' knowledge and experience in the context of technology integration and provide a foundation for them to think about all the factors that influence a teacher's decision-making about technology integration.

LDM must be coupled with practical teaching experience even in preservice teachers' course training stage. Although LDM provides some authenticity about real-classroom teaching, modeling is not a replacement, but only an enhancement of preservice teachers' practical experience. Compared with inservice teachers, preservice teachers are found to have less practical and pedagogical content knowledge about technology integration (Greenhow, Dexter, & Hughes, 2008). Preservice teachers have to gain their practical knowledge and in-depth pedagogical content knowledge related to technology integration through real classroom teaching.

In our study, one preservice teacher with field teaching experience had a very different perception about teaching than her peers who had not. During her interview, she was able to observe that the contents in a second grade lesson were too difficult because the second graders in her classroom would not be able to do the activities. Expert teachers tend to think about learning from their students' perspective (Westerman, 1991). Being engaged in field teaching, this preservice teacher can think about learning from her students' perspective and understand more about her students' developmental stages. Therefore, LDM must be coupled with practical teaching experience even in the preservice teachers' course training stage. Teaching projects such as the course projects the preservice teachers did in this study can be helpful. Although some teaching conditions (such as "fake" students) are artificial or hypothetical, instructors' feedback on their performance is crucial to help them understand what real teaching would be like.

The technology use in LDM is highly contextual. Instructors should help preservice teachers develop flexible understanding of the technology integration contexts in the modeling and transfer their learning to other contexts.

When preservice teachers transfer their learning to a new context, "contextual breakdown" (West & Graham, 2007, p. 137) may happen: The context in the modeling does not match the preservice teachers' teaching context. West and Graham (2007) found that contextual breakdown was the major reason why some preservice teachers benefited the least from their live modeling. In our study, the preservice teachers expressed some concerns related to "contextual breakdown." For example, some preservice teachers thought it was unrealistic to teach with technology as modeled because they felt sufficient technology resources were lacking in their classrooms. The reserved attitude toward using technology to teach was more obvious when they observed discrepancy between the targeted grade level in the modeling and the grade level they taught.

The contextual breakdown may result from preservice teachers' rigid understanding of the technology integration contexts. Teachers' technology integration developmental models indicate that the less advanced that teachers are in the developmental stage, the less confident and creative they are in using technology for instruction and the less likely they are to transfer technology use into new contexts (e.g., Russell, 1995; Sandholtz, Ringstaff, & Dwyer, 1997). The preservice teachers in this study were still in their early developmental stage of technology integration. They tended to directly imitate their instructors' technology integration ideas and believed technology did not fit when the contexts were different. However, it is unrealistic to provide technology integration examples that address all K–12 teaching contexts in LDM. Thus, helping preservice teachers to develop flexible understanding of the technology integration contexts in the modeling is important. Discussions following LDM about how to make variations or adaptions to accommodate students' different needs or classroom environments can be helpful. It would also be helpful to discuss preservice teachers' concerns about applying technology-integration ideas to their own teaching contexts.

Conclusions

In this study, an LDM strategy was designed and implemented to help preservice teachers develop TPACK. In the course-training stage of the teacher preparation program, this strategy is in general effective for providing the initial experience essential to helping preservice teachers understand how to teach with technology. The LDM helped the preservice teachers bridge their content knowledge and their pedagogical knowledge, expand their understanding in pedagogical knowledge, and transfer the technology integration ideas from the modeling to real-world classroom teaching, although in a superficial and rigid way. As a result, the preservice teachers were more aware and sensitive to the major factors that would influence a teacher's decision to integrate technology for teaching. However, more research is needed to support whether developing inexperienced preservice teachers' awareness and sensitivity to these major factors is the initial stage of their TPACK development. Moreover, although LDM provides the initial technology integration experience needed for inexperienced preservice teachers, LDM alone is not sufficient to enhance their TPACK development. Preservice teachers have to gain practical and pedagogical content knowledge from other educational courses or experiences in their program and from classroom teaching opportunities. The role of LDM is to help connect their overall knowledge base about teaching in the context of technology integration at the initial stage of TPACK development. In addition, when LDM is used, discussing adaptations of technology integration in various contexts and preservice teachers' concerns of classroom application may help them develop flexible understanding of the technology-use contexts in the modeling and transfer their learning to new contexts.

The understanding of the LDM strategy in this study can help teacher educators adopt and adapt this strategy in their teacher preparation programs. However, more research is needed to understand

how preservice teachers learn from LDM, especially from cognitive modeling. In this study, although cognitive modeling seemed helpful for the preservice teachers to transfer knowledge and skills learned in the behavior modeling, the evidence was not strong. Furthermore, it was not clear how the behavior modeling affected preservice teachers' decision-making process and how preservice teachers imitated the decision-making process that the instructors modeled. Future research can focus on identifying preservice teachers' decision-making process in technology integration and how such a process is influenced by both behavior and cognitive modeling. Understanding their decision-making process can give teacher educators insight into designing more effective modeling strategies for preservice teachers' technology preparation.

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References

Bandura, A. (1977). *Social learning theory.* Upper Saddle River, NJ: Prentice Hall.

Bandura, A., & Walters, R. H. (1963). *Social learning and personality development.* New York: Holt, Rinehart and Winston, Inc.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32–42.

Brush, T., Glazewski, K., Rutowski, K., Berg, K., Stromfors, C., Van-Nest, M. H., et al. (2003). Integrating technology in a field-based teacher training program: The PT3@ASU project. *Educational Technology, Research and Development, 51*(1), 57–72.

Brush, T., & Saye, J. W. (2009). Strategies for preparing preservice social studies teachers to integrate technology effectively: Models and practices. *Contemporary Issues in Technology and Teacher Educatio*n [Online serial], *9*(1). Retrieved from http://www.citejournal.org/vol9/iss1/socialstudies/article1.cfm

Cochran, K. F., DeRuiter, J. A., & King, R. A. (1993). Pedagogical content knowing: An integrative model for teacher preparation. *Journal of Teacher Education, 44*(4), 263–272.

Doering, A., Hughes, J., & Huffman, D. (2003). Preservice teachers: Are we thinking with technology? *Journal of Research on Technology in Education. 35*(3), 342–361.

Feiman-Nemser, S., & Parker, M. B. (1990). Making subject matter part of the conversation. *Journal of Teacher Education, 41*(3),32–43.

Gorrell, J., & Capron, E. W. (1989). Cognitive modeling effects on preservice teachers with low and moderate success expectation. *The Journal of Experimental Education, 57*(3), 231–244.

Gorrell, J., & Capron, E. (1990). Cognitive modeling and self-efficacy: Effects on preservice teachers' learning of teaching strategies. *Journal of Teacher Education, 41*(4), 15–22.

Graham, C. R., Tripp, T., & Wentworth, N. (2007). U*sing preservice teacher work samples as a means for assessing and improving technology integration in field experiences.* Paper presented at the 18th annual conference of Society for Information Technology & Teacher Education, San Antonio, TX.

Greenhow, C., Dexter, S., & Hughes, J. E. (2008). Teacher knowledge about technology integration: An examination of inservice and preservice teachers' instructional decision-making. *Science Education International, 19*(1), 9–25.

Harmon, P., & Evans, K. (1984). When to use cognitive modeling. *Training and Development Journal, 38*(3), 67–68.

Hughes, J. (2005). The role of teacher knowledge and learning experiences in forming technology-integrated pedagogy. *Journal of Technology and Teacher Education, 13*(2), 277–302.

Jonassen, D. H. (1995). Supporting communities of learners with technology: A vision for integrating technology with learning in schools. *Educational Technology, 35*(4), 60–63.

Kay, R. (2006). Evaluating strategies used to incorporate technology into preservice education: A review of the literature. *Journal of Research on Technology in Education, 38*(4), 383–408.

Koehler, M. J., & Mishra, P. (2005a). Teachers learning technology by design. *Journal of computing in Teacher Education, 21*(3), 94–102.

Koehler, M. J., & Mishra, P. (2005b). What happens when teachers design educational technology? The development of technological pedagogical content knowledge. *Journal of Educational Computing Research, 32*(2), 131–152.

Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge? *Contemporary Issues in Technology and Teacher Education, 9*(1), 60–70.

Koh, J. H. L., & Divaharan, S. (2011). Developing preservice teachers' technology integration expertise through the TPACK-Developing Instructional Model. *Journal of Educational Computing Research, 44*(1), 35–58.

Kolodner, J. L., Camp, P. J., Crismond, D., Fasse, B., Gray, J., Holbrook, J., Puntambekar, S., & Ryan, M. (2003). Problem-based learning meets case-based reasoning in the middle-school science classroom: Putting Learning by Design into practice. *Journal of the Learning Sciences, 12*(4), 495–547.

Kolodner, J. L., Gray, J., & Fasse, B. B. (2003). Promoting transfer through case-based reasoning: Rituals and practices in learning by design classrooms. *Cognitive Science Quarterly,* 119–170.

Lederman, N. G. (1999). Teachers' understanding of the nature of science and classroom practice: Factors that facilitate or impede the relationship. *Journal of Research in Science Teaching, 36*(8), 916–929.

Loughran, J. (1997). Learning through modeling: Developing preservice teachers' understanding of reflection. *Teaching Education, 8*, 23–8.

Lu, L., Johnson, L., Tolley, L. M., Gillard-Cook, T., & Lei, J. (2011). Learning by design: TPACK in action. In C. D. Maddux, D. Gibson, B. Dodge, M. Koehler, P. Mishra, & C. Owens (Eds.), *Research highlights in technology and teacher education 2011.* Society for Information Technology and Teacher Education.

Mishra, P., & Koehler, M. J. (2006).Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017–54.

National Education Association (NEA). (2008). *Access, adequacy and equity in education technology.* Washington, DC. Retrieved from http://www.edutopia.org/files/existing/pdfs/NEA-Access,Adequacy,andEquityinEdTech.pdf

Niess, M. L. (2005). Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge. *Teaching and Teacher Education, 21*(5), 509–523.

Russell, A. L. (1995). Stages in learning new technology: Naïve adult email users. *Computers in Education, 25*(4), 173–178.

Sandholtz, J. H., Ringstaff, C., & Dwyer, D. C. (1997). *Teaching with technology: Creating student-centered classrooms.* New York: Teachers College Press.

Sarason, I. G. (1973). Test anxiety and cognitive modeling. *Journal of Personality and Social Psychology, 28*(1), 58–61.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1–22.

Virta, A. (2002). Becoming a history teacher: Observations on the beliefs and growth of student teachers. *Teaching & Teacher Education, 18*, 687–698.

West, R. E., & Graham, C. R. (2007). Benefits and challenges of using live modeling to help preservice teachers transfer technology integration principles. *Journal of Computing in Teacher Education, 23*(4), 131–141.

Westerman, D. A. (1991). Expert and novice teacher decision making. *Journal of Teacher Education, 42*(4), 292–305.

Zhao, Y., & Frank, K. (2003). Factors affecting technology uses in schools: An ecological perspective. *American Educational Research Journal, 40*(4), 807–840.