Scaffolding Technology Integration Using Guided Problem-Solving

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Abstract

Computers and Internet have become widely available to teachers and students, yet tomorrow’s teachers are not well prepared to effectively use technology in teaching. The author designed problem-based case scenarios and divergent and critical thinking scaffolds to guide preservice teachers’ learning to teach with technology. The study conducted an in-depth investigation of the preservice teachers’ (n=4) experience and perceptions about this guided problem solving approach by analyzing interview transcriptions and responses to scaffolds with grounded theory methods. Facilitated by the scaffolds, the preservice teachers used divergent and critical thinking skills along with their own strategies in identifying instructional problems, generating and evaluating solutions, and developing lesson plans integrated with technology. However, their personal history based assumptions and strategies tend to lead them toward convergent and uncritical thinking. Finally, the author discussed the ill-structured nature of technology integration problems, the preservice teachers’ characteristics in learning, and the value of the guided problem solving approach in preparing tomorrow’s teachers to use technology.

Introduction

Well, I had no idea what Web 2.0 tool was. I knew I guess Internet sites like Myspace and Facebook. I knew they were things out there but I didn’t know how prevalent they were in the education department. I didn’t realize the resources that were available to education majors or educators in general. Thinkfinity was one that we use that I would definitely be interested in using it in the future. The Delicious Account we set up, the Social Bookmarking we did, the Inspiration things we did, they were all great resources as [for] an educator. And many of them could be used for the students as well. And I look forward to using those in the classroom. (Jason)

Jason kept naming different technology tools when talking about what he learned on the Educational Technology course. His comments not only reflected a beginning preservice teacher’s excitement about the variety of available technologies but also indicated his interests of applying those tools in his future class. However, despite the abundant technology resources and the preservice teachers’ enthusiasm, research shows that most preservice teachers were not receiving adequate preparation of teaching with technology before entering the field (CEO Forum, 2001; Yildirim, 2000; Kay, 2006). Single educational technology courses usually focus more on training technology skills detached from teaching. Method courses have not been well integrated with technology because many faculty members lack technology skills and cannot provide good examples. Collaborations between preservice and inservice teachers are promising but tend to be constrained by administrative issues. As a result, most preservice teachers are not well prepared to teach with technology when they begin their teaching career. Even though they are more comfortable with technologies, they use it less than experienced teachers in delivering instruction or engaging students in learning activities (Russell, Bebell, O'Dwyer, & O'Connor, 2003).

How can teacher education programs prepare preservice teachers to use technology effectively in their future classroom? Researchers suggest that preservice teachers should be provided with high level learning opportunities that address authentic pedagogical problems (Mishra & Koehler, 2003). They should not only be exposed to examples of classroom use of technology (Russell et al., 2003) but also engage in hands-on activities to develop their technology integration skills by constructing and implementing their own lessons (Dawson, Pringle, & Adams, 2003).

Informed by researchers’ suggestions, this study was focused on facilitating preservice teachers’ learning to teach with technology through a guided problem solving approach. Case scenarios, embedded with instructional problems that teachers may encounter in real classroom settings, were created to engage preservice teachers in an authentic-oriented learning environment. As the essence of this approach, problem-solving scaffolds with an emphasis on divergent and critical thinking were designed to guide preservice teachers in identifying the ill-structured instructional problems and generating technology-integrated lesson plans and artifacts as solutions. The purpose of this study was to understand the experience and perceptions of the preservice teachers in learning technology integration through this approach, as well as to identify the issues and challenges need to be addressed in
future implementation. Since little is known about using guided problem solving as a strategy for preparing preservice teachers to teach with technology, findings from this study will inform the design of the scaffolds and contribute to the knowledge of researchers and teacher educators in the field of preparing tomorrow’s teachers to use technology. Three research questions were posed in this study:

1. What are the roles of the scaffolds in facilitating preservice teachers’ problem-solving?
2. What strategies do preservice teachers use during the problem-solving process?
3. How do preservice teachers perceive their problem-solving experience?
4.

Theoretical Framework

**Technology Integration as an Ill-structured Problem**

Teaching is an ill-structured discipline characterized by the complex concepts and principles, the dynamic nature of the situations, and the variability of features across cases (Mishra, Spiro & Feltovich, 1996; Spiro & Jehng, 1990). Integrating technology into teaching further complicates the domain, because technology brings unprecedented opportunities, affordances, and constraints associated with teaching content and pedagogy, thus expanding the problem space of teaching. Designing and implementing technology integrated lesson is an ill-structured problem-solving process that represents a special challenge to knowledge application in the teaching domain.

The typical characteristics of ill-structured problems, including the lack of prototypic cases, ill-defined elements, multiple domains and solutions (Jonassen, 1997), are evident in technology integration. First of all, technology integration is always situated in a context with specific subject matter, grade level, student backgrounds, and available technologies, etc (Mishra & Koehler, 2006). The way of incorporating technology, pedagogy, and content in teaching vary from case to case. Also, many aspects of technology integration problems are not well specified for the teacher, such as the goal state of using technology, the appropriate pedagogies, the available tools and their functions, the potential constraints, etc. It is clear that the teacher, as the problem solver, needs to clarify the situation before trying to solve the problem. As suggested by the Mishra and Koehler’s (2006) technology, pedagogy, and content knowledge (TPCK) framework, teaching with technology requires the integration of three knowledge domains – technology, pedagogy, and content – as well as the complex interplay among them. Technology is not something add-on to pedagogy and content but can raise fundamental questions and initiate reconfiguration of the three components. Most importantly, there is no single right solution to technology integration problems (Mishra & Koehler, 2006). Ways of using technology in teaching are divergent rather than convergent in a given situation, which is the same for solutions to any ill-structured problems. The teacher should consider a variety of solutions and make rational decisions based on their judgments about the context.

**Divergent and Critical Thinking in Ill-Structured Problem-Solving**

Runco (2003) views problem-solving as a creative critical process, during which creative thinking helps generate ideas for solving the problem, while critical thinking helps to evaluate those ideas and select the best solution. With a close examination of both the creative and critical sides of problem-solving, the essential thinking skills can be identified. The creative side of problem-solving is centered by divergent thinking, which involves thinking of many ideas (fluency), varied ideas (flexibility), new ideas (originality), and adding details to improve the ideas (elaboration) (Guilford, 1967; Basadur et al., 1986). The critical side of problem-solving includes critical thinking skills such as clarifying the situation, making inferences with available information, evaluating sources, assumptions, arguments, and ideas, and monitoring the thinking process and outcomes (Bruning et al., 2004; Ennis, 1987; Halpern, 1997; Perkins, 1986). Thinking skills on both sides play a significant role in ill-structured problem solving such as technology integration, which is an instructional design process that requires a design structure based on diversified perspectives as well as multiple solution ideas and evaluation criteria for reaching the best solution (Jonassen, 1997; Jonassen, 2000).

**Preparing Preservice Teachers for Technology Integration**

With respect to the ill-structured domain of technology integration, teacher educators and researchers realize that preservice education is a natural and important place to start preparing teaching candidates with necessary skills (Kay, 2006). Various strategies have been created for developing preservice teachers’ technology integration skills, such as faculty modeling in method classes (e.g. Vannatta & Beyerbach, 2000), collaboration with mentor teachers
(e.g. Thompson et al., 2003), incorporating technology in field teaching (e.g. Brush et al., 2003). However, evidence suggests that teacher education programs have not been successful in preparing new teachers to use technology effectively in teaching (CEO Forum, 2001; Yildirim, 2000; Kay, 2006). One of the major obstacles is that preservice teachers lack opportunities and supports to inquire into technology integration by designing and implementing lessons for relevant teaching situations (Dawson, Pringle, & Adams, 2003). In other words, they are not receiving enough training for solving ill-structured technology integration problems, which makes them feel unprepared when beginning their teaching career.

However, the complexity of technology integration problems poses challenges to preservice teachers who are novices in teaching. As discussed previously, successful technology integration requires divergent and critical thinking skills, systematic problem-solving skills, and integrated knowledge of technology, pedagogy, and content. Research on preservice teachers’ learning shows that they come to teacher education programs with powerful, personal history based theories about good teaching, preventing them from thinking critically about their assumptions (Knowles & Holt-Reynolds, 1991; Schwarz & Gwekwerere, 2006). Also, they recall self experience as a student as a base for generalizing beliefs about students’ learning as well as modeling the learning experience they want to provide in their classroom (Holt-Reynolds, 1992). This tendency may conflict with the desired skill of thinking divergently to consider different perspectives and alternative teaching strategies. Moreover, although it may not be difficult for preservice teachers to acquire technology skills, they are not likely to have sufficient technological pedagogical content knowledge, which should be developed from authentic professional practices (Mishra & Koehler, 2006).

Ill-structured problem-solving situates learning in authentic environments and requires the learner to use higher order skills for reasoning and knowledge application (Ge, Chen, & Davis, 2005; Jonassen, 1997). Despite the above challenges, learning to solve technology integration problems with divergent and critical thinking can be a beneficial way for preparing preservice teachers to teach with technology. The essential responsibility of teacher educators is to design learning environments that can provide contexts and scaffolds for ill-structured problem-solving (Hannafin, Land, & Oliver, 1999; Jonassen, 1997; van Merriënboer & Kirschner, 2001) so as to enhance preservice teachers’ understanding and practical skills of teaching with technology. According to literature on problem-solving, the core element of the context is the case that involves contextualized problems that the learners must solve (Jonassen, 1997). For technology integration, preservice teachers should be provided with cases centered by instructional problems that can be solved with a variety of technology-integrated teaching strategies. Moreover, procedural, elaborative, and metacognitive scaffolds should be designed to facilitate the ill-structured problem solving process (Ge, Chen, & Davis, 2005).

To sum up, developing lessons incorporating technology into teaching and learning is an ill-structured problem-solving process that requires divergent and critical thinking skills. As novice lesson designers, preservice teachers will encounter challenges in solving technology integration problems and may not use divergent and critical thinking skills automatically. Both problem scenarios and scaffolding strategies are needed to prepare preservice teachers to teach with technology through ill-structured problem solving.

Methods

This study was conducted on an introductory technology integration course at a southeast university for two semesters. The course instructor and the researcher collaborated on developing three case scenarios and the problem solving scaffolds (See Appendix A for example). Each of the cases described instructional dilemmas reflecting a particular purpose of teaching with technology, including promoting communication and collaboration, creativity and innovation, and critical thinking skills. The scaffolds outlined the major steps of the problem-solving process and intended to promote students’ divergent and critical thinking skills. For each case project, the students were asked to identify and solve the instructional problems by developing a technology-integrated lesson plan. They were required to strictly follow the scaffolds in case one and were allowed to skip some of the steps in case two and three.

Data Collection

The researcher used a qualitative research design to study preservice teachers’ experience and perceptions about the guided problem solving approach. To recruit research participants, the researcher read the students’ online autobiography and invited those with a clear goal of becoming school teachers to participate in this study. Four students - two from the first semester and two from the second semester - volunteered to participate in a one-hour semi-structured interview. The interviews were conducted and audio recorded at the end of each semester. The interview questions began with the participants’ previous experience with teaching and learning, and then focused
on their scaffolded instructional problem-solving process as well as their perceptions about the problem-solving activities. For this paper, the researcher selected to present an analysis two interviews from each semester. The participants’ responses to scaffolds and their lesson plans were also collected for analysis.

Participant description

The four participants came from three different teacher preparing programs. Jason was a junior student in technology education major. He had participated in one practicum, during which he developed and implemented a lesson on engineering design process. Claire was a sophomore student in early childhood education major with a focus on math and science. She had been teaching crafts class to young students in the enrichment program of a local elementary school. Brian was a sophomore student in middle school education major with a focus on math and science. He had not worked with middle school students he wanted to teach but he had been teaching bible studies to youths at the church. Sarah was also a sophomore student in middle school education major, concentrating on language and math. Along with the technology integration course, she was taking another course requiring 48 hours’ practicum in a seventh grade math class and a seventh grade language arts class.

Data Analysis

The researcher used grounded theory methods (Glaser & Strauss, 1967) to analyze the data. Strauss and Corbin (1990) believe grounded theory is “discovered, developed, and provisionally verified through systematic data collection and analysis of data pertaining to that phenomenon”. The researcher conducted systematic analysis by using techniques such as open coding, focused coding, and theoretical categorizing. She tried to identify inductive codes and categories in analyzing the first two interviews and applied the typical categories to the other interviews as a way of focused coding. Constant comparison was used in both creating and sorting codes to generate categories. Ezzy (2002) describes constant comparison as a process of developing and identifying codes that can be compared for similarities and differences and believes “comparisons allow data to be grouped and differentiated, as categories are identified and various pieces of data are grouped together” (p. 90). With tables of categories and quotations from all four interviews, the researcher searched for common themes across the participants as well as the strong themes within each individual. As themes were identified, the researcher wrote memos to describe them and attached the quotations as evidence for supporting the themes. As Ezzy (2002) argues, “sophisticated use of grounded theory draws on both inductive and deductive methods of theory generation (p. 12)”. For the last step of data analysis, relationships among the inductively generated themes and categories were analyzed and connected to the existing knowledge in literature.

Findings

Based on coding the transcriptions and generating categories, six major themes anchored around the three research questions emerged from the data, such as the scaffolds promoted divergent and critical thinking to some extent; the preservice teachers used self-experience and made inference in identifying and solving the problems; although the preservice teachers developed new perceptions about problem solving, their underlying assumptions remained unchallenged. These themes were identified either because they were repeated by more than one participant or because they represent a strong idea throughout one participant’s entire interview. Each major theme involved multiple dimensions or sub themes that were closely related to one another. The themes will be presented following the research questions of this study.

Roles of the Scaffolds in Facilitating Problem Solving

Promoting Divergent Thinking to Some Extent

Encouraged by the problem-solving scaffolds to create as many ideas as possible, the preservice teachers were able to use some divergent thinking skills in finding multiple problems and generating alternative solutions. However, their divergent thinking was hindered by the lack of real world experience as a teacher and their focus on previous experience as a student. They also had inadequate understanding of the purpose to use divergent thinking. Divergent problem-finding promoted the preservice teachers to identify the most essential problem as well as to consider the other possible problems as constraints to be addressed. Sarah said, “I wrote down all of the problems that I could find, just everything I could think of” and then “picked the one that I thought was really the biggest
challenge that would help the biggest number of students.” Claire mentioned the problem that she would overlook without brainstorming. “Another detail I would have skipped over like in the challenges was you know there are some take charge students.” She realized that she had to “monitor the groups to make sure those students do not dominate the other students”. In her final lesson plan, she decided to make groups “according to students’ ability and work ethic”.

Divergent thinking was evident in generating solutions of teaching with technology, especially in the first case project when they followed the scaffolds strictly. Three preservice teachers considered a variety of technology tools that could be integrated. For example, with the problem that students may have difficulty accessing information for the project of identifying career opportunities, Jason said he added in a Delicious Account that would make the student bookmark websites that would be related to the career they chose… required each group to access a set number of Blogs related to the career pathway they choose… I used the Gmail accounts as well within the groups to promote communication and collaboration within the groups.

Along with brainstorming, Jason and Claire took an open attitude toward the divergent solutions they generate. Jason said, “Whether I thought they would be used or not, I wanted to right down and just see if they would be used.” Claire also mentioned, “I put down like I was going to do a Photostory… I put this down as a solution but I don’t think that’s really going to be what I wanted to do.” They both reported that they ended up using a better solution different from the one they preferred at the beginning.

However, with insufficient field experience, the preservice teachers had difficulty identifying a variety of “real” challenges they might encounter in a classroom setting. Jason felt “it was actually tougher than I thought would be… I had to think of something to say they are easily getting off task, they are not paying attention to what you do”. Brian found his only difficulty was to “get enough challenges”, and he actually “started making up different challenges”. They were imaging the potential problems based on prior experience. More importantly, they tended to use convergent thinking when relying on critical personal experience relevant to the problem situation. The scaffolds’ role in supporting divergent thinking was very limited in such cases. For example, in resolving the second case on communication and collaboration, Brian referred to his experience as a higher-achieving student and believed that the problem in case two was “trying to teach the higher-achieving students and not hold them back, while also teach the lower-achieving students”. His solution was to “group them up and have them work together and in hopes that the lower-achieving students will learn from the higher achieving students”. With confidence in his ideas, Brian ignored the other problems portrayed in the case scenario and did not consider alternative solutions.

Moreover, the preservice teachers did not fully understand the purpose of brainstorming and regarded it as a course requirement, which was another factor inhibiting divergent thinking. Both Claire and Sarah valued quality over quantity when working on the second and third case. For example, Claire said in case two, “I came up with two, kind of pretty in-depth ones to choose from. I could have expanded them into three or four but I tried to really narrow it into two that I thought would be most applicable.” Jason also restrained from divergent thinking because of his initial preference and time limitations.

Although the preservice teachers reported brainstorming ideas in finding problems and generating solutions, particularly in the first case, these actions were not sustainable throughout the three case projects. They regarded divergent thinking as a requirement in the scaffolds and chose to skip over when the scaffolds became optional. They did not realize that the purpose of thinking divergently was to explore even better ideas. Also, as mentioned earlier, excessive reliance on personal experience as a student and the lack of real world teaching experience limited the preservice teachers’ ability to think of divergent ideas.

Facilitating Critical Thinking in Problem Solving

The scaffolding steps of identifying challenges, framing problems, and creating criteria to evaluate the solutions facilitated the preservice teachers’ critical thinking. However, when the preservice teachers focused their attention on generating solutions only, they were less likely to use critical thinking skills.

The preservice teachers had an initial tendency to overlook the complexity of problem analysis and shift to solution generation rapidly. Brian believed that “it was pretty evident [what] the instructional problem was in the case, so the real big problem is solving it.” So he mainly focused on “the way I was going to teach it”. Claire also tended to focus on solutions before truly identifying the problems. She said that after reading the first case scenario “I had some ideas… automatically in my head.”
However, by following the scaffolds to articulate the challenges and problems before generating solutions, three of the preservice teachers realized the need to clarify the problem space. As Claire was working on her second case project of promoting students’ creativity in learning American Revolution, she paid more attention to her problems and goals. After finishing all the cases, Claire believed that

I can’t just say okay this is what I want to do and just go and do it. I have to look at each of these different things I am going to encounter, like the different standards, the different challenges, and think about that and figure out what would be best in the end.

Sarah also found it worthwhile to spend time thinking critically at the beginning stages of problem-solving. She said the scaffolds gave her “a better way to make sure that I am using the right tool to solve the problem”.

Metacognition enables the problem solver to actively monitor and control his or her problem-solving performance based on goals. Novice problem solvers usually have limited metacognitive abilities. However, while using the scaffolds, the preservice teachers demonstrated metacognitive thinking skills.

Jason mentioned, in selecting his criteria, he “thought back to what problems were most prevalent” and tried his best to “make sure the criteria fit the lesson [and] the instructional problem”. Both Claire and Sarah looked at the curriculum standards they wanted to teach, the characteristics of their students, and their pedagogical goals such as “create enough jobs for everyone involved”, “keep the students on task”, “encourage critical thinking and problem solving”, etc.

Moreover, Jason and Claire talked about using the criteria to monitor and adjust their lesson plans. Considering the criteria that the solution should help “develop appropriate limitations and requirements” for students, Jason refined his solution in designing the lesson plan.

I had to go back and think well how could this rubric help me with limitations? And I had to reorganize my thoughts on… they [students] are not just going to develop a rubric, they are going to develop a rubric that they believe they can accomplish… they set the task that they are willing to try.

The scaffolding step of using criteria to grade the potential solutions assisted the preservice teachers’ decision making process. Three of the preservice teachers critically evaluated their potential solutions and realized the benefits of making decisions based on criteria. Before the evaluation in case one, Jason thought “another one [solution] would win”, but as he applied the criteria to the solutions, he found “that’s [that solution was] not as good as I thought was going to be” and finally chose a different solution that was “a better fit”. Claire described similar experience in case one,

On my first case, I was like “Oh yeah this is the best solution for this project”. But when I really thought about is this really going to meet all of these criteria that I think needs to be met, it ended up being a different one.

Nevertheless, there were cases when the preservice teacher failed to use critical thinking while following the scaffolds ostensibly. As mentioned earlier, Brian focused more on generating solutions to the problem he found. His exclusive emphasis on the solutions also blinded him of the complexity in creating criteria and evaluating solutions. Brian found it “pretty simple” to develop criteria, which were based on the solutions he preferred rather than his goals of solving the instructional problems.

I decided it [criteria] rather quickly. After I figured out I need to use this kind of learning and this kind of learning. Then I could make my criteria because I could base it on how I am going to teach my kids.

As a result, Brian found all the solutions were satisfying and realized that “I could use all of these”. For example, in case one, instead of judging the strength of the solutions, he finally combined all of them into a single one, believing that it would “better aid my students” and could be used in “pretty much any situation”. Brian’s lack of critical thinking reflected his limited understanding of the purpose for making criteria and evaluating the solutions.

In general, with the assistance of the scaffolds, the preservice teachers were able to thinking critically by clarifying the problem space before generating solution, using metacognitive skills to monitor and control the problem-solving process, and judging the strength of potential solutions based on criteria. However, when the preservice teachers failed to recognize the complexity behind finding problems and selecting solutions, they were less likely to be aware of the need for critical thinking.

Preservice Teachers’ Strategies for Solving Problems

Using Self Experience to Identify Problems and Solutions

Because the case scenarios were situated in a generic classroom setting, without specifying grade levels and subject areas, the preservice teachers had to adapt them to their own context while working on the problems. They frequently used their previous experience, mostly as a student and sometimes as a teacher, to help problem solving.
Three of the preservice teachers mainly relied on their experience as a student in K-12 school or college to find the problems they might encounter. When Claire was talking about her potential challenges in teaching the standard on making graphs with data, she said, “I can remember when I was doing graphs... that a lot of students have trouble with it. And I was like is this an area that fourth graders struggle with.” In the case of using technology to promote communication and collaboration, Sarah also referred to the problem she experienced in her Freshmen English Writing class.

We did the peer review but we didn’t do it online we just brought our paper in class. And I thought about how it got so messy and it was so confusing for me to see. Are they talking about this in it or are they talking about that in it, so then I used my own problem that I had to figure out a better solution than the one I had experienced.

The problems identified by the preservice teachers based on personal learning experience were related to but different from those described in the case scenarios, such as students’ unequal participation, lack of mutual understanding, and diversified learning abilities. Previous experience focused the preservice teachers’ attention on the problems they were familiar with as a student, but were unable to support their exploration of the other problems that should also be addressed by the teacher.

Different from the others, Jason related to his practicum experience when looking for instructional problems. As he reported,

In all three of the cases, I immediately referred back to the practicum I did earlier… I found that a lot of students usually lose focus quickly if they don’t have enough things to do. Students didn’t have or unable to access stuff on their own.

Jason identified problems not only from his own observation but also from his communication with the mentor teacher, who mentioned the situation that students did not want to explore questions on their own but expected the teacher to give the answer. Jason used this problem in his third case project on critical thinking. Although the instructional problems Jason found were not derived from the case scenarios either, they reflected a teacher’s perspective in contrast with the students’ perspective adopted by the other preservice teachers.

In terms of generating solutions, previous learning experience played a major role as well. However, since the preservice teachers were not taught with technology when they were in K-12 classroom, they tried to incorporate technology into the learning activities they had experienced. For instance, Sarah adapted the peer review activity in her Freshmen English Writing class to her seventh grade language arts class. She designed the solution of having students write a paper in Google Docs and review partners’ writing by “highlighting and adding comments”. Because most of the preservice teachers attending the course were at the preliminary stage of their teacher preparation program and had not taken any method courses yet, they lacked pedagogical content knowledge, which was an integral component of successful technology integration. As a result, empirical experience with different learning activities became the major source for them to compensate pedagogical content knowledge.

Nevertheless, both Jason and Sarah, who had been observing real classrooms of their subject area, used their field experience to evaluate the appropriateness of the learning activities for their targeted students. Jason said, in making his lesson plans, he “thought of previous experience with students… what ways did work and what ways didn’t work.” Sarah also emphasized her strength of using observation experience for making good judgments.

I can kind of think OK I have seen my teacher do this with seventh graders and they love it, or I have seen my teacher trying to do something like this and they don’t even want to try. So just by being in the seventh grade classroom that semester... I think I had a better idea about if the kids would actually want to do it and if it would actually work in a classroom.

Overall, although the preservice teachers can use their own learning experience for identifying instructional problems and designing solutions, the lack of teaching experience was still a big barrier for them to perform in a professional way. The preservice teachers with relevant real world experience showed some advantages, as they were better able to find real problems and judge the feasibility of their solutions.

Making Inferences to Generate and Evaluate Solutions

When the preservice teachers had little direct experience, either as a student or a teacher, to rely on, they tended to make inferences with the information they identified in the problem space. This strategy was most evident as the preservice teachers were generating ideas of teaching with technology or anticipating the effectiveness of their solutions.
As mentioned earlier, the preservice teachers had not used the latest technology tools when they were K-12 students, making it impossible for them to directly use the same learning activities from their classrooms. Based on analyzing the process that the preservice teachers generated technology integration solutions, two major ways of making inferences emerged: activity-based inference and tool-based inference.

While using activity-based inference, the preservice teachers first designed a learning activity, which usually originated from their previous experience, to address their problems or goals and then added some tool(s) to enhance that activity with technology’s affordances. Take Brian for example, he designed the group activity involving both higher-achieving and lower-achieving students to solve his problem and incorporated Smart Board, arguing that “it’s not like write on chalk board or write and erase board, they can do it on Smart Board and then I can go over and correct it and other students can correct it”. Activity-based inference helped the preservice teachers concentrate on the problems and goals of their teaching situation. However, technology was likely to be something dispensable if the match between the pedagogical activity and the technology’s affordances was inappropriate.

While using tool-based inference, the preservice teachers first picked a technology tool with functions pertinent to the content they wanted to teach and then designed learning activities based on that connection to address their instructional problems. Claire thought about using Web 2.0 tool to facilitate communication and collaboration in learning to make graph. She said she “researched some different Web 2.0 tools to see if there is something for how to make a graph or ways to find data” and chose to use Delicious Account for students to “find and share research [where they can gather data] they like with their fellow students” and use Mind Meister, a web concept mapping tool, for students to “add information to a collaborative mind map to organize the information”. Tool-based inference helped the preservice teachers identify good connections between technology’s affordances and the content and ways of learning. However, this strategy tended to focus the preservice teachers’ attention on the tool they prefer to use rather than driving them to explore a variety of choices.

Another way of making inferences happened when the preservice teachers were envisioning the results of their solution ideas in order to make decisions. Due to the lack of field experience, the preservice teachers did not have sufficient experiential knowledge to judge the effectiveness of their solutions. Also because of the limitation of the course, they had no chance to test their ideas. Therefore, two preservice teachers made inferences through role playing or imagination to predict the results of implementing the learning activity they designed. Jason positioned himself as a student when reasoning about the benefits of asking students to research their preferred careers online and share the resources using Delicious Account.

I actually thought back and said well if I was forced to use this as the teacher assigned this to me, would I have done any better? And I believe I would have. I believe the outcome would have been different. I believe I would know more... So I believe the students would be interested in doing this kind of work. Similarly, Claire gave up her initial idea of asking students to make graphs on “band ticket sales” in case one after imagining the possible consequences.

It was beneficial for preservice teachers to look ahead by reasoning through the appropriateness of their learning activity design. However, because of limited experience-based evidence, all the three types of inferences - activity-based inference, tool-based inference, and imagination-based inferences - may be inaccurate thus misleading their judgments.

Preservice Teachers’ Assumptions and Perceptions about Problem Solving

Assumptions Underlying the Problem Solving Process

The preservice teachers had assumptions and beliefs about themselves and their students, which they took for granted throughout the problem solving and lesson designing process. Originated from their prior experience of learning and teaching, these assumptions and beliefs had become their rationale for using certain strategies to design lesson activities.

The preservice teachers also had assumptions about their content and pedagogical knowledge. Two of the preservice teachers believed that they had sufficient understanding about the teaching content or the pedagogy to be used, so that they did not need to consult additional resources. In designing the lesson on American Revolution, Claire reported that

I felt a lot of it [information about revolutionary war] came from my mind because I am a huge history buff too. So ((laughing)) I could think of the different events of the war, without necessarily having to go and look at them from different sources.

Brian was very confident in his knowledge about teaching methods as well as his solution for approaching the situations he faced.
Actually a lot of methods just came out of my head, because of my past three educational classes. I just kind of knew that you need to have hands-on learning, just different stuff like that. I just kind of already knew that in my head a little bit. So I didn’t have to use the Internet as much to find ways to teach. Although these assumptions suggested that the preservice teachers had some preparation on content and pedagogy, which was the prerequisite for solving the instructional problems, they blocked their metacognitive awareness of the need to further explore the teaching content and strategies and how to integrate them with technology.

Moreover, the preservice teachers had common assumptions about the students’ problem with learning, their preferred activities, and technology’s role in learning. They almost reached an agreement on the major instructional problem they would encounter in their class. That was, the students were unable to concentrate on study and would easily get off-task. Jason found that students “usually lose focus quickly if they don’t have enough things to do”. Claire believed that “students were so easily distracted that they move off task”. Brian also mentioned “having trouble keeping the kids’ attention”. Their assumptions about how this problem could be solved were also quite similar: the students needed interesting and entertaining activities to keep their focus or attention. Jason believed that “the work often times has to be new to them, something different and something interesting”. Brian thought “when they [students] are moving around a little more, going outside, coming back in, you could actually teach more”. The preservice teachers believed it important to integrate technology mainly for two reasons: students were comfortable with technology and would be more attentive in learning with technology. Claire said, “Since this is a digital age, students are growing up in that, and they will really need some of that incorporated into their learning.” Brian assumed that “technology solves the problem getting the curriculum across to the students” because students were “technologically sound”. Both Jason and Brian believed that hands-on activities with technology would keep students “on-task and focused” because “they [students] can create things that they wouldn’t be able to create otherwise” and “they [students] can see it with their eyes and learn it in that [hands-on] way”.

With all these assumptions about their knowledge and the learner characteristics, the preservice teachers were very likely to design a “fun” lesson that would work for them as a student to keep their envisioned students on-task, especially when they failed to consider multiple instructional problems and did not use proper criteria to evaluate their solutions.

Newly Developed Perceptions on Solving Instructional Problems

Although the preservice teachers’ assumptions about themselves and their students were not challenged, their perceptions about the instructional problem solving process evolved as they were using the scaffolds, which positively influenced their understandings regarding the ways of designing a better lesson.

The preservice teachers realized the importance of clarifying the problems and goals before setting out to solve the problems. Jason found it necessary to “not only develop a lesson but go through this process to make sure my students are getting the most out of a lesson.” Claire also emphasized that “I have to look at each of these different things I am going to encounter, like the different standards, the different challenges, and think about that and figure out what would be best in the end”. Both of them were conscious of keeping their goals and problems in mind to adjust their solutions. Claire and Sarah reflected on their tendency of sticking to the initial idea. Claire said, “I can’t go straight to the solution any more I have to actually go through and think about the details a little.” Sarah found that “it took more time at the beginning to do it all, but every project turned to work exactly how I wanted it to work. So just go through all the steps and not just pick something because it sounded really good to begin with.” Their emphasis on analyzing the situation before making a decision reflected their increased awareness of considering alternative choices and environmental constraints in solving problems. Additionally, both Jason and Brian indicated their understanding about the significant efforts needed in lesson design. Jason said, “I should think a lot harder about my lessons when I design them”. Brian said he learned that “when I am a teacher it’s [the lesson is] not just going to unfold for me. I have to go and research and find out stuff by myself”. As novice lesson designers, they began to have a sense of the complexity involved in lesson planning.

The preservice teachers also developed some new perceptions about divergent and critical thinking. They talked about the benefits of thinking divergently and implied the need to be open-minded toward the initial ideas. Jason said, “Before case one I would say there’s probably not much need to do a lot of brainstorming.” But after working on that case, he realized “if I hadn’t done the brainstorming I would have chose a solution that probably wasn’t the best one.” Therefore, he believed that thinking of “many possible solutions” rather than sticking to a convergent solution, would benefit the teacher and the students. In terms of critical thinking, the preservice teachers pointed out the value of creating and applying criteria. Brain believed that “it’s important for us to realize what kind of criteria we had to meet to effectively teach them [the students] in the classroom”. Claire stressed that creating criteria helped her “really concentrate and figure out what is the most important overall”. The preservice teachers
also perceived it as an effective way to distinguish the better solutions based on criteria. Sarah said, “It really helped to be able to see on a scale of one to ten, does this work with what my criteria are.” In the second case, when she was not required to follow the scaffolds, she still evaluated the solutions using her two main criteria – being able to solve the problem and using technology integral to the project – indicating her awareness of thinking critically about the potential solutions.

By following the scaffolding procedure, the preservice teachers not only improved their performance but also developed new perspectives and attitudes toward instructional problem solving, which was evidenced by their understanding of identifying details in the problem space, paying efforts to lesson design, thinking divergently about initial ideas, and making decisions based on criteria. However, these new understandings were focusing on the instructional problem solving skills, independent from their assumptions about themselves and their students. The preservice teachers’ pedagogical content knowledge may not develop significantly along with the new perceptions.

Discussion

Data analysis revealed that both the problem-solving scaffolds and the preservice teachers’ own strategies were influencing the way they addressed the instructional problems with technology integrated lesson plans. Analysis of preservice teachers’ perceptions about their problem solving experience indicated two categories respectively associated with the scaffolds and the strategies. Figure 1 summarized the major findings and their connections.

**Figure 1. Major Findings of the Study**

<table>
<thead>
<tr>
<th>Role of Scaffolds</th>
<th>Self Strategies</th>
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<td><strong>Promoting divergent thinking to some extent</strong>&lt;br&gt;Using divergent thinking in finding problems and generating solutions&lt;br&gt;Using limited divergent thinking due to the lack of teaching experience and the reliance on self experience as a student&lt;br&gt;Having inadequate understanding of the purpose for divergent thinking</td>
<td><strong>Use self experience to identify problems and solutions</strong>&lt;br&gt;Using self experience, mostly as a student and sometimes as a teacher, to identify instructional problems&lt;br&gt;Recalling pervious learning experience to generate solution ideas&lt;br&gt;Using field experience to evaluate the appropriateness of learning activities</td>
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<tr>
<td><strong>Facilitating critical thinking in problem solving</strong>&lt;br&gt;Clarifying the problem space before generating solutions&lt;br&gt;Using metacognitive skills to monitor and control the problem-solving process&lt;br&gt;Judging the strength of the potential solutions based on criteria&lt;br&gt;Using little critical thinking when failing to recognize the complexity of the problems and solely focusing on generating solutions</td>
<td><strong>Make inferences to generate and evaluate solutions</strong>&lt;br&gt;Using activity-based inference and tool-based inference for generating solutions&lt;br&gt;Predicting the potential results of implementing the solutions to help decision making</td>
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<tr>
<td><strong>New understandings of solving instructional problems</strong>&lt;br&gt;Realizing the importance of focusing on the problems and goals, clarifying the details of the problem space, and paying sufficient efforts&lt;br&gt;Recognizing the benefits of thinking divergently to generate many ideas and thinking critically to evaluate ideas with criteria</td>
<td><strong>Assumptions underlying the problem solving process</strong>&lt;br&gt;Assuming sufficient knowledge about the teaching content and the pedagogy in their own mind&lt;br&gt;Having common assumptions about the students’ problem with learning, their preferred activities, and technology’s role in their learning</td>
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New Understandings | Existing Assumptions
The preservice teachers were able to use divergent and critical thinking skills during problem solving. Some of them carefully explored multiple problems in their teaching situation, and all of them considered different technology tools in generating potential solutions. They also began to think critically by clarifying the details in the problem space as well as monitoring and controlling the problem-solving process with goals and criteria. Compared with the preservice teachers’ initial tendency of abiding by convergent solutions, their problem-solving performance had been enhanced by following the scaffolding procedure. As the preservice teachers realized the benefits of thinking divergently and critically, they developed some new perceptions about designing lessons for approaching instructional problems. But due to the inadequate understanding of the purpose of divergent and critical thinking, although the preservice teachers talked about the advantages of using those skills, they did not use them as intended by the scaffolds, especially when they were not required to follow the scaffolds strictly.

Meanwhile, the preservice teachers frequently used their own experience as a student or as a teacher to assist problem solving. They also used activity-based and tool-based inferences for generating solutions and tried to predict the potential results of those solutions as a way of evaluation. These strategies made it possible for the preservice teachers to complete the instructional problem-solving steps, even though they had neither taken any method courses nor started their field teaching. However, to some extent, these strategies also conflicted with the scaffolds and negatively influenced the preservice teachers’ divergent and critical thinking performance. Some of the preservice teachers failed to consider alternative problems and solutions in the case scenario when they were exclusively relying on their own experience with similar teaching situations, in which the problem and the solution were evident to them. As they used convergent thinking, they were inclined to underestimate the complexity involved and think less critically about the solutions. The negative aspect of the strategies can be traced back to preservice teachers’ underlying assumptions. They did not view themselves as a teacher or a student all the time but switched perspectives on their roles constantly. With the role of a teacher, they tended to assume that they already knew enough about the teaching situation, overlooking the need to further inquire into the problems and solutions by using resources other than their mind. With the role of a student, they tended to assume the equivalence between themselves and their students and to design an optimized version of the learning activities they had experienced for their students.

Implications

Preservice Teachers’ Technology Integration

Ill-structured design problems such as technology integration require knowledge from multiple domains and extensive experience in the field. The preservice teachers with deficiencies in both areas used personal history based theories and experience, which were tenacious and powerful (Knowles & Holt-Reynolds, 1991), to help find and solve the design problems. They adapted the case scenario by recreating it exclusively based on what they personally witnessed or experienced. Similar to Knowles and Holt-Reynolds’s (1991) findings, the preservice teachers failed to place their experience in a more diverse context and disregarded the problems different from their own. Also, due to the lack of classroom experience as teachers, they tended to recall critical prior experiences as a student to plan their lessons, to predict students’ response, and to evaluate certain teaching strategies (Holt-Reynolds, 1992).

In addition to relying on personal history, this study showed that the preservice teachers also used inference strategies to design technology-integrated learning activities that were not available from their own experience. They used activity-based inference to modify and extend previous learning activities by incorporating technology. They also used tool-based inference to create original learning activities by matching technology’s affordances with the need of their teaching situations. With these inference strategies, the preservice teachers were likely to go beyond directly applying self learning experience to lesson design, because they had to integrate the technology elements that may give rise to fundamental changes in the lesson structure. However, the preservice teachers’ utilization of both prior experience and inference strategies were still supported by their established beliefs and assumptions generalized from personal history.

Scaffolding Divergent and Critical Thinking in Technology Integration

Educational technology courses in teacher preparation programs have been criticized for teaching standalone technology skills rather than cultivating preservice teachers’ ability of effective technology integration (Gunter, 2001; Whetstone & Carr-Chellman, 2001). Aside from incorporating technology in method courses and field teaching, some teacher preparation programs have started project-based learning in educational technology courses,
in which the preservice teachers have chance to design technology-infused lessons (e.g. McRobbie et al., 2000). Ill-structured design problem solving activities were involved as well, but they were not situated in a problem-based environment and did not emphasize the systematic problem-solving process and the related thinking skills. Meanwhile, according to literature, problem solving entails a critical creative process that involves divergent thinking, which supports creative ideation, and critical thinking, which ensures goal-directed actions (Mayer & Wittrock, 2006; Runco 2003). This viewpoint fits well with the design aspect of technology integration problems. However, divergent and critical thinking is rarely mentioned in the project-based learning of technology integration.

This study redesigned project-based learning by creating a problem scenario and scaffolding the problem solving process with a focus on divergent and critical thinking, hoping to provide a situated context and more guidance for preservice teachers to integrate technology. Findings from this study indicated that this was a beneficial way for preparing preservice teachers to teach with technology. The problem-based teaching scenario together with the divergent thinking scaffolds promoted the preservice teachers to consider different constraints and challenges before integrating technology and to brainstorm various solutions by inquiring into the possible combinations of technology, pedagogy, and content. The critical thinking scaffolds facilitated them to focus on the important problems to be solved, develop criteria for evaluating the divergent solutions, as well as to monitor and adjust their lesson design. Divergent and critical thinking scaffolds not only enhanced the preservice teachers’ performance but also exposed them to the complexity behind solving technology integration problems, from which they began to develop new understandings and skills of teaching with technology.

Nevertheless, problems arising from this study should also be pointed out. Because of the preservice teachers’ characteristics as novices, their assumptions and strategies led them toward convergent and uncritical thinking, inhibiting the intended effects of the problem situation and the scaffolds. Although they reported new perceptions about lesson design after completing the projects, their assumptions and strategies remained unchanged and were not integrated with the new understandings emerged from using the scaffolds. In addition, some of the preservice teachers failed to recognize the purpose of divergent and critical thinking, resulting in the lack of motivation and misuse of some scaffolding steps. Future research questions may include how to improve the scaffolds in ways that can encourage the preservice teachers to critically reflect on their underlying assumptions, how to make them understand the point of using divergent and critical thinking in solving technology integration problems, and how to help them develop new strategies that can facilitate divergent and critical thinking.

This study contributed to the field of Preparing Tomorrow’s Teachers to use Technology (PT3) by suggesting a new strategy of teaching educational technology course, which paves the way for the preservice teachers to use technology in their method courses, field teaching, and future career. Teacher educators in the field of educational technology may experiment with the guided problem solving approach when using project-based learning in their class, so as to provide more structure for the novice lesson designers and nurture the desirable thinking skills. Teacher educators who wish to integrate technology into method courses or field teaching may also use the divergent and critical thinking scaffolds to help preservice teachers plan for incorporating technology into the pedagogies and content they have learned. This study may also inform educational researchers interested in PT3 about the possibilities and challenges in developing preservice teachers’ technological pedagogical content knowledge.

Conclusion

The major purpose of this study was to examine the preservice teachers’ experience and perceptions about the guided problem solving process in order to understand the appropriateness of this approach in preparing them to teach with technology. Developing lessons effectively incorporating technology tools is an ill-structured design problem challenging for preservice teachers. Problem-solving scaffolds with an emphasis on divergent and critical thinking have the potential for developing preservice teachers’ knowledge and skills in designing technology-integrated lessons. Problems and limitations found in this study reminded the researcher of the preservice teachers’ characteristics in learning and also indicated directions for improving the scaffolds. In conclusion, the guided problem solving approach is worthwhile for further study and will become a useful strategy contributing to the research and practice in the PT3 field.
References


Cuban, L. (1999). The technology puzzle: Why is greater access not translating into better classroom use? Education Week, 68, 47.


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Appendix A: Sample Case and Scaffolds

Communication and Collaboration

The grant your school applied for was awarded and you have access to several new computers in your classroom. You are excited about the computers and want to use them to support students' communication and collaboration, which are important skills for your students to have. From your previous experience, you know that students are more motivated to learn when they are given the opportunity to collaborate in groups and communicate their ideas to a "real audience". More importantly, they can help each other with difficulties and negotiate conflicting opinions through collaboration, which leads to deeper understanding of course content.

However, you remember that things don't always go smoothly when your class does collaborative projects. You remember that during the last collaborative learning project, students seemed to be actively talking to each other, but not everyone learned as much as they were expected to due to a number of problems. For example, some students contributed a lot and even dominated the teamwork, while some students were not truly engaged and kept talking about irrelevant things. Some groups of students really seemed to respond well from the activity, while others seemed to learn very little. While negotiating different ideas, some students failed to listen to each other carefully before they gave responses, which resulted in unpleasant collaboration that ended up with conflicts, disagreements, and even quarrels.

The current curriculum standard you are planning to teach can best be achieved by using teaching strategies that emphasize peer interaction and collaborative learning. You know from your EDIT 2000 class that technology can provide your students with rich learning resources, productivity tools, and communication tools. You decide to integrate technology with teaching strategies to address the problems you have experienced with communication and collaboration.

**Step 1: Select Curriculum Standard**
Select a curriculum standard from your subject/grade level that involves or requires communication and collaboration.
1) What curriculum standard will you address in this lesson?
2) Why did you choose this curriculum standard?

**Step 2: Identify the Challenges**
Situate your the standard that you are going to teach into the case scenario and think about what specific challenges, in terms of communication and collaboration, you might meet in teaching this standard. List your challenges in the following area (Number each challenge).

**Step 3: Frame the Instructional Problem**
Based on the challenges you listed in Step 2, which one is the biggest issue? This will be your instructional problem. Describe the problem that you want to solve in this case project. Make sure your instructional problem is relevant to communication and collaboration and could benefit from technology integrated teaching and learning.
1) What is your instructional problem?
2) Why is this instructional problem important?

**Step 4: Generate Solutions**
Think about how you might incorporate technology into teaching and learning to solve your instructional problem. Review Chapter 3 in your textbook to learn about communication and collaboration and the sample lessons while you are working on this step. Consider the different technological tools you have learned either in EDIT 2000 or by yourself and brainstorm as many solution ideas as you can. List your solutions in the following area (Number each solution).
**Step 5: Select Criteria**
Your task now is to select the most promising solutions from your Step 4. Generate criteria that will help you determine the appropriateness of your solutions. Select and list FIVE criteria that you think are most relevant and important for evaluating your solutions. Each criterion should have a different focus.

Five Criteria

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**Step 6: Apply Criteria**
Apply the criteria to your solutions for the Instructional Problem. Use each criterion to rank the solutions in an evaluation matrix. Use a scale from 1 (poorest) to 10 (best) and enter the numbers in the appropriate columns. Add the ranks you have given to each solution and enter the sums of the TOTAL column.

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**Step 7: Design your Lesson**
Turn your most promising solution into a practical lesson plan. Explain more specifically how you will implement your lesson, how you will use technology to support communication and collaboration, and why your lesson activity will solve your the instructional problem. Here is the information you should include:

- **Lesson Title**
- **Grade/Content Area**
- **Lesson Duration**
- *State Objectives (these will come directly from the Georgia Performance Standards)*
- *Select Tools, Materials, and Teaching Methods (what will you use to accomplish this learning activity?)*
- *List Student Task/Product (what is the specific task you want students to complete? This should be no more than 3 sentences).*
- *Describe Learner Participation (describe the steps of the learning activity. How will students be divided into groups with specific responsibilities, how will the lesson be introduced, how will you monitor student learning during the activity, what will students be doing during the activity?)*
- *Evaluate Learner Outcomes (describe how you will know students have achieved your stated learning objectives).*
- *Create a Student Sample (Provide one sample that you expect your students would create in this lesson).*

**Step 8: Reflection**
Take a moment to reflect on your performance in case one. This helps you learn from your experience and do a better job in case two.

1) As I worked on case one, I did well in...
2) As I worked on case one, I had difficulties with...
3) As I worked on case one, I wish I had spent more time on...
4) To do a better job in case two, I need to...