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Impact of Problem-Based Learning (PBL) on Teachers' Beliefs Regarding Technology Use

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Abstract

Although computers are now commonplace within our lives, integration within schools is much less ordinary. While access and training are no longer considered significant barriers, attention has turned to the potential influence of teachers' beliefs. In response, problem-based learning (PBL) has been proposed as an effective approach for changing beliefs. This study investigated the impact of PBL on preservice teachers' beliefs regarding technology use and on their intended teaching practices. Participants included 48 preservice teachers enrolled in a one-credit educational technology course. Results showed that beliefs regarding technology use did not change significantly. However, participants significantly shifted their intended teaching practices from teacher-directed to student-centered learning. Implications for practice are discussed. (Keywords: teachers' beliefs, problem-based learning, technology integration.)

Although digital technologies have become common tools within our lives, teachers have yet to embed them within their daily teaching practices (Cuban, 2001). For example, after studying the technology uses of 78 K–12 teachers, Cuban reported that 80% of teachers used computers primarily for e-mail. Additionally, 65% never used computers for individual enrichment for advanced students, and 95% never used computers to facilitate student-to-student interaction.

There are many reasons why teachers do not use technology to its full potential including limited classroom space, unwillingness to take students to labs, and lack of access at teachers' and students' homes. Other barriers include finding the time and resources to implement classroom technologies (Ertmer, Addison, Lane, Ross, & Woods, 1999; Parr, 1999; Vannatta & Beyerbach, 2000; Zhao & Frank, 2003).

Barriers to integration exist both within and outside of teachers. These internal and external barriers, as explored by Ertmer (1999), have different characteristics. External, or first-order, barriers include a lack of access to computers, software, planning time, or administrative support. Internal, or second-order, barriers relate to teachers' beliefs about instructional technology, preferred teaching methodologies, and willingness to make changes to classroom practices. First-order barriers are more easily recognized and easier to fix while second-order barriers may require major changes in teachers' beliefs and daily teaching practices (Ertmer, 1999).

Due to the scope and cost of removing first-order barriers and the complexity of addressing second-order barriers, developing good technology use is a slow process. For example, a recent survey conducted by the U. S. Department of Education (2000) demonstrated that only one-third of teachers felt well prepared to use computers and the Internet in their classrooms, although 99% of public schools have Internet connections. That is, even after first-order barriers are removed, it is still difficult for teachers to integrate technology into the classroom, possibly because of second-order barriers. Sugar (2002) emphasized the importance of addressing teachers' beliefs about technology integration and removing second-order barriers in order to achieve technology integration. However, these internal barriers are persistent; teachers' beliefs regarding technology integration appear to be extremely difficult to modify (Ertmer, 2005).

Teachers' Beliefs About Technology

Teachers' beliefs refer to internal constructs that help teachers interpret experiences and that guide specific teaching practices (Nespor, 1987; Pajares, 1992). According to Fang (1996), "teacher's beliefs are shaped by many factors. Among them are the influences of discipline subculture, the quality of preservice experience in the classroom, and the opportunity for reflection on the preservice experience" (p. 50). Although labeled a "messy construct" by Pajares (1992), beliefs are still considered the "best indicators of the decisions individuals make throughout their lives" (p. 307). Kagan (1992) cited significant evidence supporting the relationship between teacher beliefs and their decisions about classroom practice.

According to Miller and her colleagues (2003), teachers' beliefs about technology are comprised of three related, but independent components: pedagogical beliefs about teaching and learning, self-efficacy beliefs about technology use, and beliefs about the perceived value of computers for student learning. In a study by Russell, Bebell, O'Dwyer, and O'Connor (2003), these three components were found to be the main predictors of teachers' classroom technology use. In this study, we use these same three components to operationalize "teachers' beliefs about technology."

Pedagogical beliefs. Based on the results of a study with middle school teachers (Fulton & Torney-Purta, 2000), experiences during teacher preparation programs and early teaching assignments exert major influences on teachers' beliefs about teaching, learning, and technology. Wang (2002) examined preservice teachers' beliefs regarding their role in a classroom with computers. Results indicated that preservice teachers were more likely to use technology as a teacher-centered tool, based on the teaching methods from which they learned. Other studies have found similar results; when attempting to implement new methods without enough time to practice, preservice teachers tend to revert to traditional methods (Russell et al., 2004).

According to Richardson (2003), belief change in preservice teachers is more important than knowledge transmission during teacher preparation because beliefs impact action in more critical ways. One recent study (Russell, O'Dwyer, Bebell, & Miranda, 2004) suggested that changing teachers' beliefs about technology is needed in order to change teachers' classroom uses of technology.

It is generally acknowledged that preservice teachers come to their teacher education programs with an existing set of beliefs, based on their own experiences as learners, and that these experiences play a critical role in shaping their future practices (Kennedy, 1997; Richardson, 2003). In general, Becker (1999) suggested that teachers who have student-centered beliefs tend to use technology more frequently and to use it in more meaningful ways. That is, low-level technology uses (e.g., word processing, using technology to teach remedial skills) tend to be associated with teacher-centered practices while high-level uses (e.g., engaging students in inquiry-based activities, collaborating with peers at a distance) tend to be associated with student-centered, or constructivist, practices. Consequently, in order to change teachers' practices, specifically where technology is involved, it may be important for teachers to embrace more student-centered beliefs because teachers will base their practices on their beliefs (Albion & Ertmer, 2002; Kagan, 1992; Richardson, 2003).

Self-efficacy beliefs. Bandura (1997) defined self-efficacy as personal beliefs about one's capability to learn or perform actions at designated levels. In other words, teachers' self-efficacy beliefs comprise beliefs about what they are capable of doing with technology in the classroom as opposed to the knowledge they have about what to do (Ertmer, Conklin, Lewandowski, Osika, Selo, & Wignall, 2003). Researchers (Albion, 1999; Marcinkiewicz, 1994; Sheingold & Hadley, 1990) have found that teachers' self-efficacy beliefs regarding technology use is a critical predictor of their uses of technology in the classroom. According to the survey results of 72 teachers (Chen, Burnam, Howie, Aten, & Nambiar, 2003), teachers' self-efficacy beliefs regarding technology use were the strongest predictor of their classroom uses. Furthermore, Albion (2000) reported that preservice teachers' self-efficacy beliefs for technology use enhanced their expectations for using technology in their future classrooms.

Beliefs about the value of technology. According to Cuban (2001), teachers have received conflicting advice about how to integrate technology in the classroom and so are skeptical about the value that technology offers. Some researchers (Becker, 1999; Zhao & Frank, 2003) found that teachers who placed a more positive value on computers tended to use computers more frequently in their instruction. That is, beliefs about the value of computers greatly enhanced teachers' perceptions about the effectiveness of computers for teaching and learning. As such, the perceived relevancy of technology in the classroom can have significant impact on subsequent use in the classroom (Kellenberger, 1997).

Problem-Based Learning (PBL)

Current literature suggests that teachers' beliefs can be changed through practices that emphasize reflection on one's personal beliefs, hands-on experiences, and engagement in authentic problems from K–12 classrooms (Derry, Siegel, Stampen, & the STEP team, 2002; Ertmer, 2005; Tochon, 1999). For example, Derry et al. documented successful belief change after engaging preservice teachers in authentic displays of teaching (e.g., real cases, video cases). Through these authentic experiences, preservice teachers developed a better understanding of constructivist teaching practices, became more successful at implementing constructivist methods, and achieved meaningful reflections on the nature of teaching and learning.

As an authentic, hands-on teaching approach, problem-based learning (PBL) has been advocated as a potentially effective means for impacting teachers' beliefs (Derry et al., 2002). A PBL learning approach starts with an authentic, ill-structured problem that requires students to develop expertise in information seeking and decision-making to solve problems. As such, PBL is believed to enhance students' critical thinking skills, increase motivation, and improve social skills through group work (Albion, 1999; Duch, Groh, & Allen, 2001; Sage, 2000).

In teacher education programs, a PBL approach using problems and issues from K–12 classrooms, can help preservice teachers recognize different perspectives and encourage them to elaborate, defend, or modify their current beliefs about classroom practices. As a result, PBL can serve as a catalyst for shifting beliefs by helping preservice teachers reflect on their beliefs while obtaining new knowledge, engaging in problem solving, critical thinking, collaboration, and decision-making (Levin, 2001; Lundeberg & Levin, 2003; Pierce & Lange, 2001).

Although some researchers have described strategies for changing preservice teachers' beliefs (Richardson, 2003; Tatto & Coupland, 2003), previous research has not investigated, specifically, how to change teachers' beliefs regarding technology use. Furthermore, little, if any, research has investigated how PBL might impact preservice teachers' beliefs regarding technology use. This study was designed to fill that gap. Specifically, this study asked:

1. What is the impact of problem-based learning on preservice teachers' beliefs regarding technology use? More specifically, what is the impact of PBL on preservice teachers' self-efficacy beliefs, pedagogical beliefs, and beliefs about the instructional value of computers?
2. How do preservice teachers' intended teaching practices change after participation in a PBL approach to technology integration?

METHOD

Participants and Course

Participants were solicited from three intact sections of a one-credit educational technology course, *Classroom Applications of Educational Technology,* at a large Mid-western university. The course met once a week, for two hours, over the first eight weeks of the semester. From among the 50 students enrolled in the course in fall 2005, 48 students agreed to participate in the study and completed the pre- and post-surveys; 46 students also completed the pre- and post-lesson plans.

Research Design and Implementation Procedures

This study employed a quasi-experimental research design using pre- and post- surveys and lesson plans to investigate the impact of problem-based learning on preservice teachers' beliefs regarding technology use. Two intact sections were assigned to the treatment condition (PBL: n = 12 and n = 16) and one to the control condition (control: n = 20). One instructor who had previous experience teaching the course, both traditionally and with PBL, taught all three sections. Their was no relationship between the researchers and the instructor or students.

To initiate the PBL activity we used two 6-minute digital video clips of interviews with a middle school principal and the superintendent of a local school district. From these interviews, the students learned that the school district had recently purchased wireless laptops for all of their teachers and students. Now, the administrators needed to hire new teachers who could integrate technology into their classrooms. At the end of the interviews, the administrators announced that they would examine students' portfolios at the end of the term in order to identify the most promising teachers for the new positions.

In the first week of the course, the participants in the PBL group watched the digital video clips through the course Web site and then formed small groups of two or three students. This problem situation prompted a driving question for the class, "What does it take to be a successful teacher who integrates technology?" Each group "created" a potential teacher candidate, including the development of a Web-portfolio, to apply for the new position.

In the second week, each student submitted a lesson plan, which included the use of technology, following specific guidelines that required them to describe learners, goals, assessment methods, resources, and so on. Early lesson plans were compared with those developed at the end of the course to examine how students' intentions to use technology changed over time.

During the semester, students watched digital video cases of exemplary technology integration in K–12 classrooms, including interviews with teachers. After watching the digital video cases, students discussed classroom problems and the strengths and weaknesses of the solutions. Also, each group created artifacts related to the skills, knowledge, and attitudes required to succeed as technology-using teachers in their content areas. In addition, students submitted reflections with each artifact as well as a final course reflection describing their PBL group experience.

Each small group created a digital portfolio to apply for the new positions in the school district. There were three main artifacts in each digital portfolio: 1) an artifact to demonstrate skills (e.g., digital curriculum vitae), 2) an artifact to demonstrate knowledge (e.g., lesson plans integrating technology), and 3) an artifact to highlight attitudes toward technology (e.g., an essay of teaching philosophy). At the end of the semester, each group made presentations to an interview panel composed of school administrators (including those who appeared in the initial video case) and content experts (e.g., professors and instructors in the College of Education). After each presentation, the interview panel asked questions about the candidates' portfolios. During this time, students in the other groups completed peer evaluations using an evaluation form.

The participants in the control group reviewed different multimedia programs used in the K–12 curriculum and evaluated them with a software evaluation form (not based on PBL). Course content was delivered mainly by the instructor. Two lesson plan projects, using Web resources and instructional software, and one digital video development project, were completed. The first two lesson plan projects were completed by individuals and the video development project was completed by a group. At the end of the course, the participants submitted their lesson plans for integrating technology.

Data Collection

Pre- and post- surveys were used to investigate the impact of problem-based learning on teachers' beliefs regarding technology use. Teachers' beliefs were examined via a 54-item survey, Teachers' Beliefs regarding Technology Use Survey (TBTUS), composed of three components as suggested by the literature: teachers' pedagogical beliefs, teachers' self-efficacy beliefs for using technology, and teachers' beliefs about the perceived value of computers for instructional purposes. All items were presented in a 7-point rating scale; students were asked to rate their level of agreement from 1–completely disagree to 7–completely agree (see Appendix A).

Items used to measure teachers' pedagogical beliefs and teachers' self-efficacy beliefs had been widely used in previous research (Bai & Ertmer, in press; Ertmer et al. 2003; McCombs, 2002). The pedagogical belief items (Appendix A, items 1–35) were adapted from a three-factor survey developed by McCombs (2002) as a part of the Assessment of Learner-Centered Practice (ALCP) and had been field-tested and validated over a four-year time period. Bai and Ertmer (in press) conducted a confirmatory factor analysis on the scale with 230 students and its results showed how well the proposed model (three-factor structure) fit the data. The model yielded a chi-square of 873.62 (df = 557, $p < .0001$) and the chi-square degrees of freedom (df) ratio was 1.57 (873.62 / 557 = 1.57). The model was acceptable following the rule of thumb that a model fits if the ratio is less than 2 (Hatcher, 1994). Although the Cronbach reliability coefficients were somewhat low on the pretest (from .56 to .74), results of the post-survey showed acceptable Cronbach coefficient alphas ranging from .72 to .88 (n = 48) on the three-factors.

Items used to measure preservice teachers' self-efficacy for integrating technology (see Appendix A, items 36-42) were adapted from Ertmer et al. (2003). The reliability of the items with the pre- and post-survey data (n = 48) showed a Cronbach alpha reliability coefficient of .97 on the pre-survey and .95 on the post-survey.

Items used to measure teachers' beliefs about the perceived value of computers for instructional purposes (see Appendix A, items 43-54) were selected from surveys employed by practitioners in the field (Chen et al., 2003). All items were evaluated by an expert in the area of technology integration for preservice teachers and modified based on her suggestions, providing the instrument with a measure of content validity. The reliability of the items with the pre- and post-survey data (n = 48) showed a Cronbach alpha reliability coefficient of .82 on the pre-survey and .91 on the post-survey.

Pre-and post-course lesson plans were used to measure changes in participants' intended teaching practices. Participants' lesson plans were analyzed with a rubric and the graders were blind to both the participant and the timing of the lesson plan. The rubric addressed seven categories: 1) teachers' roles, 2) students' roles, 3) curricular characteristics, 4) learning goals, 5) types of activities, 6) assessment strategies, and 7) types of technology (see Appendix B). Each lesson plan was scored on each category according to a scale (1 = teacher-centered learning, 4 = student-centered learning). The seven category scores were added; possible scores ranged from 7 to 28. Two graders discussed what characterized a score of 1 through 4 while grading 10 sample lesson plans. Following that, each grader independently scored the same 30 lesson plans (30% of all the lesson plans) and discussed discrepancies. After reaching consensus, each grader graded 31 lesson plans individually, for a total of 62 additional plans and reached 91.47% agreement following recommended guidelines (Stemler, 2004).

Data Analysis

The data from the pre- and post-surveys were used to determine the impact of PBL on teachers' beliefs regarding technology use. An analysis of covariance (ANCOVA) was conducted, using the pre-survey as a covariate. Data from the pre- and post-course lesson plans were analyzed using the rubric developed. First, an analysis of covariance (ANCOVA) was used to determine the impact of PBL on teachers' intended teaching practices. The pre-course lesson plan score (total score) was used as a covariate. Second, a multiple analysis of variance (MANOVA) was used to determine the overall impact of PBL on sub-categories of teachers' intended teaching practices represented by the lesson plans. Because covariates with pre-lesson plan scores of each sub-category were not simultaneously significant, MANOVA was used instead of MANCOVA. Third, follow-up univariate analyses were conducted on each sub-category where significance was found, using the Bonferroni correction procedure to control for Type I error. That is, each sub-category was tested at the .007, alpha level (.05 divided by 7).

RESULTS

Teachers' Beliefs Regarding Technology Use Survey

Overall, the pre-survey scores were significant as covariates in the ANCOVAs. However, the results of the survey showed that there were no significant differences between treatment groups in the categories of teachers' pedagogical beliefs, self-efficacy beliefs for technology integration, or beliefs about the perceived value of computers for instructional purposes.

Lesson Plans

The results of the ANCOVA showed a significant difference between groups in the amount of change demonstrated in intended teaching practices, $F(1, 43) = 8.80$, $p = .004$, $\eta 2 = .67$ (see Tables 1 and 2, p. 254). Overall, participants in the PBL group showed greater change than participants in the control group in their intended teaching practices, moving from a teacher-centered to a student-centered learning approach. Table 3 (p. 255) presents the means for each of the 7 sub-categories of the lesson plans (pre- and post-course) for the two groups.

MANOVA results showed an overall effect of treatment on sub-categories of lesson plans: Hotelling-Lawley Trace = .64, associated $F(7, 38) = 3.50$, p =

Table 1: Analysis of Covariance (ANCOVA) of Lesson Plans (LP)

Source	Type III SS	*df*	Mean Squares	*F*	*p*
Covariate (pre-LP)	763.39	1	763.39	54.30	< .0001
Group	123.73	1	123.73	8.80	0.004

Table 2: Adjusted Means of the Lesson Plans

Group	*N*	Adjusted Means
Control	20	15.57
PBL	26	19.09

.0054, $\eta^2 = .36$ (see Table 4). ANOVA indicated significant differences between groups, with the PBL group showing more student-centered learning approaches in four categories: 1) students' role, 2) curriculum characteristics, 3) learning goals, and 4) types of technology use. Each category is described in more detail in the following section.

Students' roles. Results revealed that PBL participants described students' roles in a more student-centered way following treatment, than did students in the control group: $F(1, 44) = 11.37$, $p = .0016$, $\eta^2 = .21$. For example, on the pre-course lesson plans, participants in the PBL group described situations where the primary activity was for students to listen to a teacher's lecture, with no group work or follow-up activities. However, on the post-course lesson plans, participants described how students would participate in group work, have more choices for their research topics, and create different products based on collaboration. For example, a student's role was described in the pre-course lesson plan as "getting work done" during classroom activities that included research, presentation, and developing a poster. However, in the post-course lesson plan, the same participant described the student's role as the following:

> The students' role is to work with other students and learn how to be a team player. Teamwork is an important attitude to learn, as students will be using it for the rest of their lives. The students also need to be able to split up work evenly, so that work can be done in an effective way.

Curricular characteristics. Results revealed that PBL participants described curricular characteristics in a more student-centered way following treatment, than did students in the control group: $F(1, 44) = 14.76$, $p = .0004$, $\eta^2 = .25$. On the pre-course lesson plans, participants described how the introduction of specific skills and knowledge followed a pre-determined sequence. That is, the curriculum was structured such that all the students followed the same sequence. However, in the post-course lesson plans, curricula included more project-based approaches with multiple components, ranging from simple-level worksheets to higher-level products such as essays, reports, and hands-on projects, encouraging students to find their own paths through the learning process. For example, in a pre-course lesson plan about learning a piece of com-

Table 3: Means of Each Sub-Category On Pre- and Post-Course Lesson Plans

	Control group (n = 20)				PBL group (n = 26)			
	Pre		Post		Pre		Post	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Teachers' role	2.20	1.00	2.20	0.89	2.80	0.89	2.84	0.88
Students' role	2.05	0.82	2.10	0.85	2.57	0.85	2.92	0.79
Curriculum characteristics	1.95	0.94	1.95	0.82	2.30	0.97	3.07	1.09
Learning goals	1.80	1.00	1.65	0.98	2.30	1.01	2.76	1.10
Types of activities	2.20	0.69	2.05	0.82	2.42	0.75	2.80	0.98
Assessment strategies	1.90	1.11	2.00	1.07	2.73	1.21	2.88	1.14
Types of technology use	1.85	0.98	1.75	0.85	2.69	1.01	3.07	0.97

Table 4: Results of MANOVA On Lesson Plans

Sub-category	Hotelling's T	F	df	p	η^2
Students' role	.64 (p < .01)	11.37	1/44	< .007	21
Curriculum characteristics		14.76	1/44	< .007	.25
Learning goals		12.67	1/44	< .007	.22
Types of technology use		23.29	1/44	< .007	.35

puter software, a participant described how a teacher would demonstrate the software menu and ask students to follow the step-by-step procedure described in a handout or manual. However, in the post-course lesson plan, the same participant described how a teacher would show multiple examples of projects created with the graphic program, show basic functions of the software, and demonstrate one example. Then, the teacher would allow each group to choose a project, based on their own needs and interests, to demonstrate their new skills. That is, students could use their own ideas to create an artifact instead of following one linear procedure established by the teacher.

Learning goals. Results revealed that PBL participants described learning goals in a more student-centered way following treatment, than did students in the control group: $F(1, 44) = 12.67$, $p = .0009$, $\eta^2 = .22$. While focusing only on content-based learning goals in the pre-course lesson plans, participants looked beyond students' growth in subject content to problem solving, communication, or decision-making skills in the post-course lesson plans. For example, the topic of "ink-printing a t-shirt design" was described for an art class. In the pre-course lesson plan, the participant described how students would start the class using computers to either design an object to print onto their t-shirts, or finding an object to use from the Internet. However, in the post-course lesson plan, the participant described an instructional problem that involved the National Football League searching for a new symbol to replace the old one.

Students were asked to design their own symbol to replace the old one. The preservice teacher expected to stimulate students' creativity, problem-solving, and critical thinking through this process.

Types of technology use. Results revealed that PBL participants described uses of technology that were more student-centered following treatment, than did students in the control group: $F(1, 44) = 23.29, p < .0001, \eta^2 = .35$. Some technology uses were described in the pre-lesson plans, such as using PowerPoint and an LCD projector to deliver a lecture. For example, to learn mechanics and the history of small engines in a technology education class, technology use was described in the pre-course lesson plan only in terms of teachers using technology to deliver a lecture as illustrated by this comment: "Teacher will have prepared an extensive PowerPoint presentation with slides that show motion and small video clips that last the duration of the first class period."

As another example, in a pre-course lesson plan about nutrition, a participant described how teachers used technology to demonstrate how to use a software program and students used a spreadsheet program to record numbers from the price tags on food items in the local grocery store. However, in the post-course lesson plan, a greater variety of technology was used for student learning. For example, after choosing a country or culture, students would do research on daily meals and find recipes for favorite dishes. Students would use the Internet for research and prepare a presentation based on their research. Although students would still learn about nutrition, the use of technology was different. While in the pre-course lesson plans, the technology was used solely by teachers to deliver a lecture or demonstration, in the post-course lesson plans it was used by students to both conduct research and to share research results.

DISCUSSION

The purpose of this study was to investigate the impact of problem-based learning (PBL) on preservice teachers' beliefs regarding technology use and on their intended teaching practices as captured by detailed lesson plans. Our first research question examined the impact of problem-based learning on teachers' beliefs regarding technology use. This question was answered by examining beliefs in three sub-categories: 1) teachers' pedagogical beliefs, 2) teachers' self-efficacy beliefs for technology integration, and 3) teachers' beliefs about the perceived value of computers for instructional purposes. No statistical significance was found on any measure related to beliefs. This means that, in this study, the use of problem-based learning, when compared to traditional teaching approaches (control), did not significantly impact preservice teachers' beliefs regarding technology use.

The lack of significant results on the TBTUS may be due to a number of reasons. First, intact classes may have caused sampling problems since random assignment of students to treatment conditions was not possible. While it was necessary, for the purposes of this study, to use the same instructional method with the entire class, changes that occurred (or did not occur) in one class may have been due, not to the treatment, but to some other unique characteristic of the intact class (e.g., students in the earlier class may have been less engaged due to tiredness), thus making interpretation of the results more difficult.

Second, the instrument, TBTUS, may not have been sensitive enough to capture changes in preservice teachers' beliefs regarding technology use. Since preservice teachers' lesson plans showed significant changes in intended teaching practices, it may be that the TBTUS simply was unable to detect these types of changes in beliefs. However, more important to consider is the intrinsically difficult nature of measuring beliefs (Pedersen & Liu, 2003; Rokeach, 1968).

Third, the eight-week course may have been too short to impact teachers' beliefs regarding technology use. Due to the uniqueness of the one-credit course, the course was implemented as a weekly two-hour class over eight weeks. When considering that teachers' beliefs are described as a second-order barrier to the implementation of technology (Ertmer, 1999), changing them is likely to take a long time. Richardson (2003) pointed out that changing preservice teachers' beliefs is difficult during an academic course, especially one that is not accompanied by significant and structured involvement in a field experience.

The second research question, related to changes in intended teaching practices, yielded a statistically significant result. That is, this study supported the hypothesis that preservice teachers participating in PBL, modify their intended teaching practices to reflect a more student-centered learning approach than those who do not participate in PBL. Specifically, preservice teachers in this study incorporated more student-centered strategies in their descriptions of: 1) students' role, 2) curriculum characteristics, 3) learning goals, and 4) types of technology use.

It is likely that the preservice teachers' experiences during the PBL activities and their observations of the course instructor's approaches influenced their descriptions of their intended teaching practices. That is, during the semester students participated in solving an authentic problem, observed exemplary teachers' practices, and engaged in group work, discussion, reflection, and presentation. Many of these same activities were included in students' post-course lesson plans. Engagement in PBL seemed to have impacted preservice teachers' ideas of their own teaching practices, which were then captured in their final lesson plans.

While it is possible that the participants' lesson plans reflected their "true" beliefs, it is also possible that they did not. That is, while it appears as though students' lesson plans were influenced by the PBL approach in which they were participating, this may have reflected only surface changes and students may have held stronger central beliefs regarding technology use that remained unaffected. For example, Ertmer (2005) explained:

> Although teachers may express the beliefs that technology is best used for high-level problem-solving activities, their day-to-day uses may include a large number of drill-and-practice applications, because they hold a more central belief that teachers are responsible for assuring that their students learn foundational, or prerequisite, skills. (p. 29)

Ertmer (2003) suggested three ways of scaffolding belief change in teacher preparation programs: 1) building collaborative structures, 2) modeling effective technology use, and 3) reflecting on current practices and beliefs. The results of this study suggest the possible importance of those approaches when embedded within PBL. Each component is described below.

First, a variety of collaborative activities were included within the PBL activities. Through group work and small and large group discussions, preservice teachers shared ideas about how to develop and improve their PBL artifacts. In addition, collaboration with the school administrators who provided the problem situation in the video clips, as well as the faculty members in the College of Education, increased the authenticity and value of the students' final presentations. The interview panel asked questions about students' portfolio presentations and provided meaningful feedback on their work. Also, preservice teachers posed questions for the interview panel as to actual expectations for new teachers and what types of preparation they needed before graduation. Through this collaboration with school administrators and faculty members, preservice teachers gained a clearer vision of the needs of the profession and how they might address them. In addition, the course instructor benefited from collaboration with two course supervisors and an instructional designer. This kept the course moving in a positive direction, provided prompt and improved support for preservice teachers during the PBL process, and supported the course instructor. Although it was not "inside-the-classroom" collaboration, this "outside-the-classroom" collaboration with PBL experts provided better solutions for managing the PBL process.

Second, the course instructor demonstrated effective use of technology as well as a student-centered learning approach during the PBL process. One interesting finding of this study was that participants in the PBL group designed post-course lesson plans that incorporated the features of PBL. This suggests that the course instructor's modeling activities impacted preservice teachers' intended teaching practices toward student-centered learning.

Third, opportunities for reflection were provided in the lesson plans. In both lesson plans, students were asked to provide a rationale for why they chose specific instructional approaches and why those choices would be effective. Through this process, preservice teachers reflected on their intended teaching practices. Furthermore, individual reflections on each artifact and on the PBL course were required of all preservice teachers. Although the artifacts were developed during group work, it was necessary for the students to reflect on the artifacts individually, considering what was done well and what needed to be improved. Furthermore, by reflecting on the PBL process at the end of the course, preservice teachers had the opportunity to connect and integrate their experiences with their current teaching ideas. Perhaps because of these reflection opportunities, PBL strategies were included in many post-course lesson plans.

As Ertmer (2005) summarized from other studies, beliefs are created through a process of enculturation and social construction; they can be shaped through an intense experience, or a series of events. In addition, change in teachers' beliefs may follow rather than precede teaching practices, and by helping teachers adopt new practices that are successful, the beliefs associated with these practices may also change.

The results of this study provide ideas about how PBL might be used to impact teachers' intended teaching practices. If preservice teachers were to participate in a series of student-centered approaches such as PBL, their intended teaching practices about teaching, learning, and technology may show changes during their teacher education programs. Then, over time, these intended practices may impact preservice teachers' beliefs regarding technology use. Finally, these changed beliefs are likely to impact teachers' future teaching practices. Changes in intended teaching practices may be an important first step in changing teachers' beliefs regarding technology use and future teaching practices.

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References

Albion, P. R. (1999). Self-efficacy beliefs as an indicator of teachers' preparedness for teaching with technology. *Computers in the Social Studies, 7*(4). Retrieved November 17, 2002, from http://www.cssjournal.com/albion.html

Albion, P. R., & Ertmer, P. A. (2002). Beyond the foundations: The role of vision and beliefs in teachers' preparation for integration of technology. *Tech Trends*, *46*(5), 34–38.

Bai, H., & Ertmer, P. A. (in press). Teacher educators' beliefs and technology uses as predictors of preservice teachers' beliefs and technology attitudes. Journal of Technology in Teacher Education.

Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: Cambridge University Press.

Becker, H. J. (1999). *Internet use by teachers: Conditions of professional use and teacher-centered student use***.** Irvine, CA: Center for Research on Information

Technology and Organizations. Retrieved October 12, 2003, from http://www.crito.uci.edu/tlc/findings/internet-use/text-tables.pdf
Chen, E., Burnam, B., Howie, J., Aten, H., & Nambiar, V. (2003, April). *Predicting teachers' computer use in the classroom.* Paper presented at the annual meeting of the American Educational Research Association, Chicago, IL.
Cuban, L. (2001). *Oversold and underused: Computers in the classroom*. Cambridge, MA: Harvard University Press. Retrieved July 12, 2004, from http://www.hup.harvard.edu/pdf/CUBOVE.pdf
Derry, S. J., Siegel, M., Stampen, J, & the STEP Research Group. (2002). The STEP system for collaborative case-based teacher education: Design, evaluation and future directions. In G. Stahl (Ed), *Proceedings of computer support for collaborative learning (CSCL) 2002* (pp. 209-216). Mahwah, NJ: Erlbaum.
Duch, B. J., Groh, S. E., & Allen, D. E. (Eds.) (2001). *The power of problem-based learning*. Sterling, VA: Stylus.
Ertmer, P. A. (1999). Addressing first- and second-order barriers to change: Strategies for technology integration. *Educational Technology Research and Development, 47*(4), 47–61.
Ertmer, P. A. (2005). Teacher pedagogical beliefs: The final frontier in our quest for technology integration? *Educational Technology Research and Development, 53*(4), 25–39.
Ertmer, P. A., Addison, P., Lane, M., Ross, E., & Woods, D. (1999). Examining teachers' beliefs about the role of technology in the elementary classroom. *Journal of Research on Computing in Education, 32*, 54–72.
Ertmer, P. A., Conklin, D., Lewandowski, J., Osika, E., Selo, M., & Wignall, E. (2003). Increasing preservice teachers' capacity for technology integration through the use of electronic models. *Teacher Education Quarterly, 30*(1), 95–112.
Fang, Z. (1996). A review of research on teacher beliefs and practices. *Educational Research, 38*(1), 47–64.
Fulton, K., & Torney-Purta, J. (2000). *How teachers beliefs about teaching and learning are reflected in their use of technology: Case studies from urban middle schools*. Paper presented at the International Conference on Learning with Technology, Temple University, Philadelphia, PA. Retrieved January 11, 2005, from http://l2l.org/iclt/2000/papers/126a.pdf
Hatcher, L. (1994). *A step-by-step approach to using the SAS(R) system for factor analysis and structural equation modeling*. Cary, NC: SAS Institute.
Kagan, D. M. (1992). Implications of research on teacher belief. *Educational Psychologist, 27*(10), 65–70.
Kellenberger, D. (1997). Predicting pre-service teacher perceived computer use under differential access to resources. *Journal of Educational Computing Research, 16*, 53–64.
Kennedy, M. M. (1997). *Defining an ideal teacher education program*. Washington, DC: National Council for the Accreditation of Teacher Education. Retrieved August 24, 2004, from http://www.msu.edu/user/mkennedy/publications/Kennedy%20to%20NCATE.pdf
Levin, B. B. (Ed.). (2001). *Using problem-based learning in teacher education*. Alexandria, VA: ASCD.

Lundeberg, M. A., & Levin, B. B. (2003). Prompting the development of preservice teachers' beliefs through cases, action research, problem-based learning, and technology. In J. Rath & A. C. McAninch (Eds.), *Advances in teacher education series, 6* (pp. 23-42). Greenwich, CT: Information Age.

Marcinkiewicz, H. R. (1994). Computers and teachers: Factors influencing computer use in the classroom. *Journal of Research on Computing in Education*, 26, 220–237.

McCombs, B. L. (2002, March). *ALCP college survey validation results*. Denver, CO: University of Denver Research Institute.

Miller, S., Meier, E., Payne-Bourcy, L., Shablak, S., Newman, D., Wan, T. W., Casler, E. C., & Pack, G. (2003, April). *Technology as a catalyst for change: A leadership model for transforming urban teacher programs.* Paper presented at the annual meeting of the American Educational Research Association, Chicago, IL.

Nespor, J. (1987). The role of beliefs in the practice of teaching. *Journal of Curriculum Studies, 19*, 317–328.

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62*, 307–332.

Parr, J. M. (1999). Extending educational computing: A case of extensive teacher development and support. *Journal of Research on Computing in Education, 31*, 280–302.

Pedersen, S., & Liu, M. (2002). The transfer of problem-solving skills from a problem-based learning environment: The effect of modeling an expert's cognitive processes. *Journal of Research on Technology in Education, 36*, 303–320.

Pierce, J. W., & Lange, H. G. (2001). Providing structure for analyzing authentic problems. In B. B. Levin (Ed.), *Energizing teacher education and professional development with problem-based learning* (pp. 38–55). Alexandria, VA: Association for Supervision and Curriculum Development.

Richardson, V. (2003). Preservice teachers' beliefs. In J. Rath & A. C. McAninch (Eds.), *Advances in teacher education series, 6* (pp. 1-22). Greenwich, CT: Information Age.

Rokeach, M. (1968). *Beliefs, attitudes, and values,* San Francisco: Josey-Bass.

Russell, M., Bebell, D., O'Dwyer, L., & O'Connor, K. (2003). Examining teacher technology use: Implications for preservice and inservice teacher preparation. *Journal of Teacher Education, 54,* 279–310.

Russell, M., O'Dwyer, L., Bebell, D., & Miranda, H. (2004). *Technical report for the USEIT study*. Boston, MA: Boston College, Technology and Assessment Study Collaborative. Retrieved October 12, 2004, from http://escholarship.bc.edu/cgi/viewcontent.cgi?article=1024&context=intasc

Sage, S. M. (2000). A natural fit: Problem-based learning and technology standards. *Learning & Leading with Technology*, *28*(1), 6–12.

Sheingold, K., & Hadley, M. (1990). *Accomplished teachers: Integrating computers into classroom practice.* New York: Center for Technology in Education, Bank Street College of Education.

Stemler, S. E. (2004). A comparison of consensus, consistency, and measurement approaches to estimating interrater reliability. *Practical Assessment, Re-*

search & Evaluation , 9(4). Retrieved April 5, 2005, from http://PAREonline.net/getvn.asp?v=9&n=4
Sugar, W. (2002). Applying human-centered design to technology integration. *Journal of Computing in Teacher Education, 19*(1), 12–17.
Tatto, M. T., & Coupland, D. B. (2003). Teacher education and teachers' beliefs: Theoretical and measurement concerns. In J. Rath & A. C. McAninch (Eds.), *Advances in teacher education series, 6* (pp. 123–181). Greenwich, CT: Information Age.
Tochon, F. V. (1999). *Video study groups for education, professional development, and change*. Madison: Atwood.
U. S. Department of Education (2000). *Teachers' tools for the 21st century: A report on teachers' use of technology* (OTA-HER-616). Washington, DC: U.S. Government Printing Office.
Vannatta, R. A., & Beyerbach, B. (2000). Facilitating a constructivist vision of technology integration among educational faculty and preservice teachers. *Journal of Research on Computing in Education, 33*(2) 132–148.
Wang, Y. (2002). When technology meets beliefs: Preservice teachers' perception of the teachers' role in the classroom with computers. *Journal of Research on Technology in Education, 35*(1) 150–161.
Zhao, Y., & Frank, K. A., (2003). An ecological analysis of factors affecting technology use in schools. *American Educational Research Journal, 40*, 807–840.

APPENDIX A: TEACHERS' BELIEFS REGARDING TECHNOLOGY USE SURVEY (TBTUS)

		Completely Disagree	Strongly Disagree	Somewhat Disagree	Undecided	Somewhat Agree	Strongly Agree	Completely Agree
1	Students have more respect for teachers they see and can relate to as real people, not just as teachers.							
2	There are some students whose personal lives are so dysfunctional that they simply do not have the capability to learn.							
3	I can't allow myself to make mistakes with my students.							
4	Students achieve more in classes in which teachers encourage them to express their personal beliefs and feelings.							
5	Too many students expect to be coddled in school.							
6	If students are not doing well, they need to go back to the basics and do more drill and skill development.							
7	In order to maximize learning, I need to help students feel comfortable in discussing their feelings and beliefs.							
8	It's impossible to work with students who refuse to learn.							
9	No matter how bad a teacher feels, he or she has a responsibility not to let students know about those feelings.							
10	Addressing students' social, emotional, and physical needs is just as important to learning as meeting their intellectual needs.							
11	Even with feedback, some students just can't figure out their mistakes.							
12	My most important job as a teacher is to help students meet well-established standards of what it takes to succeed.							
14	I can't help feeling upset and inadequate when dealing with difficult students.							
15	If I don't prompt and provide direction for student questions, student won't get the right answer.							
16	Helping students understand how their beliefs about themselves influence learning is as important as working on their academic skills.							
17	It's just too late to help some students.							
18	Knowing my subject matter really well is the most important contribution I can make to student learning.							
19	I can help students who are uninterested in learning get in touch with their natural motivation to learn.							

		Completely Disagree	Strongly Disagree	Somewhat Disagree	Undecided	Somewhat Agree	Strongly Agree	Complerely Agree
20	No matter what I do or how hard I try, there are some students who are unreachable.							
21	Knowledge of the subject area is the most important part of being an effective teacher.							
22	Students will be more motivated to learn if teachers get to know them at a personal level.							
23	Innate ability is fairly fixed and some children just can't learn as well as others.							
24	One of the most important things I can teach students is how to follow rules and to do what is expected of them in the classroom.							
25	When teachers are relaxed comfortable with themselves, they have access to a natural wisdom for dealing with even the most difficult classroom situations.							
26	Teachers shouldn't be expected to work with students who consistently cause problems in class.							
27	Good teachers always know more than their students.							
28	Being willing to share who I am as a person with my students facilitates learning more than being an authority figure.							
29	I know best what students need to know and what's important; students should take my word that something will be relevant to them.							
30	My acceptance of myself as a person is more central to my classroom effectiveness of my teaching skills							
31	For effective learning to occur, I need to be in control of the direction of learning.							
32	Accepting students where they are no matter what their behavior and academic performance makes them more receptive to learning.							
33	I am responsible for what students learn and how they learn.							
34	Seeing things from the students' point of view is the key to their good performance in school.							
35	I believe that just listening to students in a caring way helps them solve their own problems.							
36	I am confident that I can use technology as an effective teaching tool.							
37	I am confident that I can use one computer effectively during large group instruction.							
38	I am confident that I can develop effective lessons that incorporate technology.							
39	I am confident that I can use technology effectively to teach content across the curriculum.							

		Completely Disagree	Strongly Disagree	Somewhat Disagree	Undecided	Somewhat Agree	Strongly Agree	Completely Agree
40	I am confident that I can overcome difficulties using technology in the classroom (time, scheduling, accountability).							
41	I am confident that I can manage the grouping of students while using technology as a teaching tool.							
42	I am confident that I can meet the challenges of technology integration.							
43	Computers can provide instruction suited to individual students' needs.							
44	Computer use promotes student-centered learning and self-discovery.							
45	Computers can enhance my students' creativity and imagination.							
46	Computers can engage my students in collaborative work.							
47	My students can learn problem-solving more effectively with computers.							
48	Writing is easier for my students when they use computers.							
49	I encourage and model smart choices about the tools students might use to accomplish tasks, using books, a spreadsheet or digital information when each one is the best.							
50	I encourage students to use the Internet and e-mail to communicate with experts, other students and people from around the world to enrich their learning.							
51	I expect students to organize their thinking using Inspiration and other software program to make mind maps.							
52	I ask students to use networked computers to explore important questions and issues arising out of the content of my class.							
53	I am making more time now than I used to for students to do more of the thinking, analyzing, interpreting, inferring, and synthesizing of information.							
54	I am getting quite good at recognizing worthy uses of new technologies while avoiding the silly, trendy uses that waste time without delivering much of value.							

APPENDIX B: LESSON PLAN RUBRIC

	Teacher-centered **Level 1: point 1**	**Mixed but more toward teacher-centered** **Level 2: point 2**	**Mixed but more toward student-centered** **Level 3: point 3**	**Student-centered** **Level 4: point 4**
1. Teacher roles (teacher's activity)	Transmitter of knowledge; expert source; director of skill/ concept development through structured experiences	Mixed role of lecturer and facilitator but more toward directed (i.e., prepare only single resource)	Mixed role of lecturer and facilitator but more toward constructivist (i.e., prepare various resources)	Guide and facilitator as students generate their own knowledge; collaborative resource and assis-tant as students explore topics
2. Student roles (Student activity)	Receive information; demonstrate competence; all students learn same material and complete same activities	Mixed role of receiver of content and active learner with/without collaboration but more toward directed (i.e., more passive way following teachers' structured instruction)	Mixed role of receiver of content and active learner through collaboration but toward constructivist (i.e., more active way to engage in different activities)	Collaborate with other; develop competence; students may learn different material or engage in different activities
3. Curriculum char-acteristics	Based on skill and knowledge hierarchies; skills taught one after the other in set sequence	Mixed methods but more toward directed and follow more hierarchies (i.e., structured research topic)	Mixed methods toward constructivist and more holistic approach (i.e., individual research)	Based on pro-jects that foster both higher and lower level skills concurrently (i.e., multiple com-ponents, multiple learning paths)
4. Learning goals	-Stated in terms of mastery learning and behavioral competence in a scope and sequence (clearly stated skill objectives with test items matched to them) -Teacher-selected goals	Mixed goals with mastery knowledge/skills and construction of knowledge but more toward directed (e.g., following more sequenced knowledge/skills)	Mixed goals with mastery knowledge/skills and construction of knowledge but more toward constructivist (e.g., more self-directed and their own research based goal)	-Stated in terms of growth from where student began and in-creased ability to work independ-ently and with others (global goals that specify general abilities like problem-solving and research skills) -Student-selected goals and self-directed learning

5. Types of activities	Lecture, demonstration, discussions, student practice, seatwork, testing	Either group work or hands-on activities (i.e, more toward individual work with hands on or more towards group work without hands-on activities)	Mixed activities of group work with hands-on activities (i.e, more toward group work and more towards with hands-on activities)	Group projects, hands-on exploration, product development, problem solving activities with flexibility in grouping
6. Assessment strategies	Written tests and development of products matched to objectives; all tests and products match set criteria; same measures for all students	Mixed assessment with both written test and performance test but more toward to directed (More test and less or performance test is not clearly described)	Mixed assessment with both written test and performance test but more toward to constructivist (More performance test, but it is not clearly described with rubric)	Performance tests and products such as portfolios; quality measured by rubrics and checklists; measures may differ among students
7. Types of technology use	Evident technology use based on teacher-centered learning (e.g., using drill-practice s/w, use single media to deliver lecture)	Mixed technology use based on both teacher-centered and student-centered learning but more toward directed (i.e. use tutorial style or information driven s/w, combine more lecture and technology use is more for teacher-centered and less student-centered)	Mixed technology use based on both teacher-centered and student-centered learning but more toward constructivist (i.e. combine less lecture and use multiple media, single media for constructivist way for more student-centered)	Evident technology use based on student-centered learning (i.e., problem solving method)
Total score: ______________				