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RESEARCH ARTICLE

Investigating the influences of a LEAPS model on preservice teachers' problem solving, metacognition, and motivation in an educational technology course

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Abstract This paper discusses a qualitative study which examined students' problem-solving, metacognition, and motivation in a learning environment designed for teaching educational technology to pre-service teachers. The researchers converted a linear and didactic learning environment into a new open learning environment by contextualizing domain-related concepts and skills and providing ill-structured, collaborative problem-solving opportunities. The intervention called Learning Environments Approaching Professional Situations (LEAPS) took into account issues surrounding motivation and situativity that are of particular interest to instructional developers and design-based researchers. In this study, four classes were assigned as either traditional or LEAPS environments from which four cases were selected for further examination. The results suggested that the LEAPS approach was beneficial in supporting students' problem-solving, motivation, and self-reflections, but only under specific conditions. The implications for instructional design and motivation are discussed.

Keywords LEAPS · Learning environments · Educational technology integration · Situated cognition · Situated learning

Introduction

Educational technology instruction and integration continue to be important aspects of pre-service teacher preparation. In many education programs, preservice teachers are required to take instructional technology courses intended to address computer skills deficiencies, but also to help teachers gain valid knowledge to successfully integrate instructional technologies in their future practice (Thompson et al. 1995; Zachariades and Roberts 1996;

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Moursund and Bielefeldt 1999; Brush et al. 2001; Angeli 2005; Pope et al. 2005; Phelps et al. 2005). Moreover, the rapid development of new technologies forces educational institutions to constantly update and integrate these new technologies as well as the multiple, novel ways of learning them into teaching and learning (Gülbahar 2008).

Unfortunately, traditional teacher preparation courses often fail to effectively enhance students' conceptual knowledge, reasoning and problem solving, reflection, and motivation in instructional technology (Mehlinger and Powers 2002; Moursund and Bielefeldt 1999; Lewis et al. 1999; Rao and Sylvester 2000). Accordingly, it has been observed that recent graduates of teacher preparation programs lack relevant knowledge, skills, and critical thinking abilities that are needed to be effective teachers (Applegate and Shaklee 1992). A lack of robust coursework and intellectual challenge is one explanation (Romanowski and Oldenski 1998). Incidentally, researchers have for some time now deplored the perceived gap between student learning and future teaching practice that currently depicts educator preparation, as it seems many graduates easily forget what they have learned after graduation and display flawed knowledge (Farr 1987). Researchers point to the loss of instructional time and resources when teachers learn about technology in school, yet fail to use and integrate it in their future teaching practice (Pope et al. 2002, 2005; Hew and Brush 2007; Wright and Wilson 2006).

Traditional approaches to teaching educational technology to preservice teachers have come under criticism for being perceived as intrusive and standing apart from the rest of the teaching curriculum (Rubio and Sedersten 2001). Consequently, teachers fail to comprehend the interrelationships between domain-related content, content-related pedagogy, and the integration of technology (So and Kim 2009). Researchers have suggested that preservice teachers do not recognize the current or future utility value of these stand-alone courses. This means teachers are not appropriately motivated (Pierson and Cozart 2004) to learn from these courses in the present because they lack the essential future orientation for using and integrating educational technology in their teaching practice (Bielefeldt 2001; Willis and Montes 2002; Wang et al. 2004; Hew and Brush 2007). These courses simply do not help teachers learn with future application in mind (Wang 2002; Ertmer 2005). Furthermore, it is thought that even if teachers see the value of technology and wish to use it in their future teaching practice, they are unable to do so because they typically do not get enough opportunities to practice technology integration in their educational programs (Iding et al. 2002; Collier et al. 2004).

None of the above problems are exclusive to educational technology training within teacher preparation programs; they also are depictive of shortcomings within the domain of education itself (Koschmann et al. 1996; Partnership for 21st Century Skills 2010). Listed among the deficits of education, learners lack valid knowledge in domain content and pedagogy (Brush et al. 2001; Angeli 2005; Phelps et al. 2005), do not engage in reflection and self-directedness (Knowles 1975), and do not develop cognitive reasoning and knowledge application strategies (Feltovich et al. 1992). Albeit, in response to these shortfalls, innovations around technology integration in educator preparation programs must shift focus away from teaching educational technologies solely as productivity tools, but also as cognitive tools (Jonassen 1996, 1997, 2000, 2003). A new focus geared toward learning how to learn with technologies must be embraced (Kiewra and DuBois 1998; Royer 2002; Doering et al. 2003; Partnership for 21st Century Skills 2010). Preservice teachers need to develop competence and confidence in problem-solving, but also must employ self-monitoring strategies that guide their authentic autonomous, life-long learning (Chi et al. 1989; Brush et al. 2001; Collier et al. 2004).

The Learning Environments Approaching Professional Situation (LEAPS) model, introduced by the lead author (Lubin 2005), is a design model that is pertinent to the current discussion as it encapsulates learning within the cognitive, metacognitive, and affective domains. The LEAPS model theoretically samples from situated learning (Brown et al. 1989), human motivation (Maehr 1984), and open learning environments literature (Hannafin et al. 1999). A LEAPS approach to technology integration fosters knowledge construction, problem-solving, reflexivity, autonomy, competence, and confidence in using technology. The goal of the proposed research was to investigate the effectiveness of a LEAPS intervention for teaching educational technology to pre-service teachers. A more thorough discussion of the LEAPS model will be undertaken later in the paper.

In our evaluation, we converted a traditional, linear, and didactic learning environment (a computer literacy course for undergraduates in the teacher education program) into a LEAPS environment. To do this, we contextualized instructional technology concepts, introduced ill-defined, authentic problem-solving activities into the curriculum, and additionally implemented these elements within an open learning environment. The general goal of this study was to examine students' cognitive and affective processes in the LEAPS environment. The following questions were investigated:

1. How can the LEAPS environment influence pre-service teachers' problem-solving in a real-world technology task?
2. How can the LEAPS environment influence pre-service teachers' metacognition in a real-world technology task?
3. How can the LEAPS environment influence pre-service teachers motivation and affect during problem-solving activities?

Theoretical perspectives

With regards to a theoretical framework for our alternative approach, we started out with a motivational theory that is reliable at predicting learning and performance outcomes—Personal Investment (Maehr 1984). Then, following a critical review of the literature on learning environments, we proposed a non-linear, dynamic, open-ended learning (OLE) approach specifically for teacher education in instructional technology that emphasizes the mediating role of the individual in uniquely defining meaning, determining learning needs, establishing learning goals, and engaging in problem-solving activities (Hannafin et al. 1999). Finally, we integrated some salient features of situated learning (Lave 1993; Lave and Wenger 1991), where the goal was to engage pre-service teachers in participating in communities of practice (Sutherland et al. 2005), developing identities as members of the teacher community, and deepening their professional knowledge (Barab and Duffy 2000; Lave and Wenger 1991; Lave 1993). Below we describe the individual features of these perspectives that are relevant to the new combined approach for teaching educational technology to preservice teachers. Subsequently, we will detail the development and evaluation of the proposed model.

Situated cognition

Situated learning has received extensive attention in many educational settings (Roschelle and Clancey 1992; Greeno 1998; Worthy and Patterson 2001) including teaching educational technology to pre-service teachers (Curtin et al. 1994; Brush et al. 2001). Situated learning focuses on the roles of the physical and social environment and the contextual nature of learning (Lave and Wenger 1991; Brown et al. 1989). Students learn by engaging in activities in the locations authentic to those activities.

In the strictest sense, true situated learning for preservice teachers should involve being immersed in schools settings outside of the university classroom (Hernandez-Ramos and Giancarlo 2004). More generally, the definition of situated learning may be extended to include learning occurring in the physical setting of university classrooms, if classrooms can be modified to correspond to professional teaching situations. Proponents of situated learning (Clancey 1993; Greeno 1998) have concurred that while it is true that school activities do not perfectly correspond to future experiences, classrooms may provide the context in which learners can experience the types of activities that they may encounter in future professional contexts (Senge 1994). We proposed to design learning environments that move toward becoming professional situations, in which learners can become explicitly aware of their cognitions and experiences and understand their roles in actively deriving meaning from their physical and social surroundings. Situated learning supports social interaction, collaboration, and increased student involvement and reflection in settings very close to their natural contexts (Barab and Duffy 2000).

Human motivation

In his theory of personal investment, Maehr (1984) emphasized the roles of motivation and meaning in classroom contexts and stated three main propositions: (a) the study of motivation begins and ends with the study of behavior, (b) the meaning of a situation to the behaver determines the behavior, and (c) the meaning of a situation to the behaver can be assessed and its origins determined (Maehr 1984). Maehr identified behavioral patterns in classroom situations (direction, persistence, continuing motivation, activity, and performance) from which motivational inferences may be derived. Although Maehr (1984) provides a unified theory of motivation, the current study draws strictly from the indicators of motivation that have been identified.

Learning environments

Open learning environments emphasize self-directedness on the part of the learner in terms of defining meaning, initiating instances of learning, identifying and establishing learning goals, and becoming active participants rather than passive recipients in the learning process (Land and Hannafin 1996, 1997; Hannafin et al. 1994; Hannafin et al. 1999). Students in these environments are motivated by engaging in authentic activities that are comparable to post-college activities in size and complexity. However, educators must be cognizant of students' zones of proximal development (Vygotsky 1978) to ensure that the complexity and uncertainty fit the learners' abilities. Open learning environments must provide adequate scaffolding with both embedded tools and resources and teacher coaching and modeling (Land and Hannafin 1996, 1997; Hannafin and Land 1997; Hannafin et al. 1994, 1999). Finally, peer interactions have been shown to have positive influences on students' learning in such environments (Ge and Land 2003).

LEAPS: A model for professional teacher preparation in technology

LEAPS emphasizes the development of pre-service teachers' motivation, adaptability, and confidence for learning computer technology. The new approach encourages self-regulation, autonomy, and lifelong learning (Phelps et al. 2005). By placing personal investment at the core of our approach, we were able to investigate not only students' problem-solving ability, but also their metacognitive awareness regarding their perceptions of confidence for updating new knowledge and skills on their own (Phelps et al. 2005).

Fundamental to the LEAPS Model is the assertion that learning is constructed from the interconnections and interactions of learners' characteristics and the characteristics of their learning environments. Thus, LEAPS takes into account issues surrounding motivation and situativity that are of particular interest to educators, instructional developers, and design-based researchers. Learners' individual characteristics occupy one end of the learner-environment interaction. Learners vary in motivational disposition and educators have no control over students' entering personal attributes and characteristics. Still, educators must strive to create the appropriate conditions within the environment to foster learning by engaging in the processes that influence and alter motivation and disposition so that students can be self-regulated and reflective learners.

Maehr's (1984) theory of personal investment explains student behaviors in classrooms in terms of behavioral patterns listed as direction, persistence, continuing motivation, activity, and performance (Maehr 1984). These behaviors capture the concept of Personal Investment (PI), that is, the way a person chooses to invest his or her resources to achieve set goals (Maehr 1984). Some people choose to pursue certain task over others, persist in some tasks and not others, and reject certain tasks all together. It is the meaning of a given situation to the student that determines his or her behavioral choices. The meaning of the situation to the individual is a function of (a) the behavioral options or alternatives that the individual perceives as being available to him or her in any situation (action possibilities), (b) the individual's own sense of self, and (c) the individuals' goals (Maehr 1984). Understanding that the characteristics of the learning environment occupy the other end of the learner-environment interaction, we observe that encouraging students to engage or invest in their learning environment is key to the LEAPS approach.

The ideal products of this learner-environment interaction are cognition and self-regulation in problem-solving and metacognition through self-reflection on learning. Metacognition refers to students' knowledge of their own cognitive processes or learning, knowledge about the limitations of their cognitive processes, and knowledge about their abilities to select, use, monitor, evaluate, and revise strategies to acquire knowledge and solve problems (Flavell 1985; Garner and Alexander 1989). Educators thus need to teach lessons and create conditions that foster metacognitive awareness (Kiewra and DuBois 1998). Metacognition is also important for self-regulation. Self-regulation is knowledge about one's own thinking and learning that involves planning, monitoring, and evaluation (Woolfolk 2007). Effective planning involves having a firm grasp of a goal and understanding the demands of the tasks, as well as ones' own limitations, related to that goal. Students need to learn how to monitor their own progress to determine whether or not their strategies are working and when they need to use new ones.

Finally, students must be able to evaluate whether their efforts are worthwhile. The knowledge about their limitations will impact their self-confidence and self-efficacy, especially when they are considering undertaking difficult tasks. In addition, students must see plainly how the use of appropriate strategies will benefit them or they will not be convinced of their usefulness (Garner and Alexander 1989; Zimmerman 1990, 1994, 2000; Woolfolk 2007). Importantly, in terms of how these elements interact, Zimmerman (2000) offers a model for self-regulation that involves three "cyclical self-regulatory phases", namely forethought, performance, and self-reflection (p. 16). The forethought phase includes some value components such as self-efficacy beliefs, goal setting and reasons for pursuing goals, and expectations about the outcomes of pursuing goals that are directly related to Maehr's (1984) motivation model. Maehr (1984) suggested that an individual's personal investment for pursuing goals is related to the way he or she constructs meaning in a given environment.

Learning in a LEAPS environment centers on solving ill-defined technology-related problems, while acquiring sufficient self-awareness of one's competence and confidence. Learners experience the limits of their own cognition in a nurturing environment that fosters the development of appropriate self-monitoring strategies. Students are afforded opportunities for independence and autonomy as they develop new knowledge and skills and establish adequate justifications for their decisions. Learning is collaborative and the instructor's role is that of a facilitator. The power of the LEAPS Model is that it allows educators to examine and monitor all of those essential components of learning in one holistic, open learning environment for teaching technology to preservice teachers.

LEAPS in practice

The instructional context for this research was a basic computer literacy class "Productivity Tools for Education," in which the principal investigator was the instructor. The course was a one-credit-hour laboratory course that introduced students to applications of computer software and hardware configuration using Mac Operating System. The goal of the course was to enable students to use word processing, spreadsheet and database development, and the Internet to solve educational, information communication and management problems. The problem anchored in this research required students to plan their first parent-teacher conference allowing researchers to monitor student-initiated tasks and activities within this problem-solving context. To test the viability of our theoretical model, we converted a traditional educational technology course for pre-service teachers to a LEAPS environment based on the following design framework for LEAPS. In Table 1, we highlight some basic differences between the LEAPS and the traditional learning environments. Note, Table 1 also appears in (Huang et al. 2011).

In the LEAPS environment, we prearranged for problem tasks to be ill-defined, which required students to define sub-problems of the project first and identify the software applications to be used to produce the needed documents and accomplish their goals. Students in LEAPS were not given specific information about the materials and specific computer applications they should use, but rather they had autonomy to define the context from which to solve the problem. In addition, students in the LEAPS environment were encouraged to provide rationales and justifications for their solutions. Furthermore in LEAPS, students worked on solving problems as members of small groups. Therefore, in the context of LEAPS students had the following responsibilities: (a) clarify the problem context; (b) define problems; (c) identify goals and sub-goals; (d) select appropriate tools for their tasks; (e) create appropriate solutions that satisfy the problem situation; and (f) determine group members' strengths, assign responsibilities, and delegate tasks (Lubin 2005).

In the LEAPS classroom, the role of the instructor was to facilitate and to provide instructional support. The instructor served as a mentor or guide. The instructor intentionally refrained from answering questions immediately as they were posed, but instead cautiously invited students to explore possibilities for solutions. The intention was to help students be self-directed in generating solutions and seeking outside help. Students were prompted to first exhaust their personal resources, then seek help from peers, and then ask the instructor if all else failed. Additionally, and importantly, the instructor primed students

Table 1 Differences in design framework between LEAPS and traditional learning environment

Comparison	LEAPS	Traditional
Individual or group work	Group	Individual
Project goal	To prepare all the materials needed for the first parent-teacher conference defined by students	To prepare six documents for the first parent-teacher conference defined by the teacher
Project description	No specific descriptions	Precise, detailed descriptions and handouts for step-by-step instructions
Tasks/ activities	Group defined problems, identified goals, and initiated tasks and activities	Individuals just followed the instructions step-by-step to complete the tasks required by the teacher and task specifications
Support from instructor	Instructor was a facilitator and mentor, providing guidance, resources, and tools, and encouraging self-directed learning	Instructor was a "workshop" teacher, providing any help whenever needed, from technical problem to answering questions that are concerned with seeking a problem solution
Culture and Identity	Promoted the identity of professional teacher community	Students assumed the identity of a "student"

to make self-references and to explore their self-concept as professional teachers. This was done by continually and purposefully asking students to think of themselves as professional teachers in their first classroom, to imagine what that would be like, and to imagine how they would carry out their tasks with the resources they imagined they would posses. Students were reminded that they were members of a professional community and to authenticate this notion, at the end of the semester, students were required to seek feedback on their group projects from a professor in the College of Education, who represented members of their immediate professional community.

Conversely, we took a typical and conventional approach to instruction in the traditional learning environment. In this environment, the instructor was the main source of instruction in the content domain and an essential source of information on how to solve problems encountered in the learning context. The instructor transmitted his/her expectations, definitions, solutions, and justifications in a manner similar to a typical workshop facilitator, whose primary responsibility was to demonstrate example solutions and answer questions from patrons. The requirements of the class project were explicitly articulated. Students were expected to complete six well-defined components that constitute the parent teacher conference, including a welcome sign, a parent sign-in sheet, an address database, a students' performance summary, a mail merge template, and the final mail-merged letters to be sent to parents. Students were provided with handouts detailing instructions on how these components could be completed. The final requirement was for all students to turn in their individual projects in the end, even though students were allowed to collaborate and/or help each other during the class.

Although the LEAPS and the traditional environments were different, the domain content and the pacing of instruction remained the same. Further, the enabling contexts, resources, tools, and scaffolds were carefully adjusted to correspond to the two distinct learning environments even as the assignments and the projects remained compatible. Basic computer applications taught in both contexts included word processing, basic computer graphics, database, mail merge, and web search. Students learned new applications in each of the weekly classes from week 1 through week 5. The parent-teacher conference project was introduced in the 3rd class, and from that point onwards, students spent part of each class period working on their project until the 6th class when they had the entire class period to work on their projects. Students took a practice examination in the 7th class and a final examination in the last class.

Every class session lasted 1 h and 50 min, and students met once every week for 8 weeks. Class participation included regular attendance, student discussion, hands-on practice on the computer, and helping peers when appropriate. As part of the class ethics, students were required to keep workstations neat, shut down the computers when leaving, and maintain aplomb in the face of frustration. The laboratory was set up with the instructor's workstation at the front of the class directly facing the students, equipped with a computer projector hanging from the ceiling and a projector screen to the left of the instructor in the corner of the room. The students' workspaces consisted of four long tables running across the width of the classroom with five identical, open personal workstations on each. All the Macintosh computers were preloaded with the necessary software. The configuration of the class allowed the instructor to walk around to attend to students. However, the layout was not very well suited for group-work since the tables were fixed and students had to stay within their respective rows to work on projects.

The following was similar across the two environments. The first day was used for orientation and course overview and introduction to the Mac OS. After Day 1, students were allowed to use the first 10 min of class for whatever purpose they chose, for example, checking emails. Directly afterward, the instructor would briefly review the topics covered in the previous class session, solicit feedback, questions and concerns, and then preview the application-specific topics that would be covered that day. This was done to provide a sense of continuity and contiguity between the class sessions. The instructor would then conduct a 20–30 min presentation introducing students to software applications, provide approximately 20 min for practice, and then provide a 10-min break. After the break the students worked on their projects, which was the other major component of the class. The instructor carefully designed a complex and integrative problem-solving unit spanning 8 weeks, which was intended to allow students to gain a complete understanding of the concepts underlying productivity tools and integration software in educational use.

Method

This study was designed as a naturalistic and descriptive study using comparative case-study method (Yin 1984, 1989, 2002). Our aim was to understand students' learning experiences and interactions within a LEAPS model (Lubin 2005). We compared this learning to what was simultaneously taking place in a comparable traditional learning environment. We anticipate an important design question to be whether our learning environments represented natural settings or artificially created ones. We intend in advance to avoid any misperceptions that our study participants were simply arranged or assigned into different artificially constrained research groups. Design-based researchers (Palincsar and Brown 1984; Brown 1992) have recommended treating learning environments as holistic and complex systems, and so, we viewed both the LEAPS and traditional learning environments as naturalistic and authentically bounded systems. While our focus was on LEAPS, design-based researchers also emphasize the value of having a reference group. Thus we hoped that a concurrent glimpse into a directed learning environment would provide useful information in terms of evaluating the LEAPS environment.

As such, the directed/traditional learning environment in our study served merely as a reference group against which constructive comparative evaluations were made. Rich, thick descriptions necessitated both comparisons and contrasts of the cultures, activities, and contexts as well as the individual characteristics and learner-environment interactions. This required that the environments under observation and people who use them were comparable in scope and complexity. While we necessarily needed to plan the elements within both learning environments, we made strides to protect their authenticity and integrity. In planning, we fully realized the obvious epistemic differences in these environments and their implications on learning outcomes. We do not treat or think of the traditional group as a control group, since doing so would mean setting-up a "straw man". Thus, we explicitly invite our readers not to view our methodology as experimental or causal-comparative in nature. Instead, our attempt is a design that depicts a qualitatively grounded case study with a comparative structure.

Participants

Sixty pre-service teachers from age 18 to 30 enrolled in an educational technology course (Productivity Tools for Education) were targeted for discriminative sampling (Strauss and Corbin 1998) based on the following specific criteria: (a) student consent, (b) representativeness of class composition, and (c) completeness of the data sources (Land and Zembal-Saul 2003). Subsequently, Groups L1, L2, and L3 consisting of three, four and four students respectively became the three cases selected for in-depth and detailed investigation in a LEAPS class. Group T was made up of three students and became the case representing a traditional class. It is important to note that Group T is simply a designation/moniker for the students in the traditional environment, who were observed as part of this study. These students were not placed into a group and were not required to work together, even though they were allowed to. Students reported their prior knowledge and entry-level skills and their feelings of competency about using technology on a competency survey at the beginning of the first day of class. Apart from a few notable differences in prior knowledge and feelings of competence, the cases were fairly homogeneous. The students were all at least fairly competent in using MS Word on a PC, calculating data and drawing graphs, sending web-based email, and performing online research on both PC and Macintosh platforms. Nearly all students reported feeling "not competent" using MS Excel. Refer to Table 2 for details.

Data sources and analysis

Observations were the primary data collection technique. While the instructor served as a participatory researcher jotting down important notes, a research assistant took the field notes at every class session. Observations also consisted of documenting the events, activities, and behaviors of students and the instructor through video recording. The two field observers generated on-site observational notes as well as off-site reflective notes after the observations. Through observations, we expected to gain insights into learner-environment interactions during problem-solving activities on problem representations (defining and decomposing the problem) and problem solutions (solution planning, implementation, and evaluation) (Bransford and Stein 1993; Jonassen 1997). The researchers also closely examined the videos and searched for instances of Maehr's indicators of motivation (Maehr 1984). The researchers were interested in students' choices and persistence in behaviors, therefore, based on both observation notes and

Table 2 Case profiles based on students' self-report at the beginning of the course

Student group	PC (hr p/week)	Mac (hr p/week)	Word (platform: PC/Mac)	Excel (platform: PC/Mac)	Online search (platform: PC/Mac)	Web email (platform: PC/Mac)
Group L1—LEAPS						
Evelyn (F, elementary ed.)	20	3	All of them very competent (both)	Somewhat competent (both)	All of them very competent (both)	All of them very competent (both)
Constance (F, elementary ed.)	20	3		Very competent (both)		
Tamara (F, special ed.)	20	3		Very competent (both)		
Group L2—LEAPS						
Antoinette (F, elementary ed.)	2	2–4	All of them very competent (PC)/ Competent (Mac)	All of them not at all competent	All of them competent—Very competent	All of them competent—Very competent
Giselle (F, early childhood)	2	0				
Katherine (F, elementary ed.)	10	2				
Marcellus (M, social studies)	25	2				
Group L3—LEAPS						
Cheryl (F, early childhood)	8	1	Competent (PC)	Somewhat competent (PC)	All of them competent—Very competent (both)	Competent (PC)/ Somewhat competent (Mac)
Aretha (F, elementary ed.)	15	3	Competent (both)	Not at all competent		Competent (both)
Eva (F, social studies)	12	3	Competent (both)	Not at all competent		Competent (both)
Cyril (M, micro biology)	52	4	Very competent (both)	Very competent (both)		Very competent (both)
Group T—Traditional/Directed						
Esther (F, elementary ed.)	15	2	Very competent (PC)	Not at all competent	Very competent (both)	Very competent (both)
Andrea (F, elementary ed.)	20	3	Competent (both)	Somewhat competent (both)	Very competent (both)	Very competent (both)
James (M, music ed.)	15	2	Competent (both)	Very competent (both)	Somewhat competent (both)	Very competent (both)

videotaped data, the researcher analyzed how students used the (a) first 10 min of class designated as free time, (b) 10-min break in the middle of each class period, and (c) serendipitous free time in class including practice and problem-solving time.

Interviews were 30-min, semi-structured dialogues between a researcher and a student and were conducted at the end of the 8-week class section. Interview sessions were documented using digital recorders and were subsequently transcribed. Through interviews, we wanted to understand students' motivational dispositions and problem-solving skills and their metacognitive processes. The student-generated materials including, brainstorming summaries, sketches, drawings, written solutions and justifications, and final products (consisting of initial drafts, previous versions of work, and other work excluded from the final products) were also collected as one of the data sources. Students' work provided rich data upon which to make inferences about students' problem-solving abilities. Surveys were used to gather demographic information and information about students' prior knowledge in the subject. These surveys were analyzed descriptively and were used to provide the participants' profiles.

Analysis of the data was conducted in a series of phases and focused on cross-case comparison driven by the research questions. First, interviews and field notes were displayed chronologically in a narrative script format and then coded with the use of the research questions and the theoretical framework as our guide for open coding. The data were inspected by categories and instances by disaggregating the text (color coding and separating) into fragments. The fragments were then re-aggregated using a series of thematic headings that emerged from the data (Atkinson 1990, 1992). A spreadsheet was used to assist the disaggregating and re-aggregating process. Second, the researchers returned to the original videotaped data. The observation notes on the video data were coded and clustered (Merriam 1988). This process gave the researchers an opportunity to query the actual interactions, verify and confirm the initial findings, and identify other themes that may have been missed in the previous phase of analysis. Third, the final products generated by students were analyzed and compared with other sources of data. Finally, the researchers searched for the appropriate patterns and interrelationships among all the data sources to help explain the findings.

Researcher roles

The primary researcher played dual roles of an instructor and a researcher. We acknowledge the validity issues and the morass of interpretation since the primary researcher was an instructor inside the learning environment. Thus, we took some measures to guard against biased interpretation of the data. For example, the secondary researcher served as an outside researcher and performed member checks regarding the data interpretation in the data analysis process. Furthermore, while the primary researcher took post-class reflection notes, a graduate student was invited to serve as an assistant helping to videotape all the class sessions and take field notes, which were cross-referenced to and triangulated with the first researcher's reflection notes. In this way, we were able to obtain both emic and etic (experience-near and experience-distant) perspectives (Geertz 1976, 1983) on the data analysis.

Results

Question 1 How can the LEAPS environment influence pre-service teachers' problem-solving in a real-world technology task?

For the purpose of analysis, the problem-solving process was examined in the following phases: (a) problem representation, and (b) developing solutions, each of which contained further subheadings (Smith & Ragan, 1999). Table 3 summarizes the major themes identified during problem-solving activities.

Problem representation

Defining and decomposing the problem

Several important themes emerged from the analysis. Defining problems involves searching for relevant information, that is, knowledge about the principles involved in the domain. This information can be categorized in two ways: (a) the learner's prior knowledge about the domain and (b) the domain knowledge gained from classroom instruction.

It was noted that all the groups reported feelings of competence in using MS Word and nearly all reported little or no competence with MS Excel, with the exception of Evelyn in Group L1 and Cyril in Group L3. In addition, at the time that the project was first introduced, the students were already introduced to MS Word and had practiced using it, but were not yet introduced to MS Excel. Correspondingly, when seeking what information was useful and available for defining the problem, only Group L3 proposed to explore the use of MS Excel.

Prior knowledge, however, did not account for all the differences in learners' representations of the problem. Learners' confidence in their ability emerged as another major theme in terms of decomposing the problem into sub-goals. After MS Excel was treated as part of the course instruction, Group T included the use of Excel in their definition of the problem, whereas, among the LEAPS students, only Group L3 group used Excel. The researchers found that when learners were specifically directed to use new knowledge to explore a specific solution path, they attempted to do so in spite of their comfort level with the new knowledge. Group T reported feeling "not competent" using MS Excel, but proposed to use this application because they were specifically directed to do so. On the

Table 3 Major themes identified during problem-solving activities

	Process sub-stage	Major themes
Problem representation	Definition	Information: Prior knowledge; Impact of instruction
		Learners' perceptions of confidence, Comfort level with novel information
		Goal information: Time information, Deadlines
	Decomposition	Information: Prior knowledge; Impact of instruction
		Learners' perceptions of confidence, Comfort level with novel information
		Goal information: Time information, Deadlines
Developing solutions	Solution planning	Uncertainty: Learners' perceptions of competence
		Learners' expectations of help and personal responsibility
		Social distribution of problem solving
	Solution implementation	Prior knowledge
		Expectations of help
	Solution evaluation	Nature of the task: Well-structured vs. ill-structured
		Prior knowledge on problem-solving

other hand, when learners had the opportunity to explore alternative justifiable solutions, they did not choose to use the new knowledge because they were not comfortable using it, as evidenced by Groups L1 and L2.

Even when the new knowledge had a direct impact on the solution of the problem and it was suggested to "…use everything you have learned in your solution of the problem," only Group L3 opted to use MS Excel without being specifically directed to do so because one member, Cyril, reported feeling very competent about using it. Evelyn (Group L1) also had prior knowledge of MS Excel, but she reported feeling only somewhat competent and may have declined to share her expertise with the rest of her group.

In summary, the results suggest that in the absence of complete knowledge, and after learning new knowledge in a domain, students in the open learning environment needed to be prompted and scaffolded to intentionally use the new knowledge. Otherwise, they used the autonomy provided in the environment to avoid using some new knowledge with which they were not comfortable. The results also suggest that the diversity of prior knowledge among group members in a LEAPS environment influenced how the problem was defined and decomposed.

Developing solutions

In this study, the process of forming solutions was analyzed in three interrelated phases: solution planning, implementation, and evaluation.

Solution planning

Solution planning is highly interrelated with problem representation, particularly, the decomposition of the problem into smaller units. The findings can be framed into the following themes: (a) uncertainty versus learners' perception of competence, (b) learners' expectations of help, and (c) social distribution of problem-solving. Group T did not have to do a lot of defining since the problem was well-defined and straightforward. Likewise, they did not do much by way of planning and did not seem to evaluate the information beyond what was immediately provided in directions. Group T seemed confident and competent at this stage and there did not seem to be any uncertainty about solving the problem. LEAPS students responded differently. Their level of uncertainty was very high at this stage. Many questions were asked including "what do we do here?", "What problem is this referring to?", and so on.

Students' uncertainty was handled differently across the two learning environments. Group T students had few questions at this stage, and if they had questions, the instructor answered them promptly. The instructor in LEAPS refrained from answering questions directly to give students the opportunity to derive answers themselves. For example, when asked by Group L1 what the guest book was, the instructor replied, "Have you thought about the Thank-you letter?" The instructor was suggesting that in order to send thank-you letters the teachers needed to know who attended the PTA conference, hence the need for a guest book. When Antoinette from Group L2 asked, "What are we supposed to do?" the instructor replied by asking "What do you think you need to be doing?" followed by "What can you do right now?" Students from Group L2 also asked how to work in groups, "by dividing up the work?", "Is each group going to turn in one project (one graphic, one letter, etc.)?" The instructor explained that it was up to the group to decide how to proceed. It was observed that students in the LEAPS environment asked themselves or their peers more metacognitive questions directly due to their uncertainty. The instructor tended to toss the questions back to students to further challenge their reflective thinking instead of answering straightaway.

According to our field reports “students did not seem familiar with this kind of group project. The instructor explained that the big point was that by the end of the project everyone had contributed sufficiently in solving the problem. He emphasized that they were responsible for making their team work.” Another example is when Aretha from Group L3 asked, “how are we going to format the handout?” Field notes revealed, “the students were directed to not just think about technology in terms of how to do specific things with technology. Instead, ask what is the technology’s purpose or usefulness to start with? Then ask yourself what skills do I already possess?”

Learners’ expectations of help was another highly interrelated theme that stemmed directly from the uncertainty. Group T knew that help was forthcoming and were not afraid to take advantage of every opportunity. Albeit their level of uncertainty and questioning was low at this stage. On the contrary, the students in Groups L1, L2, and L3 quickly took notice of the nature of the help they were receiving and began to seek help within their individual groups.

A final subtheme of solution planning is the social distribution of problem solving. This refers to how the various sub-tasks would be distributed. For Group T, it was fairly evident they were fully responsible for all the work. In fact, they were specifically instructed that each student was responsible for his or her own work. For LEAPS students in Groups L1, L2, and L3, it was more of a social activity. It was observed that students decided to either collaborate or cooperate. Collaborating involved all the students working simultaneously to solve each component of the problem. On the other hand, cooperation meant that different students worked on different parts separately. Students may have preferred to collaborate because it was harder to decide who would be best suited for particular tasks since they all shared similar skills and background. The groups with diverse skills and prior knowledge were able to make clearer decisions about who was most suitable for which task.

The results suggest that when the prior knowledge in the group was fairly similar there was more collaboration in the problem-solving process, as in Group L1 and L2. Unlike the other LEAPS groups, Group L3 was fairly heterogeneous in skills and demonstrated a high level of cooperating at this stage. Incidentally, during collaboration the students were more apt to challenge others’ decisions. For example, Marcellus suggested some elements (such as names, grade level, date, and the like) be put on the handout. Katherine challenged his assertions by asking whether there was a purpose for adding the date. She suggested adding questions instead. A further example of this challenge was when Evelyn suggested to her group that it was time to start focusing on “big ideas.” “We need to discuss what format would be easier, thinking about using ‘paragraphs,’ what goes into each paragraph, what to cover and how to cover, sheets to give parents, thinking about children’s names,” she asserted.

Solution implementation

This process involves applying the principles in the domain and confirming that they were applied appropriately across different situations. This process also involves giving reasons for the choice of application. Analysis of the data suggests that this process can be framed around two main themes: (a) prior knowledge and (b) expectations of help. The solutions were implemented in a manner congruent with the solution planning phases. Group T students in the traditional class used the principles and concepts involved in word processing, database, spreadsheet, and integration features (mail merge) to solve the problem.

They did not deviate from the suggestions on the project handout. Although the initial prior knowledge for MS Excel was low for these students, the subsequent course instruction on Excel had direct impact on their problem solving. Also, Group T students were given a grading rubric that LEAPS student did not receive. LEAPS students instead were told, "…you should be able to apply everything you have learned in class up to this point. This includes but is not limited to all of the following: word processing, graphics development, spreadsheets, and databases. You may use any or all resources at your disposal including your classmates and your instructor."

There were differences in terms of how the different groups confirmed that they were applying the principles appropriately. Group T students relied heavily on the instructor for confirmation. It is at this stage that their feelings of uncertainty increased. This was evident in the high frequency of hand-raising and question asking. Group T students implemented their solution in a series of short discrete units. At each step, they would stop and ask the instructor to confirm whether they had done it correctly. For example, in one instance, in a 25 min period, Andrea sought confirmation from the instructor five times with questions like "does this look like what I am supposed to be doing?", "Does my Welcome Sign have everything in it?", and, "I want to sort the data but can you stay and watch if I am doing it right?" In the same block of time, James and Esther asked three similar questions including "does my guest book look right?" "Is this what my welcome sign supposed to look like?", and "Should I send the letter to one parent or both parents?"

LEAPS students asked fewer questions at this stage. It appeared that their feelings of uncertainty had decreased at this phase. The students in these groups asked questions of each other instead of the instructor. Moreover, they did not implement their solution in small pieces, but rather, as a whole chunk and asked for confirmation only when the whole chunks were complete. In addition, the preponderance of questions directed to the instructor was not to seek confirmation about implementation, but rather, for technical consultation. The students were attempting to apply the technology in ways that were similar in application, yet different from the examples demonstrated in the course instruction. These applications required skills beyond what they had learned in class. They were inquiring whether the technology was suitable and robust enough to satisfy their needs, not whether they were solving the problem correctly with the technology. Evelyn from Group L1 asked, "We just wanted to know…uh, if we wanted to add more personal information in the thank-you letter, could we increase our database or is that going to mess up the mail-merge. How much can Word take?"

The differences in the type of questioning across the two learning environments were explained in terms of learners' expectation for help. Group T students were used to the instructor being readily available and forthcoming with answers. They came to rely heavily on instructor help. On the other hand, LEAPS students came to realize that they were responsible for making sense of their learning. In fact, early in the process when Giselle from Group L2 asked the instructor "Should we collect contact information in the hand-out?" her group member Marcellus responded "let's try to figure out what we need, cause you know he [instructor] is going to say 'what do you think?'"

Solution evaluation

Beyond confirming whether the domain principles are being applied appropriately in various situations, the problem-solver also must confirm that the application of those principles actually satisfies or solves the problem. The way the students evaluated their solutions could be framed around the theme "expectations of help." These expectations are influenced by the nature of the task (well-structured vs. ill-structured). The task was well-structured for Group T students. This group was given handouts with detailed directions about how to go about solving the problem in terms of format, content, and mode of delivery (how to turn in project). In addition, these students were given the mastery criteria (rubric) for the project against which they could check to determine whether or not they had successfully completed the assignment (but not necessarily solve the problem). We could not determine whether or not students in Group T used the rubric. In fact, the students asked the instructor to evaluate and give feedback before they turned in the project. Esther asked, "Can you look at my project and see if I did everything right before I turn it in?" Andrea said, "I would like you to look at my project to see if I have everything I need." James, asked the instructor for to do a final check to see if he had everything before he felt comfortable enough to turn it in.

On the other hand, students in the LEAPS environment were given an ill-structured task but were not given a rubric. These students were required to produce a sign-off sheet with a statement of agreement about the quality of the final product and signatures from each member of the group. In addition, they were required to get an additional signature from another faculty member (beside the instructor) in the College of Education endorsing their product. The faculty were alerted in advance about the nature of these visits. The students were very apprehensive about the idea of getting the approval of another faculty member. They spent more time than Group T students in refining their products and none asked their instructor to evaluate the products before turning them in. LEAPS students also spent time negotiating which faculty member to approach. The students in Group L1 decided to approach a faculty member with whom they were all familiar, while the students in Group L2 decided to walk down the hall and peek into faculty offices and ask the first "nice" face they could find. Group L3 asked members of Group L2 to tell them who they had approached and to describe the experience so they could prepare themselves. All the students reported that the faculty members they had talked with were friendly and supportive and gave important feedback and recommendations. All the students asked the instructor for extra time to make changes to their final products based on the feedback they had received.

It appeared that the nature of the tasks in the directed learning environment influenced students' high expectations for help and that evaluating the solution was assumed to be the responsibility of the instructor. On the contrary, the nature of the tasks in the LEAPS environment contributed to students' low expectations of external help and enabled the students to be more invested in developing and refining their final products on their own before soliciting feedback from external sources. Students experienced a shared responsibility for evaluating the solutions rather than a complete reliance on an external source. In this instance, it appeared that the responsibility for evaluating the solutions was transitioned over to the students.

Strategies for solving problems

Further evidence of students' expectations of help in evaluating solutions is provided in the following examples. Students were asked to report on their problem-solving strategies, "You are given a handout to complete an assignment for your next class, but when you try to follow it you realize that the steps do not work on your computer at home. There is no one who can help you. Describe how you would find the correct solution on your own." Esther in Group T reported that she called her dad for assistance, "whenever I have a problem and I am going crazy and all that I have done hasn't helped I call him." She said she did not use the Internet or the “Help” functions, or even use other books. Andrea in Group T reported, “I’d find a computer that it could work on. I’d… I don’t know. I’d probably read it over again, make sure I’m not mistaken. And then, I would, maybe, try to… just try to figure it out on my own. And if I couldn’t figure it out, then… if I can’t ask anybody?” However, the students from LEAPS responded differently. Antoinette, from Group L2 said, “the first thing I would try to do is look at all the things at the top…yeah all the menus and I would try to see if I could figure it out from there. I would kinda explore a little bit and if I could not figure it out I would go to help and type in a question.” The other students in LEAPS groups reported using the same set of strategies. They explained that they “explored the menus,” “used the Help function,” and “tried to recall how I did it somewhere else before.”

In summarizing these results, students reported different strategies for solving problems. Although students from the directed learning environment also reported trying to figure things out on their own, they tended to “not know” specifically what strategies to use, and eventually they had to seek external human help. On the other hand, the students from the LEAPS environment were more specific in stating the various strategies, such as, exploring help menus or recalling from their prior experience, and seeking external help was not their first preference. Table 4 summarizes the major themes and the differences in students’ behaviors, confidence, and expectations during their problem-solving processes across the two learning environments, which have been discussed above.

Question 2 How can the LEAPS environment influence pre-service teachers’ metacognition in a real-world technology task?

The researchers were interested in whether or not the students were reflecting on their learning processes. During interviews at the end of the class, all the students who participated in the research were asked questions related to their metacognition and reflection. The responses to the two major questions were analyzed for evidence of students’ reflections about their learning: (a) Compared to your other courses how much control do you have over how well and how much you are learning in this class? and (b) Do you ever question yourself about whether or not you are learning in this class?

Students responded differently when asked to report on how much control they had over their own learning. For all the groups, control over one’s own learning was interpreted as a person’s choice to self-manage. Students from Group T responded to the question in terms of (a) completing assignments and (b) asking questions to gain clarification and help. Esther from Group T said she felt she had a lot of control over her learning in the class because “I either do the work or don’t do the work, and I can ask questions to get help, so if I don’t ask questions it’s my own fault.” In addition, Andrea’s response indicated that the directed learning environment somehow discouraged reflective thinking, which may be extrinsically “enjoyable” to some students as the environment was not cognitively demanding or challenging. Andrea from the same group said “I think in all my classes I control how much I learn, but in this class he [instructor] gives you the worksheet and it’s up to you to complete the assignment, and so I think you have a lot of control over what you can do and how well you can do it.” When asked about monitoring her learning performance she said, “I think I do always. I always ask about what…you know, my own potential… But this time I just went along with it…plus, I enjoyed it, like enjoying it as you go, instead of dragging your feet.” Later on she explained that “dragging your feet” referred to spending too much time reflecting.

However, the students from LEAPS were more elaborate in their responses. For these students “control over their own learning” activated schema about (a) effort in doing

Table 4 Students' behaviors, expectations, and confidence during problem-solving processes

Problem representation	Process stage	Behaviors, expectations, and confidence	Directed environment	LEAPS environment
Developing solutions	Definition and decomposition	• Level of confidence with new information	• Low	• Low
		• Expectations of help	• High	• Low
		• Students use new knowledge to define problem	• Specifically directed to do so	• Not specifically directed to do so
	Solution planning	• Uncertainty of the problem state	• Low	• High
		• Frequency of questions for clarifications	• Low	• High
		• Confidence in their ability to plan appropriate solutions	• High	• Low
		• Expectations of help	• High	• Low
	Solution implementation	• Uncertainty of the problem state	• High	• Low
		• Frequency of generating questions	• High	• Low
		• Purpose of questions	• Questions were for clarification after each step	• Questions were for consultation when large chunk complete
		• Confidence in their ability to plan appropriate solutions	• Low	• High
		• Expectations of help from the instructor	• High	• Low
				• Group members with similar prior knowledge collaborated
				• Group members with diverse prior knowledge cooperated
	Solution evaluation	• Nature of the task • Expectation of the help from the instructor • Reliance	• Well-structured nature of the task plus High expectations of help promotes reliance on Instructor to confirm solution	• Ill-structured nature of the task plus Low expectations of help promotes reliance on Self and Teammates to confirm solution

assignments, (b) paying attention, (c) space to manage work, (d) understanding previous steps before moving on, (e) self-efficacy (i.e. describing a “sense” of their performance), (f) comparing their performance with others, (g) knowing personal limitations, (h) using strategies to manage limitations, (i) self-motivation, (j) desire to learn beyond instruction, and (k) self-direction (i.e. thinking about what was important to learn). The LEAPS environment appeared to encourage thoughtful reflective thinking. Students in the LEAPS environment appeared to have a elaborated schema for reflecting on their learning processes. These students also seemed cognitively aware of their learning processes. Tamara from Group L1 said,

> I thought a good bit is up to you, it’s how much effort you want to put into your assignments and how well you want to pay attention when he is talking, and referring to the handouts. We had a lot of freedom as far as what we were working on in terms of what order and how long it took us to get it finished. Some people, I assume, would want to rush and do it but I was taking my time making sure I understood every step before I went on.

Tamara said that she never questioned herself about whether she was learning because “it was very obvious that I was learning every time.” When asked about self-monitoring, she replied, “as it progresses we could see very obviously whether it was correct or not. We had a very good sense of our performance and a lot of it was group work so we could see how other groups were doing as well.” Antoinette from Group L2 did not think that the class was very different from her other education courses in terms of how much control students have over their own learning. She said, “I would say though that there is a considerable amount of space to manage your work.” She claimed that it became evident that there was a lot to learn and that she would not be able to process it. Her strategy was to take as many notes as possible. “I was getting learning overload…there was so much I was trying to remember,’ cause I did not want to lose certain points, so I took a lot of notes and things like that to try to remember.” Cheryl from Group L3 said that compared with most classes she found it surprisingly easy to motivate herself to do work in this class because “This class gave me space to decide what I thought was important beyond just what was being taught. I could add a lot more and did not feel like it was all about the syllabus.”

Question 3 How can the LEAPS environment influence pre-service teachers motivation and affect during problem-solving activities?

In this study, personal investment and affect represent learners’ motivational disposition. Maehr (1984) posited that human motivation must be understood in terms of human behavior. In this view, motivational inferences are generated from certain characteristic behaviors: (a) direction, (b) persistence, and (c) continuing motivation (Maehr 1984). The researchers used these characteristic behaviors as indicators of motivation.

Direction and persistence

Direction refers to the choice an individual makes in the presence of other possible choices. In this study, we analyzed how students used (a) the first 10 min of class designated as free time, (b) the 10-min break in the middle of each class period, and (c) serendipitous free time in class including practice and problem-solving time.

First 10 minutes of class

Each class period, the students were given the first 10 min to work on whatever they wanted. For example, they could start up their computers, check email, or prepare for class. In the first 2 weeks, all the students under investigation checked their emails, played games, or surfed the Web. There were differences in how students used their time starting in the third week and continuing throughout the rest of the semester as shown by the following examples. Over 6 weeks, Group T students rarely used the first 10 min for class-related activities. Exceptions were Esther, in Week Five, who worked on a practice exercise in Excel. Also, in Week Three, Andrea engaged with James in a conversation about information from a class handout “Computer Hardware and Software.” They compared the hardware configurations of their respective personal computers. In Week Four, Andrea reviewed the previous weeks’ handouts. The rest of the time, they used the first 10 min for recreation.

By Week Three, LEAPS students were organized into groups. In the first 2 weeks prior to forming groups, these students participated in activities that were not related to class goals. For example, in Week Two, Evelyn and Tamara (Group L1) simply sat and waited for the instructor to begin class. Their other member, Constance, checked her email and surfed the Web. Similarly, Group L2 and L3 students surfed the Web, checked email or played “solitaire.” Only Cyril (Group L3) prepared for class by reviewing handouts in both weeks two and three.

This situation changed for LEAPS students once groups were formed. From Week Four onward, the group members who were present at the start of class immediately began to work, forfeiting their 10 min of personal time. These students reported on their progress to each other, for example, in Week Three and Four, Group L3 started by updating each other on their individual progress with delegated work. In fact, it became customary for the instructor to say “please find a saving point so we can start today’s class.” This became necessary since the students were already engaged in their teams’ work. This pattern was similar for all LEAPS groups.

In summary, when the students were allotted 10 min of free time before each class all the students participated in activities unrelated to class work in the first 3 weeks. After Week Three, LEAPS students chose to use this time for class related work, whereas, Group T continued to use this time for personal activities unrelated to class. These results suggest that the formation of groups in the LEAPS environment had a positive impact on students’ direction toward learning.

Ten-minute break

Students varied in how they used the 10-min break in the middle of each class period. There was no break in Week One. Over the whole semester, Group T students left the class for each break time except Week Four, when Esther stayed at her computer to continue working on her project. An opposite situation was observed for LEAPS. Group L3 stayed in and worked during every class period. Only Tamara from Group L1 left during break in Week Three and Week Five. In addition, Giselle, from Group L2 left during the break in Week Four and Katherine from Group L2 left during the break time in Week Three. During those times the remaining members of these groups stayed in class and continued to work on projects. In summary, Group T students used the 10-min break to participate in personal activities, whereas LEAPS used the 10-min break to pursue class related goals. It seemed that the LEAPS environment had a positive impact on students' direction and persistence to learn technology. However, more information is needed to interpret this pattern.

Serendipitous "free" time

In the classrooms under investigation, the instructor attended to the serendipitous needs of students. Unanticipated breaks during lectures occurred when the instructor slowed down or interrupted instruction to attend to technical or other instructional needs of individual students. Also, there were sessions where students were allowed to practice and others where the majority of the time was allocated for working on projects. As expected, students who did not wish to participate in class related activities naturally chose to do other things. The researchers observed and analyzed how students used their "free" time. In general, most of the students used free time to practice, work on projects and participate in class related work. During concept demonstrations, most students tried to pay attention as closely as possible. During individual practice times, most students worked on the practice exercises, which were additional exercises provided by the instructor that were aligned with the application-specific topics discussed. However, sometimes the students participated in activities that were not related to class.

In Week Four, the students were allotted the second half of the class to work on a graphics development component of the major project. Students who were able to complete this section had the option of working on other components of the project. Esther from Group T unsurprisingly had finished because she was very competent with using MS Word to build graphics. Having completed that portion, she spent the rest of the time browsing a popular shopping website. In the same week, Andrea from her group spent approximately 15 min on the task and then stopped. Although she had not completed the task she proceeded to work on a document that did not seem to be related to the intended task, nor the goals of the class.

In the same week, LEAPS students spent time as groups working on their projects. These groups appeared to remain on task and did not deviate from the class goals. At the first glance it appeared that all the students in LEAPS were equally motivated to use their free time to support their learning. However, upon further investigation, it became clear that the group dynamics had a major influence on our observations that all the students were motivated. For example, in Week Four, Marcellus from Group L2 attempted to spend time doing non-related activities, but he was reprimanded by the rest of his team. Antoinette said to him, "Come on now Marcellus, you can do that [other activity] some other time, right now we have to finish this thing [project]." The rest of the team agreed and so Marcellus rejoined his group.

A similar incidence occurred in Week Five when Aretha was encouraged by her group to stay on task. It was unclear to the researchers how she had deviated from her group's goals, however, the group felt that at that time that the group's needs were more important than what seemed to be her individual needs. Cheryl said to her, "We need to find something for you to do because you are just having too much fun over there." This situation can be explained in terms of the social distribution of problem-solving activities that occurs in working groups. Whereas in some groups students who have finished their portions are allowed to wander off, in this instance, the student who had finished her portion was pulled back into the group to help other group members. The work was being redistributed at this stage. In summary, it appeared that most of the time, all students across all the groups were motivated to use their free time to continue working on class related work. Students from all groups deviated from this pattern at least some of the time.

However, group members in LEAPS who deviated from group goals were counseled by their peers to return to their tasks.

Continuing motivation

Continuing motivation refers to the behavior of returning to a task or problem by one's own volition. The term refers not only to sticking to a task, as in persistence, but also refers to returning to a task on one's own after being interrupted. In the classrooms under investigation, the instructor provided the students with exercises to provide opportunities for practice in solving problems. The instructor would complete one of the exercises along with the class to model hypothesis-driven problem-solving. The instructor would then ask the class to use the remaining exercises to practice on their own and students were given time to practice. Even though these exercises had direct relevance for the major project in the class, students were aware that they were solely for practice purposes.

Once given time to practice, all the students proceeded to complete the exercises. The instructor was aware that the remaining class time was not sufficient to complete the exercises. However, the researcher was interested in finding out which of the students would persist in completing the exercises and more importantly, who would return to the exercises in the following week. There was some evidence to suggest that students differed in their continuing motivation. The observations can be explained by learners' prior knowledge and the novelty of the information. Students who had prior knowledge in the domain and for whom some of the instruction was not novel did not return to old tasks in the next class period. On the other hand, students who had little prior knowledge and for whom the instruction was novel immediately returned to the old, uncompleted tasks.

The results can also be explained in terms of students' use of strategies to solve problems. None of the students returned to the exercises in word processing in the subsequent weeks. This is because all of the groups had a working knowledge of word processing. The only challenge to them was to learn the differences on a Mac versus a PC. However, all the students returned to the graphic building components of MS Word, except Evelyn, who had reported already knowing how to draw with word. Most of the other students were not familiar with the built-in drawing capabilities of the MS Word program. Conversely, Cyril from Group L3 and Evelyn from Group L1, who had prior knowledge of MS Excel, completed their exercises in MS Excel in the assigned week and showed no interest in returning to them in the subsequent weeks. The results suggest that the LEAPS environment has a positive influence on students' continuing motivation to learn technology. In general, it appears that the LEAPS environment had a positive influence on learners' performance levels in terms of direction, persistence, and continuing motivation.

Student affect

The researchers were interested in how students felt about their experiences in the different learning environments. During interviews the students were asked to report on their confidence, motivation, and engagement. Unsurprisingly (accounting for interviewer effect), all students reported having pleasant experiences in the classes and were enthusiastic in their responses. Students were asked, "Why did you take this class?" to enquire about the reasons students enrolled in the course in the first place. All students reported that it was a required prerequisite course. As a follow-up, students were asked, "how do you feel about that [being required to enroll in this course]? Have your feelings changed? If so, in what ways? How?" Overwhelmingly, students from both environments reported have pleasant and positive experiences and reported enjoying the class. However, students in the LEAPS environment reported some displeasure about working in groups citing the occasional absence of group members as the main cause. When group members were absent, the remaining members were stuck with completing tasks on their own.

Discussion

The focus of the study was to design and investigate a new learning infrastructure for pre-service teacher preparation in technology use. Our hope was that the attributes of situated learning and group collaboration afforded by the LEAPS environment would help to stir students' intrinsic motivation, promote autonomy, responsibility, and self-regulation, and nurture creativity and strategic problem-solving ability. Figure 1 illustrates our intended model from a theoretical perspective.

In LEAPS, learning takes place as learner characteristics merge with characteristics of the environment and the region of interaction defines the intellectual space within which learning occurs. The learner characteristics involve prior socio-cultural experiences, prior knowledge and entry-level skills, self-perceptions, personal goals, attitudes, and other motivational dispositions. Of course, educators cannot influence what attributes students bring with them upon first entering the learning environment. It is the educators' job to immediately begin motivating students. Importantly, the previous models of open leaning environments, such as OLE or CLE (Land and Hannafin 1996; Hannafin et al. 1999; Jonassen 1999), have not fully addressed learner characteristics and their interactions with

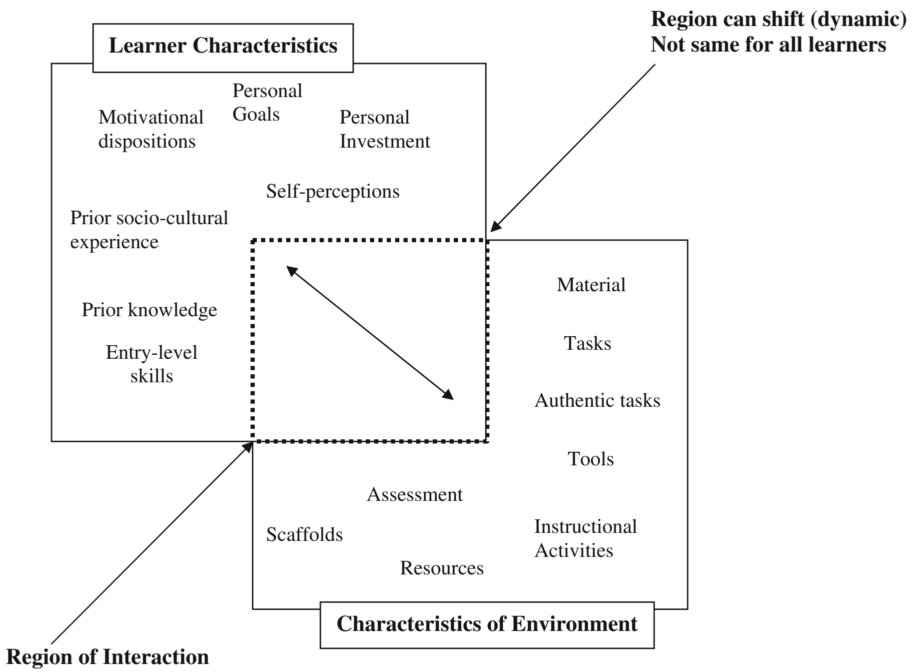

Fig. 1 A LEAPS model illustrating the interactions of learner characteristics and characteristics of a learning environment

the learning environment, and they have not explicitly incorporated learner characteristics as part of the core structure, but have largely focused instead on the environmental characteristics.

The characteristics of the learning environment include the enabling contexts (i.e., authentic tasks), tools, and scaffolds from both instructor and students. These elements are consistent with those proposed by Hannafin et al. (1999). It also includes the embedded instructional activities, content and materials, authentic activities, and assessments, as well as a teacher's expectations. The learning context thus becomes a carefully constructed open learning environment that is complex, problem-centered, and socially interactive and approximates professional situations students will encounter in the future.

Ideally, learner characteristics should be totally aligned or congruent with the elements of the open learning environment. When this happens, the LEAPS would yield the most optimal effect. However, in reality we often find incompatibility, disconnections, or misalignment between learner characteristics and a learning environment. Therefore, the research focus of the current study was to examine critically what transpires in the Region of Interaction (R–I) and to grasp the underlying interconnections involved.

Importantly, while our findings are generally consistent with the research experiences of other OLE researchers and designers (Land and Hannafin 1996, 1997; Hannafin and Land 1997; Hannafin et al. 1994, 1999; Barab and Duffy 2000; Ge and Land 2003; Sutherland et al. 2005), we are most intrigued by the parallels and tensions we have observed in the work of Barab et al. (2002) and other researchers (Ge and Hardré 2010; Ge et al. 2010; Huang, Lubin, & Ge, 2011). Barab et al. (2002) designed a case study on their Community of Teachers (CoT) program, in which in-service teachers mentored preservice teachers' engagement in authentic activities inside a professional community. The researchers discovered core sociocultural tensions that were manifested by conflicting perceptions and behaviors exhibited within the community. One of the core tensions arose when program facilitators were perceived as playing the roles of supporters/facilitators when, in fact, the situations seemingly called for a more directive approach. A second tension involved community members' perceived inability to reconcile and negotiate the theoretical and practical aspects of instruction in tandem. Tensions also ensued when new community members attempted to redefine the rules of the community, and also, when preservice teachers felt like their attempts at reflection and reflexivity would be later used against them as new standards of accountability.

Similar to Barab et al. (2002), Ge and Hardré (2010) found tensions between learners' self-processes and the affordances of the open learning environment in the context of instructional design. Ge et al. (2010) observed similar findings in the instructional context of computer science, but more importantly, the researchers revealed key interplays between project authenticity (an important element of an open learning environment) and learner characteristics. These interplays influenced learners' identity representations and perceptions, which in turn affected their goal orientation, motivation, attitudes, and commitment towards participating in the community activities of the open learning environments. Furthermore, other contributions on LEAPS (e.g. Huang et al. 2011) have also demonstrated the importance of aligning students' perceptions with the instructors/researchers' expectations in the open learning environment created for the pre-service teachers and the tension between the autonomy provided to students and the students' reluctance to fully use this autonomy.

Correspondingly, the current study confirms others' findings that OLE's could provide unique challenges to designers, researchers, and community participants that are both cognitive and sociocultural in nature. Most importantly, however, the current study interprets or explains the complexity and tensions of OLE's from a conceptual framework grounded in motivational theory. Below we first summarize our findings then discuss implications for the research. The summary of findings presented below demonstrated the interactions between learner characteristics and the LEAPS environment, and what they implied for instructional design and teaching technology.

Problem solving and prior knowledge

The LEAPS approach is beneficial in producing self-directed problem-solvers for instructional technology. Structured group work reduced the instructor's workload by prompting students to seek help and resources from peers and to rely more heavily on their self-regulated ability. However, this approach may be limited by the prior knowledge of the individual members of the groups. It was observed that when students in the LEAPS environment attempted to define problems during the problem-solving process, they relied on information from two sources: (a) initial prior knowledge and (b) information acquired from classroom instruction.

In the absence of existing prior knowledge, students either benefited from the prior knowledge of peers or acquired information from classroom instruction. Students' use of new information during problem-solving was contingent on their confidence about applying new information, but also, on their perceptions of the teacher's expectations. The LEAPS approach did not benefit students with little or no prior knowledge who had not been explicitly directed to use new information gained from classroom instruction. It appeared that when teacher expectations were not explicitly formulated, students in LEAPS avoided applying new knowledge in defining problems unless they had prior knowledge and felt comfortable. Therefore, it is important for teachers to assign students with diverse prior knowledge into the same group and to actively encourage them to apply new knowledge in solving technology problems.

Managing reflection, motivation, and affect

The results suggest that the LEAPS environment was useful in promoting students' reflection of their problem-solving process. The students in the LEAPS environment appeared to be cognitively aware of their learning processes. They demonstrated having elaborated schema for reflection and specific strategies for monitoring their learning processes. The LEAPS environment also appeared to promote student motivation. In general, students in the LEAPS environment exhibited relevant behaviors related to Maehr's (1984) indicators of motivation. Further, the results suggested that the peer interactions among group members in the LEAPS environment were beneficial in keeping students on task. Whenever an individual group member deviated from course goals, the other group member would redirect his or her efforts by redistributing the workload.

The utility of LEAPS to promote continuing motivation depended on students' prior knowledge and the novelty of the material. Students who had prior knowledge and for whom the work was not novel demonstrated low continuing motivation by not returning to previous tasks. This may be because the material was not sufficiently challenging to those students. The results suggest that a student's zone of proximal development must be considered in the design of ill-structured problems. Finally, it was noticed that not all students felt comfortable with the autonomy provided in the LEAPS environment. This suggests that more scaffolding is necessary to help students transit from a directed culture to a new culture of open learning environments.

Implications for curriculum design and classroom teaching

The immediate and logical conclusion for teaching practice, based on these findings, is to determine the implications of this research for advancing teaching and learning in the content domain of educational technology. To begin with, this type of work may require the adaptation of dual roles as teacher and researcher with the fundamental goal of designing learning environments to teach in, based on sound instructional theory, while systematically conducting research on both the learning environment and the teaching practice itself.

The most essential elements of learning in the LEAPS environment are the interactions. As we have discussed, since educators have no control over the characteristics with which learners enter the learning environment, what is important is how well the environment can be designed to provide maximal opportunities for learners to personally invest. Additionally, we see based on the findings, that it is not enough to simply provide the learning environment, but rather, care must be taken in successfully identifying learners' perceptions of their learning environment and in managing learners' perceptions. The implications for instruction based on this study surround the development of a system for managing learning interactions in these problem-centered learning environments. The management system is designed on the basis of three premises. First, expectations in the classroom are derived from perceptions of the learning environment and vice versa. Secondly, teachers and students may have different expectations about the nature of social interactions and goals of the class. Finally, teachers may choose appropriate resources to manage students' perceptions about the open learning environment.

Roles and identities

In the learning environment, a teacher plays an instrumental role in managing students' perceptions and stimulating their motivation. Teachers attempt to align or re-align students' perceptions and goals by helping students see the relevance, value, and benefits of engaging in authentic tasks. At the same time, teachers must direct students to intentionally practice new skills, while they enjoy the autonomy afforded by the open learning environment, and guide them to fully take advantage of the abundant resources, including peers, instead of relying on one single source—the teacher.

Aside from the role of the teacher, equally important elements are the students' investment, thoughts, actions, and participation, which are all contingent upon their perceived value and relevance. In this case, the authenticity of problem-solving tasks may serve as a strong motivator to help students see value and relevance and to help them determine if they want to set goals and make investment to those learning tasks.

As students formulate perceptions of the roles and responsibilities of members of the learning environment, it is important to remind students of the need to treat the context as a professional situation. Veritably, it is at this point that students adopt frames (Perakyla 1989) with which to define themselves in their environment. The frame of "professional teacher" is self-referenced, and students begin to conceptualize and crystallize this identity. Students also are able to switch frames at various points of interaction. For example, the student can adopt the frame of peer when interacting with classmates, professional colleague when interacting with the teacher, or the student may adopt the leader frame when working with other students in a group.

Social distribution of problem-solving

Students' identities are also forged and sustained by perceptions of the learning environment. Teachers can modify perceptions and send message about how they perceive students. Students will internalize teachers' expectations and perceptions based on the nature of the task and the nature of the help they receive. For instance, if the task is perceived as too easy and the teacher answers all the questions immediately, students can perceive that they are not worthwhile or not worth the teacher's effort to challenge them. Accessing students' prior knowledge will allow the teacher to plan appropriately challenging work and even help form groups. The diversity of prior knowledge within groups may help define whether students collaborate or cooperate. Students may distribute or divide the workload based on the nature of the task, the information available, and the amount of time required to complete the task. Students also have been found to redistribute the workload when it was deemed necessary at different phases of the problem-solving process. Finally, teachers assist in the delegation of tasks. Students respond differently to the amount of teacher involvement in the distribution of labor. Initially, it is the teacher who assigns tasks. Once this is done, teachers may monitor the learning process and how students are progressing to provide guidance and help to ensure fairness.

Management resources

The cognitive, motivational, and classroom management tools a teacher possesses must all come into play to address students' feelings of uncertainty and their perceptions of teacher help. The nature of the domain and tasks, the modality of instruction, the nature of the information available to students, and nature of scaffolding and facilitation all help students form perceptions of what is expected of them. The teacher must be equipped with tools, but also, must be appreciative of and adaptable to the dynamic nature of open learning environments. This calls for preparation, organization, and vigilance. Teachers may benefit from putting contingencies in place to facilitate the serendipitous needs of the participants of the learning environment. Our research provides a starting place for empirically based knowledge about how these perceptions and interactions manifest in a LEAPS classroom.

Limitations of the study

A limitation of the study relates to the issue of data selection. Because of the nature of the study, a large database was compiled from multiple data sources. We needed to decide what evidence from which data source was worthy of reporting. In the interest of being practical and by having to select only the most salient and most interesting cases and aspects of the classrooms interactions, we have not reported all the learning situations. Another limitation of the study is that we intended to explicitly capture learners' justifications (Jonassen 2000, 2003) in the problem-solving process. However, we did not provide an avenue through which students explicitly could make their justifications. While some of the evidence of students' justifications came overtly from interviews, we have tried to provide more evidence of student justifications through implicit sources, for example, from inferences drawn from student behaviors. Evidence appeared implicitly in observations about their direction, persistence, and self-reflection during problem-solving as well as in their representations and solutions of problems. Notwithstanding, we plan to examine students' justifications more expressly, in the future.

We also were concerned about the impact of the design framework on the nature of the classrooms. As students were always aware of the presence of a field researcher as well as video recording equipment, those elements may have impacted the nature of the learning environment. In considering learner-environment interactions, one cannot ignore the role of such physical presence on students' perceptions. Further, students may have formulated various types of perceptions including: (a) how the instructor reacted to their participation or non-participation in the research; (b) how they were expected to behave in the presence of field researchers, and how to "act" for the camera; and, (c) whether they thought that the research was benefiting them or whether it was just to help their instructor with his or her research. In any case, it is prudent to consider the students' perceptions of the research design in any holistic evaluation of the findings.

Implications for future research

The current study used a microgenetic approach (Brown 1992) where students are observed for only a short period of 8 weeks. In the future, we intend to monitor students' progress over time in the hopes of capturing evidence of their knowledge transfer to other courses and other future contexts. The LEAPS approach appears to be beneficial to student development, however, the effectiveness of this learning intervention is conditional and is limited if certain recommendations are ignored. More design-based classroom research will determine whether or not the results of this study will apply to other classes and contexts. Other researchers have examined learners' self-processes to explore relationships between learner characteristics and various learning environments (Ge and Hardré 2010; Ge et al. 2010; Huang et al. 2011). Correspondingly, we are interested in further exploring the interactions between the students' self-processes, such as self-awareness, self-perceptions, self-confidence, motivation, and prior knowledge, and the characteristics of LEAPS environments.

An important contribution of the current research is that it brings into sharper focus some pedagogical and logistical challenges attendant to open learning environments. For example, educators and students often mistakenly interpret the apparent "freedom" and autonomy of open environments as opportunities for less structure, accompanied with diminished standards of accountability. Participants who hold these views quickly become ensnared and then overwhelmed by the seduction of these false perceptions that inevitably lead to failure. This provides opportunities for detractors to devalue such approaches on the grounds that they do not adequately prepare students for academic success.

In reality, as we have discovered, there is some veracity to the claims that students' abilities to learn can be compromised in open learning environments, but this is most often only true when students are not given the proper scaffolding. We reiterate here that teachers must help students with the transition from directed to open learning environments. As an example, in directed learning environments, students are provided with rubrics to help them identify components of learning tasks and activities. In contrast, in cooperative, open learning environments, educators point to the value inherent in students reflecting on task goals and processes on their own. An important question that is raised is whether it is possible to also create rubrics in OLE's that maintain the innate power of reflection and self-regulation. These "partially open" rubrics could serve as process (versus content) roadmaps that provide explanations of what students should encounter affectively as they transition from more directed learning into the culture of autonomous learning presented in LEAPS. For now, these questions remain areas of consideration for future research.

References

Angeli, C. (2005). Transforming a teacher education method course through technology: Effects on preservice teachers' technology competency. *Computers & Education, 45*(4), 383–398.

Applegate, J., & Shaklee, B. (1992). Stimulating reflection while learning to teach: The ATTEP at Kent State University. In L. Valli (Ed.), *Reflective teacher education: Cases and critiques* (pp. 65–81). Albany: State University of New York.

Atkinson, P. (1990). *The ethnographic imagination*. London: Routledge.

Atkinson, P. (1992). *Understanding ethnographic texts*. Newbury Park, CA: Sage.

Barab, S. A., Barnett, M., & Squire, K. (2002). Developing an empirical account of a community of practice: Characterizing the essential tensions. *The Journal of the Learning Sciences, 11*(4), 489–542.

Barab, S., & Duffy, T. (2000). From practice fields to communities of practice. In D. Jonassen & S. M. Land (Eds.), *Theoretical foundations of learning environments* (pp. 25–56). Mahwah, NJ: Lawrence Erlbaum.

Bielefeldt, T. (2001). Technology in teacher education. *Journal of Computing in Teacher Education, 17*(4), 4–15.

Bransford, J. D., & Stein, B. S. (1993). *The ideal problem solver: A guide for improving thinking, learning, and creativity* (2nd ed.). New York: W.H. Freeman and Company.

Brown, A. L. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *The Journal of the Learning Sciences, 2*(2), 141–178.

Brown, J. S., Collings, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*, 32–43.

Brush, T., Igoe, A., Brinkerhoff, J., Glazewski, K., Ku, H., & Smith, T. C. (2001). Lessons from the field: Integrating technology into preservice teacher education. *Journal of Computing in Teacher Education, 17*(4), 16–20.

Chi, M., Bassok, M., Lewis, M., Reimann, P., & Glaser, R. (1989). Self-explanations: How students study and use examples in learning to solve problems. *Cognitive Science, 13*, 145–182.

Clancey, W. J. (1993). A situated cognition perspective on learning on demand. In *Proceedings of fifteenth annual conference of the cognitive science society* (pp. 181–183). Boulder: Lawrence Erlbaum Associates.

Collier, S., Weinburgh, M. H., & Rivera, M. (2004). Infusing technology skills into a teacher education program: Change in students' knowledge about and use of technology. *Journal of Technology and Teacher Education, 12*(3), 447–468.

Curtin, P., Cochrane, L., Avila, L., Adams, L., Kasper, S., & Wubbena, C. (1994). A quiet revolution in teacher training. *Educational Leadership, 51*(7), 77–80.

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

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.

Farr, M. J. (1987). *The long-term retention of knowledge and skills*. New York: Springer.

Feltovich, P. J., Coulson, R. L., Spiro, R. J., & Dawson-Saunders, B. K. (1992). Knowledge application and transfer for complex tasks in ill-structured domains: Implications for instruction and testing in biomedicine. In D. Evans & V. Patel (Eds.), *Advanced models of cognition for medical training and practice* (pp. 213–244). Berlin: Springer.

Flavell, J. H. (1985). *Cognitive development* (2nd ed.). Englewood Cliffs, NJ: Prentice-Hall.

Garner, R., & Alexander, P. A. (1989). Metacognition: Answered and unanswered questions. *Educational Psychologist, 24*, 143–148.

Ge, X., & Hardré, P. L. (2010). Self-processes and learning environment influencing expertise development in instructional design. *Learning Environments Research, 13*(1), 23–41.

Ge, X., Huang, K., & Dong, Y. (2010). An investigation of an open-source software development environment in a software engineering course. *The Interdisciplinary Journal of Problem-based Learning, 4*(2), 94–120.

Ge, X., & Land, S. M. (2003). Scaffolding students' problem-solving processes in an ill-structured task using questions prompts and peer interactions. *Educational Technology Research and Development, 51*(1), 21–38.

Geertz, C. (1976). From the native's point of view: On the nature of anthropological understanding. In K. Basso & H. A. Selby (Eds.), *Meaning in anthropology* (pp. 221–237). Albuquerque, NM: University of New Mexico Press.

Geertz, C. (1983). Thick description: Toward an interpretive theory of culture. In R. M. Emerson (Ed.), *Contemporary field research: A collection of readings* (pp. 37–59). Prospect Heights, IL: Waveland Press.

Greeno, J. G. (1998). The situativity of knowing, learning, and research. *American Psychologist, 53*, 5–17.

Gülbahar, Y. (2008). Improving the technology integration skills of prospective teachers through practice: A case study. *The Turkish Online Journal of Educational Technology, 7*(4), 71–81.

Hannafin, M. J., Hall, C., Land, S., & Hill, J. (1994). Learning in open environments: Assumptions, methods, and implications. *Educational Technology, 34*(8), 48–55.

Hannafin, M. J., & Land, S. (1997). The foundations and assumptions of technology-enhanced, student-centered learning environments. *Instructional Science, 25*, 167–202.

Hannafin, M., Land, S., & Oliver, K. (1999). Open learning environments: Foundations, methods, and models. In C. M. Reigeluth (Ed.), *Instructional design theories and models: A new paradigm of instructional theory* (pp. 115–140). Mahwah, NJ: Lawrence Erlbaum.

Hernandez-Ramos, P., & Giancarlo, C. A. (2004). Situating teacher education: From the university classroom to the real classroom. *Journal of Computing in Teacher Education, 20*(3), 121–128.

Hew, K. F., & Brush, T. (2007). Integrating technology into K-12 teaching and learning: Current knowledge gaps and recommendations for future research. *Educational Technology Research and Development, 55*(3), 223–252.

Huang, K., Lubin, I. A., & Ge, X. (2011). Situated learning in an educational technology course for pre-service teachers. *Teaching and Teacher Education, 27*(8), 1200–1212.

Iding, M., Crosby, M. E., & Speitel, T. (2002). Teachers and technology: Beliefs and practices. *Journal of Instructional Media, 29*(2), 153–170.

Jonassen, D. H. (1996). *Computers in the classroom: Mindtools for critical thinking*. Englewood Cliffs, NJ: Prentice-Hall.

Jonassen, D. H. (1997). Instructional design models for well-structured and ill-structured problem-solving learning outcomes. *Educational Technology Research and Development, 45*(1), 65–94.

Jonassen, D. H. (1999). Designing constructivist learning environments. In C. M. Reigeluth (Ed.), *Instructional-design theories and models: A new paradigm of instructional theory* (Vol. 2, pp. 215–240). Mahwah, NJ: Lawrence Erlbaum.

Jonassen, D. H. (2000). Toward a design theory of problem solving. *Educational Technology Research and Development, 48*(4), 63–85.

Jonassen, D. H., Howland, J., Moore, J., & Marra, R. M. (2003). *Learning to solve problems with technology: A constructivist perspective* (2nd ed.). Columbus, OH: Merrill/Prentice-Hall.

Kiewra, K. A., & DuBois, N. F. (1998). *Learning to learn: Making the transition from student to lifelong learner*. Needham Heights, MA: Allyn and Bacon.

Knowles, M. S. (1975). *Self-directed learning*. New York: Association Press.

Koschmann, T., Kelson, A., Feltovitch, P., & Barrows, H. (1996). Computer-supported problem-based learning: A principled approach to the use of computers in collaborative learning. In T. Koschmann (Ed.), *CSCL: Theory and practice of an emerging paradigm* (pp. 83–124). Mahwah, NJ: Lawrence Erlbaum.

Land, S. M., & Hannafin, M. J. (1996). A conceptual framework for the development of theories-in-action with open-ended learning environments. *Educational Technology Research and Development, 44*(3), 37–53.

Land, S. M., & Hannafin, M. J. (1997). Patterns of understanding with open-ended learning environments: A qualitative study. *Educational Technology Research and Development, 45*(2), 47–73.

Land, S. M., & Zembal-Saul, C. (2003). Scaffolding reflection and articulation of scientific explanations in a data-rich, project-based learning environment: An investigation of progress portfolio. *Educational Technology Research and Development, 51*(4), 65–84.

Lave, J. (1993). Situating learning in communities of practice. In L. B. Resnick, J. M. Levine, & S. D. Teasley (Eds.), *Perspectives on socially shared cognition* (pp. 17–36). Washington, DC: American Psychological Association.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.

Lewis, L., Parsad, B., Carey, N., Bartfai, N., Farris, E., & Smerdon, B. (1999). *Teacher quality: A report on the preparation and qualifications of public school teachers*. Washington, DC: U.S. Government Printing Office.

Lubin, I. A. (2005). *A study comparing learning environments for teaching educational technology to pre-service teachers*. Unpublished master's thesis, University of Oklahoma, Norman, OK.

Maehr, M. L. (1984). Meaning and motivation: toward a theory of personal investment. In R. Ames & C. Ames (Eds.), *Research on motivation in education (Volume 1): Student motivation* (pp. 115–144). San Diego: Academic.

Mehlinger, H. D., & Powers, S. M. (2002). *Technology and teacher education: A guide for educators and policymakers*. Boston: Houghton Mifflin.

Merriam, S. B. (1988). *Case study research in education: A qualitative approach*. San Francisco, CA: Jossey-Bass Publishers.

Moursund, D., & Bielefeldt, T. (1999). *Will new teachers be prepared to teach in a digital age: A national survey on information technology in teacher education*. Oregon: Milken Family Foundation.

Palincsar, A. S., & Brown, A. L. (1984). Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cognition and Instruction, 1*(2), 117–175.

Partnership for 21st Century Skills. (2010). *21st century knowledge and skills in educator preparation*. American Association of Colleges of Teacher Education and the Partnership for 21st Century Skills (P21).

Perakyla, A. (1989). Appealing to the experience of the patient in the care of the dying. *Sociology of Health & Illness, 11*, 117–134.

Phelps, R., Hase, S., & Ellis, A. (2005). Competency, capability, complexity and computers: Exploring a new model for conceptualizing end-user computer education. *British Journal of Educational Technology, 36*(1), 67–84.

Pierson, M., & Cozart, A. (2004). Case studies of future teachers: Learning to teach with technology. *Journal of Computing in Teacher Education, 21*(2), 59–63.

Pope, M., Hare, D., & Howard, E. (2002). Technology integration: Closing the gap between what preservice teachers are taught to do and what they can do. *Journal of Technology and Teacher Education, 10*, 191–204.

Pope, M., Hare, D., & Howard, E. (2005). Enhancing technology use in student teaching: A case study. *Journal of Technology and Teacher Education, 13*, 573–618.

Rao, M., & Sylvester, S. (2000). Business and education in transition: Why new partnerships are essential to student success in the new economy. *AAHE Bulletin, 52*(8), 11–13.

Romanowski, M. H., & Oldenski, T. E. (1998). Challenging the status quo of teacher education programs. *Clearing House, 72*(2), 111–114.

Roschelle, J., & Clancey, W. J. (1992). Learning as social and neural. *Educational Psychologist, 27*, 435–453.

Royer, R. (2002). Supporting technology integration through action research. *The Clearing House, 75*(5), 233–237.

Rubio, R. A., & Sedersten, D. S. (2001). *How we integrated technology throughout our education program.* Paper presented at the SITE 2001, Norfolk, VA.

Senge, P. (1994). *The fifth discipline fieldbook: Strategies and tools for building a learning organization.* New York: Doubleday.

Smith, P. L., & Ragan, T. J. (1999). *Instructional design* (2nd ed.). Upper Saddle River, NJ: Prentice Hall.

So, H., & Kim, B. (2009). Learning about problem based learning: Student teachers integrating technology, pedagogy and content knowledge. *Australasian Journal of educational technology, 25*(1), 101–116.

Strauss, A. L., & Corbin, J. (1998). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (2nd ed.). Thousand Oaks, CA: Sage.

Sutherland, L., Scanlon, L., & Sperring, A. (2005). New directions in preparing professionals: Examining issues in engaging students in communities of practice through a school-university partnership. *Teaching and Teacher Education, 25*(1), 79–88.

Thompson, A., Schmidt, D., & Hadjiyianni, E. (1995). A three year program to infuse technology throughout a teacher education program. *Journal of Technology and Teacher Education, 3*, 13–24.

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. (M. Cole. B. John-Steiner, S. Scribner, & E. Souberman, Eds and Trans.) Cambridge, MA: Harvard University Press.

Wang, Y. (2002). When technology meets beliefs: Preservice Teachers' perception of the teacher's role in the classroom with computers. *Journal of Research on Technology in Education, 35*(1), 150–161.

Wang, L., Ertmer, P. A., & Newby, T. J. (2004). Increasing preservice teachers' self-efficacy beliefs for technology integration. *Journal of Research on Technology in Education, 36*(3), 231–250.

Willis, E. M., & Montes, L. S. (2002). Does requiring a technology course in preservice teacher education affect student teacher's technology use in the classroom? *Journal of Computing in Teacher Education, 18*(3), 76–80.

Woolfolk, A. (2007). *Educational psychology* (10th ed.). Boston, MA: Allyn & Bacon.

Worthy, J., & Patterson, E. (2001). “I can’t wait to see Carlos!”: Preservice teachers, situated learning, and personal relationships with students. *Journal of Literary Research, 33*(2), 303–344.
Wright, V. H., & Wilson, E. K. (2006). From preservice to inservice teaching: A study of technology integration. *Journal of Computing in Teacher Education, 22*(2), 49–55.
Yin, R. K. (1984). *Case study research: Design and methods*. Beverly Hills, CA: Sage.
Yin, R. K. (1989). *Case study research*. Newbury Park, CA: Sage.
Yin, R. K. (2002). *Case study research: Design and methods* (3rd ed.). Thousand Oaks, CA: Sage.
Zachariades, I., & Roberts, S. K. (1996). A collaborative approach to helping teacher education faculty model technology integration into their courses: An informal case. *Journal of Technology and Teacher Education, 3*(4), 351–357.
Zimmerman, B. J. (1990). Self-regulated learning and academic achievement: An overview. *Educational Psychologist, 21*, 3–18.
Zimmerman, B. J. (1994). Dimensions of academic self-regulation: A conceptual framework for education. In D. H. Schunk & B. J. Zimmerman (Eds.), *Self-regulated learning and performance*. Hillsdale, NJ: Lawrence Erlbaum.
Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation*. San Diego, CA: Academic.

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