Comparing Instructional Methods for Teaching Technology in Education to Preservice Teachers Using Logistic Regression

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Abstract: This analysis was completed in the context of an ongoing design project for a junior level course (Technology in Education) in the teacher preparation program in a large New England public university. We implemented a design during Fall 2003 comparing two types of instruction: problem–based learner-centered learning cycles (PBLC) and didactic direct instruction (DI), both of which reflected our previous research findings concerning best instructional practices. Analysis using Logistic Regression identified a model that differentiated the PBLC and DI approaches in areas of preservice teachers' perceived knowledge of technology integration and technology competencies, and revealed that preservice teachers who reported more favorable computer use and more knowledge of e-portfolio development were more likely to be in the PBLC approach.

Introduction

Means & Coleman (2000) have demonstrated that not only can the wise use of educational technology improve student achievement but it can also improve students' self-concept and motivation. In contrast, according to a report by the National Center for Education Statistics (Smerdon et al., 2000), only approximately 33 percent of teachers reported feeling very well prepared to integrate educational technology into classroom instruction. In 2001, the U.S. Department of Education initiated the Preparing Tomorrow's Teachers to Use Technology (PT3) program with the goal of ensuring that new teachers enter the classroom prepared to effectively use the computers that await them. However, "technology integration is complex and teachers with little classroom experience typically have no context in which to apply what they may learn in university computer courses" (Sayvenye et al., 2003).

Technology in Education, a one-credit course, required for students who enter in their junior year into the teacher preparation program of a large New England public university, was the context for an ongoing design experiment. Constraints, such as being only one-credit, and presenting to students without classroom teaching experiences, provided us a challenging context in which to realize the course goals. The course aimed to develop students' awareness of a broad range of educational technologies and to have students consider potential technology integration into their future K-12 classrooms. Our goal in this study was to identify best research-based instructional practices related specifically to developing preservice teachers' understanding and willingness to integrate educational technology into their future teaching. Not only did we seek to find out how to effectively teach preservice teachers about educational technology by using instructional design theories, but we also hoped to contribute to the field our views regarding what preservice teachers should learn to enable them to educate children in the "new literacies" for the 21st century (Collins, 1996; Leu & Kinzer, 2000; Reigeluth, 1999; Leu et al. 2004).

Theoretical Framework

The comparative course approach (Problem-based Learning Cycles vs. Didactic Instruction) was based upon application of instructional-design theories. "An instructional-design theory is a theory that offers explicit guidance on how to better help people learn and develop. The kinds of learning and development may include cognitive, emotional, social, physical and spiritual" (Reigeluth, 1999, p. 5). Reigeluth (1999) further described the characteristics of instructional-design theory as "design oriented, they describe[describing] methods of instruction and the situations in which those methods should be used, the methods can be broken into simpler component methods, and the methods are probabilistic" (p. 7). The simpler component methods are referred to as component (mini) methods by Reigeluth. They are probabilistic, rather than deterministic, which means that providing abundant examples of concepts will not ensure that the goals for the students will be attained, but will increase the probability that they will be attained. Reigeluth stated that even though the component (mini) methods are "highly interrelated and usually highly situational in their effects on attaining the desired outcomes, an instructional-design theory is easier to apply if it describes methods on a relatively detailed level” (p. 11).

Problem-Based Learning Cycles

Learning cycles were adapted as an approach to problem-based learning in teacher technology integration because they were deemed to have a broad foundation in cognitive science (Schwartz et al., 1999). One of the purposes of using learning cycles was to contextualize preservice teachers' thinking about learning and instructional design (Schwartz et al., 1999) and to move them away from implementing technology for technology’s sake. Preservice teachers in their first year of education courses have only their own experiences as students to draw on and have not yet been in the role of teacher in the classroom. Learning cycles are typically organized around two or three successive challenges that present hypothetical realistic situations. The order of the components for the learning cycles is not prescriptive. It is flexibly adaptable to learners’ and teachers’ needs (Schwartz et al., 1999). As shown in Figure 1, Schwarz et al. (1999) proposed that learning cycles include seven components: look ahead and reflect back, the initial challenge (beginning of the first inquiry cycle), generate ideas (about issues and answers), multiple perspectives, research and revise (to help students to explore a challenge), test your mettle (formative assessment), go public (progressive deepening, general reflections and decisions), and assessment. These basic components of instruction have since been adapted to several different contexts (Bransford, Vye, Bateman, Brophy, & Roselli, 2004; Vanderbilt, 2003). The adaptation of this design for preservice teacher technology preparation is described below.

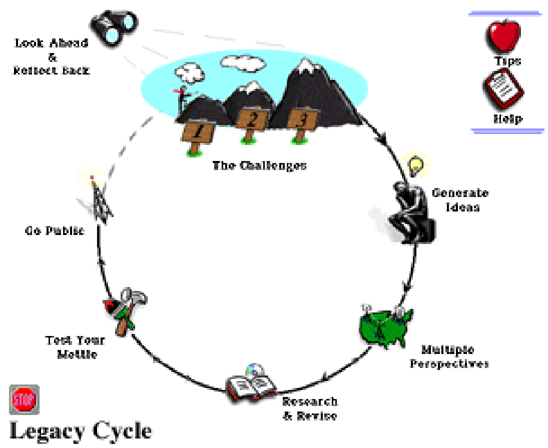

Figure 1. Main screen and learning cycles of Star Legacy

Didactic Instruction

Gagné’s instructional theory has three major components: taxonomy of learning outcomes; conditions of learning (Gagné, 1977); and nine events of instruction (Gagné, Briggs, & Wagner, 1992). A central notion in Gagné’s theory is that different kinds of learning outcomes (intellectual skills, cognitive strategies, verbal information, attitudes and motor skills) have different internal and external conditions that support them (Gagné et al., 1992). The external conditions are parameters that the teacher or instructional designer controls during instruction. The internal conditions are skills and capabilities that each learner brings to the instructional setting. Information-processing theory provided the basis for Gagné to propose an instruction model incorporating nine major events. Gagné et al. (1992) suggested that the Nine Events of Instruction are always relevant, even though they will vary with the type of learning outcome being achieved, and with the specific content of the learning. The nine external instructional events are gaining attention, telling learners the learning objective, stimulating recall of prior learning, presenting the stimulus, providing learning guidance, eliciting performance, providing feedback, assessing performance, enhancing retention and transfer to other contexts. This approach provided the basis for our direct instruction condition.

Research Design

Context

Technology in Education is a required course taken each Fall semester by approximately 130 juniors starting their first year of a 5-year integrated bachelors/master’s teacher preparation program. The course was taught in eleven sections of approximately 12 students per section, each taught by a graduate teaching assistant or professor. A faculty professor oversaw the organization, design, implementation, and teaching of the course. Each lab section met 1.25 hours per week for 12 weeks. For our 2003 implementation, there was one faculty instructor and four TAs on staff. The faculty instructor taught 3 sessions, and each TA taught 2 sessions. In Fall 2003, participants took the course implementing one of three instructional pedagogies, varying on the course section based on normal registration (no random assignment): PBLC, DI, or Hybrid 2002 Design (HD, as a comparison condition). Each instructor was assigned to and used only one of the pedagogies except for the faculty member. Instructor assignment was self selected (see Table 1). All instructors taught in treatment conditions that they never taught before, except for the faculty instructor who taught one of the HD conditions. The pre-exposure effect in PBLC and DI conditions was thus minimized. For the simplicity of comparison and providing parsimonious interpretation, in this paper, we focus on PBLC versus DI in relation to student technology competencies and integration. In our method, each instructional pedagogy was taught by two instructors, which allowed us to somewhat gain some evidence concerning instructor versus pedagogy (i.e., whether superior student performance is due solely to the selected pedagogy and materials of one approach or due to superior instructor ability, or an interaction of the two).

Table 1. Instructor Assignment

PBLC	DI	HD
Faculty instructor and TA1 each taught 2 sessions	TA2 and TA3 each taught 2 sessions	Faculty instructor taught 1 session, TA4 taught 2 sessions

Problem-Based Learning Cycles

The PBLC format organized the course into five cycles, implemented in WebCT campus edition (a course management tool) each starting with a challenge or problem (Delisle, 1997) (see http://www.education2.uconn.edu/EPSY240/learningsciences06/PBLC.htm): 1) assistive technology used for special and regular education students; 2) the Web as a data and communication tool, including a view of "new literacies" involved in online reading comprehension; 3) technologies such as Lego robotics, online games and simulations that support problem-based and project-based learning; 4) video and multimedia technologies including digital stills and movies, cable TV and live web broadcasts; and 5) online forums for teacher professional development through e-portfolios, threaded discussions, synchronous chats, and video. The PBLC design was adapted from Schwartz et al. (1999), to our local needs (see Figure 2). This PBLC design featured five major steps: 1) Present the cycle's challenge; 2) Brainstorm and develop initial solutions; 3) Consult experts and resources that consider the problem from multiple points of view; 4) Assess the solution against objective criteria and dyad partners; and lastly, 5) Publish it to WebCT as a peer effort. By repeatedly revisiting an issue at deeper levels and from differing perspectives, it was hoped students would gain deeper and more elaborated understanding.

Preservice teachers who were in PBLC treatment sections were assigned to dyads and started each learning cycle individually with Your Challenge, Completed Initial Thoughts individually and then worked through the cycle collaboratively starting with Perspectives and Resources. The challenges were case-based, anchored in realistic but fictitious contexts (CTGV, 1990, 1992). Having students experience many narratives and approaches was intended to lead to students toward creating richer case-based experiences and better case-based reasoning (Jonassen & Hernandez-Surrano, 2002; Kolodner & Guzdial, 2000). Such activity may foster generative learning (Wittrock, 1989), elicit prior knowledge (Gagné, 1977), avoid "inert" knowledge (Whitehead, 1929), and make learners' thinking explicit when putting their thoughts in the private discussion forum (Lin & Lehman, 1999). As part of the Perspectives and Resources stage of some cycles, dyads had to explore hands-on Treasure Hunt (TH) activities, again in dyads. Each TH activity consisted of instructions that gave context, directions for operating various technology and reflection questions. This design provided naive learners with multiple representations in the spirit of designing for cognitive flexibility (Spiro, Feltovich, Jacobson, & Coulson, 1991) and allowed peers to anchor their thinking and reflection in a realistic (if not real) context, which fostered knowledge in depth, and nurtured a respect for a diversity of opinion through peer collaboration. Dyads tested their understanding of the case through reflections and had opportunity to achieve mutual understandings through social construction of knowledge (Lave & Wenger, 1991). Students then posted their later thoughts in public on WebCT and social construction of knowledge expanded from dyads to the whole class as students commented on one another's solutions to the challenge. From this we expected students in the PBLC sections would likely have deeper understanding of educational technologies and thus be aware of technology skills and applications in depth, compared to those receiving direct instruction.

Didactic Instruction

Didactic or Direct Instruction is the most well-established way to meet educational goals, especially in situations where high stakes objective tests are the sole measure of student achievement *(Stebbins et al., 1977)*. For example, see http://www.jefflindsay.com/EducData.shtml. In contrast to the "learning cycles" approach, the sections that were taught using the objectivist didactic instruction followed the idea of "teaching by telling" (see http://www.education2.uconn.edu/EPSY240/learningsciences06/DI.htm). In this mode of instruction based on the work of Siegfried Engelmann, the teacher tells the students about a specific subject and delivers whole-class recitation questioning for recall. The students' task is primarily defined as remembering exactly what the teacher taught and to reproduce that information later, usually on an objective multiple choice test. In this type of lesson plan, the focus is on recall of information, not deep understanding or transfer. The five areas of technology integration concepts used in the PBLC sections were in this approach delivered in a lecture-like format (that could include the use of PowerPoint presentations, overheads, videos, and worksheets.). These lessons included expository learning, demonstration, and drill-and-practice. This is a very efficient form of instruction and fits within the limited amount of time available in the lab, which, as a one-credit class, meets for only 75 minutes one day per week for 10 weeks. Threaded discussions on WebCT campus edition were also used for facilitating lectures in the form of teacher–centered questions and answers, as opposed to the social collaborative student-centered use of discussion in the PBLC approach. The lessons were highly organized, planned and scripted and usually contained the following components:

- Link of lesson plan to subject curriculum course of study or state standard
- Materials needed
- Interesting opening of teacher and student activities
- Instructional teacher and student activities with clear focus and visual aids
- Closing teacher and student activities that provide summary
- Clear assessment tools to measure acquisition of facts and information

In designing these lessons, we attempted to adhere to Gagne's Nine Events of Instruction. The focus on the lesson was the delivery of information in a clear straightforward manner without the benefit of hands-on explorations, higher-order questioning, and with limited need for collaboration with peers. Because didactic instruction was teacher centered and student-teacher interactions were direct and short in order to fulfill the pre-defined objectives or recitation, we expected students would likely become aware of a broader range of educational technologies and thus be aware of technology skills and applications in breadth, rather than in depth compared to the PBLC sessions.

Data Source

A Likert-type scale (from 1 strongly disagree to 5 strongly agree) pre-post online survey measured student attitudes, self-reported technology competencies, comfort with technology, and preference for collaborative learning regarding projects involving educational technology (Zheng, Young & Sulzen & 2003). One-hundred-thirty-eight participants filled out the pre-survey and 122 participants filled out the post-survey. After matching pre and post data entries and filtering based on signed informed consent forms, 101 complete data sets were analyzed, a combination of 78 in both PBLC and DI conditions.

Results

An Independent Samples T-test conducted on the pre-data revealed no mean differences between the PBLC and DI groups. Independent-samples T-tests were conducted on selected variables (see Table 2) according to the aforementioned theoretical premises to detect statistical differences across the levels of the dependent variable, Instructional Group (PBLC vs. DI). Except for the Support Learning variable, Homogeneity of Variance of other variables was confirmed. Please refer to the online survey (Zheng, Young & Sulzen & 2003) for item stems.

Table 2. Result of Independent Samples T-Test (n=78)

	T	*df*	*P*
WebTech	.667	76	.507
EPortfolio	-4.319	76	.000

Paperless	-2.003	76	.049
Computer Use	-2.998	76	.004
Support Learning	-1.998	76	.049

The goals of the analysis were to predict the Instructional Group in order to determine a model that differentiated the PBLC and DI approaches in the posttest variables, in the areas of students' perceived knowledge of technology integration and technology competencies; and to rank the relative importance of the variables. Through an examination of the correlations among variables, multicollinearity was not severe. The tolerances for all variables (range from .604 to .883) were larger than .25 and the values for VIF were less than 4. The likelihood ratio test results showed that the five-variable-model fit best, $\chi 2$ = 28.87 *d f*= 5, at p = .000 level, G = 28.87 (D_0 = 106.628, D_{m1} = 83.815, D_{m2} = 77.762). When WebTech was added to the model, it reduced deviance to 77.762. Therefore $R^2_L = 1- D_{m2} / D_0$ =1- 77.762 /106.628= .27, indicating 27% of true proportion of reduction in deviance. The five-variable-model better differentiated the PBLC and DI approaches, in that it helped us detect in what degree and in what areas PBLC and DI approaches had stronger impact on students' perceived knowledge of technology integration and technology competencies. Hosmer & Lemeshow goodness of fit test (*C- hat* = 9.951, *df* = 8, *p* = .295) showed that there was a good consistency between observed and predicted probabilities.

Table 3. Variables in the Equation

	B	S.E. (B)	Wald's	Sig.	Exp(B)/OR	95.0% C.I. for EXP(B)	
						Lower	Upper
WebTech	-1.222	.532	5.279	.022	.295	.104	.836
EPortfoio	1.463	.439	11.088	.001	4.321	1.826	10.225
Paperless	-.121	.362	.112	.738	.886	.436	1.801
Computer Use	.689	.325	4.482	.034	1.991	1.052	3.767
Support Learning	.404	.464	.759	.384	1.498	.604	3.716
Constant	-3.727	2.322	2.577	.108	.024		

Results shown in Table 3 indicate that Computer Use (*Wald's* = 4.48, *p* = .034), EPortfolio (*Wald's* = 11.088, *p* =.001), and WebTech (*Wald's* = 5.279, *p* =.022), were the most salient variables in distinguishing between the PBLC approach and DI in the five-variable model. Computer Use, (1.99-1)* 100=99 %, can be interpreted as one unit of increase in computer assignment increases the odds of being in the PBLC group by 99%., EPortfolio, (4.321-1)*100 =332.1% can be interpreted as one unit of increase in EPortfolio increases the odds of being in the PBLC group by 332.1%. WebTech, (.295-1) *100 = -70.5 %, can be interpreted as one unit of increase of Web technology use decreases the odds of being in the PBLC group by 71%. The WebTech variable should be interpreted with caution since Independent samples T-test showed no statistical differences between PBLC and DI groups. Adjusting for base rate, classification error was reduced by 48% (τ_p =.48) using the five-variable model. 72.5 % of the DI and 75.7% of the PBLC were correctly predicted.

Discussion

By using the current dataset measuring preservice teachers' technology competencies, professional development, comfort with technology, and preference for collaboration regarding educational technology projects, a model to predict group preservice teachers' membership in either PBLC or a DI condition was identified through logistic regression. Students' comfort with giving their students an assignment requiring extensive *Computer Use* and students' ability to create an *EPortfolio* were the most salient variables predicting group membership. Positive slope (B) of these two variables indicated that those students who rated themselves high on these two variables tend to belong to the PBLC group. The Odds Ratio (OR) was about 2.0 for the Computer Use variable, indicating preservice teachers reporting more higher comfort giving assignments with computer use were about twice as likely to be in PBLC groups. The OR was 4.3 for the EPortfolio variable, indicating preservice teachers reporting higher EPortfolio creation skills were 4.3 times more likely to be in PBLC groups. The School of Education adopted the TaskStream™ online portfolio system for supporting EPortfolio development. EPortfolios were products developed as a result of Professional Development Learning Cycles. One way to explain why students in the PBLC condition reported much more favorable portfolio creation is that Learning Cycles might progressively promote students' understanding of their development of teaching and technological skills in a realistic setting. Students put more effort into developing their EPortfolios, and thus they rated their knowledge of EPortfolios much higher. This result informed the design team's subsequent decision-making for the following year. Given both the teacher training program's and the university's efforts to EPortfolio assessment, the finding of this study helped us in making design decisions on how best to teach EPortfolio development. Computer Use was an indicator of transfer, suggesting the PBLC group was more comfortable using what they learned in the course. In the PBLC approach, students extensively used online discussion tools and problem-based prompts for guided exploration and discussion of educational technology. Using online threaded discussions in the learning cycle format afforded future teachers direct experience with the educational value of communication technology and hence, their comfort with using computers for their own teaching may have increased. Teacher effects remain a possible limitation of the study. Even though efforts were made to maximize treatment fidelity, including informal training at TA meetings, uniform lesson plans within each treatment, and class observations, latent constructs such as teacher personality and student's interactions with teachers were not subject to experimental control. As with any design research, without replication, our evidence should be considered with caution.

Educational Importance of the Study

The importance of identifying research-based instruction in teaching educational technology to preservice teachers can be evidenced at both local and national levels. The preservice teachers in this five-year highly-competitive teacher education program are educated to be leaders with the ability to envision future needs of the work force. Research has shown that wise use of technology allows people to solve problems effectively and shorten the gaps of communication among cultures (Ge & Land, 2003; Schlager, Fusco, & Schank, 2002; Uribe, Klein, & Sullivan, 2003). Although research such as *Project Followthrough* has shown (Stebbins et al., 1977) that direct instruction is the most effective approach in three areas: skills (reading, language, spelling, and math), cognitive skills, and affective behavior, the development of 21st Century literacies and transfer from courses that occur before student teaching to eventual teaching behaviors may require more. As Reigeluth (1999) stated employers now want people who will take initiatives to solve problems and who will bring diversity, especially diverse perspectives, to the workplace. Our finding that PBLC experiences may be the best instructional practice to educate preservice teachers to embrace technology in their future teaching profession is critical to young learners in the 21st century. Furthermore, the design research technique and logistic regression may also prove useful to other teacher preparation programs that have similar circumstances and constraints in terms of how to teach educational technology.

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Acknowledgements

Thanks to Dr. Ann O'Connell for her statistics expertise and feedback. Thanks to Dr. Robert Hannafin for his support and valuable input.