A Model of Constructivist Learning in Practice: Computer Literacy Integrated into Elementary Mathematics and Science Teacher Education

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Abstract

Effective use of technology in the classroom has received much attention in education, and teacher training programs are expected to produce computer literate teachers. The purpose of this study was to compare two technology integration models. Pre- and postcourse questionnaires were administered to 73 preservice teachers completing an elementary methods course. The precourse questionnaire assessed preservice teachers' computer skills prior to entering the methods course. A follow-up questionnaire administered at the end of their first year of teaching assessed how frequently they were using technology as an instructional tool and for what purposes. The results of this study indicated that integration of technology with integrated methods courses increased the probability that teachers transferred the computer skills into their classroom as compared to preservice teachers who learned computer skills in an isolated manner. (Keywords: computer literacy, elementary classroom, preservice education, preservice teachers, transfer of computer skills.)

As we enter the 21st century, educators agree that all teachers will be faced with the challenge of knowing how to use computers. However, there are different definitions of computer literacy. The general consensus has been that computer literacy involves not only the knowledge, understanding, and value of technology that are required for a teacher to feel confident with classroom integration, but also a positive attitude in their ability to apply the theory-related concepts into their real classroom instruction. In other words, computer literacy is more than a "collection of skills" based on acquired knowledge about the use of technology (Levine & Donitsa-Schmidt, 1998). Across the nation, teacher education programs have addressed the challenge of producing computer literate teachers in various ways and at different rates. The National Council of Teachers of Mathematics (NCTM) *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989) provide guidelines for preparing preservice teachers to teach mathematics with the computer skills needed to compete in the 21st century workforce. These guidelines can be applied across the curriculum because focus on exploration, problem solving, reasoning, connections, and communication supports the underlying constructivist philosophy. These standards focus on teachers encouraging students to explore and discover information using technology such as word processors, spreadsheets, e-mail, and network browsers. Given the current emphasis on integrating computers into precollege classroom instruction, the question arises whether the use of computers as an instructional resource should be taught in a separate course or inte-

grated into the current courses in much the same manner as mathematics is integrated and taught based on the hands-on, exploratory methods supported by the constructivist philosophy.

It has only been in the past few years that a framework has been investigated to support a systemic integration of computer literacy into teacher education programs. These efforts have been led by the International Society for Technology in Education (ISTE), which has provided foundational standards for preservice teacher education. The ISTE framework has been outlined in four categories for classifying computer literacy standards: (1) basic technology operations and concepts, (2) application of technology in instruction, (3) professional and personal use of technology, and (4) the societal, ethical, and human impact of technology (Handler & Strudler, 1997). However, the question remains whether computer literacy should be taught as an isolated topic or integrated into preservice methods courses. Researchers have conducted studies to determine university students' degrees of computer literacy, and each includes different computer applications as the baseline criteria (Blubaugh, 1988; Fox, Thompson, & Chan, 1996; Furst-Bowe et al., 1996; Mitra, 1998; Russet, 1995; Sheffield, 1996; Thomas, Larson, Clift, & Levin, 1996). Furthermore, researchers have supported the integration of technology across teacher education courses as opposed to an isolated topic (Balli, Wright, & Foster, 1997; Blubaugh; Brownell & Brownell, 1991; McEneaney, 1992; Merkley & Schmidt, 1996; Schmidt, Merkley, Strong, & Thompson, 1994; Russett; Wetzel, 1993) and investigated how teachers' attitudes toward computers affects their willingness to use technology in their classroom instruction (Boone & Gabel, 1994; Hunt & Bohlin, 1993; Kellenberger, 1996; Kluever, Lam, Hoffman, Green, & Swearingen, 1994; Levine & Donitsa-Schmidt, 1998; McEneaney; Okinaka, 1992; Selwyn, 1997). At the onset of the technology-integration debate, Niess (1990) went a step further by developing a set of guidelines that could be applicable to all teachers for integrating computer-assisted instruction into the curriculum, regardless of grade level or subject matter:

1. Fit the computer to the curriculum rather than the curriculum to the computer.
2. Use the computer as a personal and professional tool.
3. Use the computer in the learning of subject matter.

These guidelines are important as teacher training and professional development programs are seeking successful ways to incorporate components for training teachers to use technology in the classroom in an effort to meet the ISTE technology standards. Too often teachers view computers as isolated instructional resources that require more time above and beyond their normal instructional planning to meet their current curriculum objectives (Thomas et al., 1996; Thompson & Schmidt, 1994). On the contrary, integration across the curriculum provides preservice teachers an exploratory and discovery environment to become confident in their abilities to use different computer applications for instructional purposes. A problem-solving environment shares the basic constructivist assumption that students become intrinsically motivated to seek

information and solve problems (Brooks & Brooks, 1993). If this same theory is applied to the integration of technology into classroom instruction, then it is essential that technology is presented properly so teachers will become confident and computer literate in a self-directed learning environment (Saye, 1997). Research studies have reported that most preservice teachers entering today's teacher education programs are more familiar with using a word processor (Fox et al., 1996; Sheffield, 1996) than with any other computer application. If it is true that preservice teachers teach as they are taught, it becomes necessary to determine the most effective way to train preservice teachers to enter into their own classrooms integrating technology appropriately and then apply this model to the professional development training for inservice teachers.

PURPOSE AND RESEARCH QUESTIONS

There is a need to investigate the most effective approach for integrating computer training into teacher education (Waugh & Rath, 1995) and most importantly, to determine which comes first, the theory or the practice? Or can the two be taught simultaneously? With the ISTE technology standards came the question of how teacher education programs could systemically provide teachers with opportunities to learn and apply computer knowledge and skills that would ensure that the technology standards are met (Handler & Strudler, 1997). As supported by the literature, computer literacy in this study refers to a teacher's ability to apply the theory-related concepts into their classroom instruction. The purpose of this study was to compare preservice teachers' confidence to transfer computer applications into their classroom instruction depending on whether they were taught computer literacy from a theory perspective focusing on skills alone or from a theory and application perspective where their computer skills were learned simultaneously as they completed interdisciplinary mathematics and science projects. The teachers' transfer rate of technology across the curriculum was assessed after they had taught in the classroom for one year to determine how much of the integrated technology training was still present as part of each group's teaching, how they were using the resources in the classroom, and their computer literacy based on their confidence in their ability to use computer applications (e.g., word processors, spreadsheets, e-mail, and the World Wide Web) as instructional tools for teaching the subject matter.

Research Questions

The research questions addressed to expand the current research were:

1. What are elementary preservice teachers' computer skills when they enter the integrated mathematics method course?
2. Will there be a difference in elementary preservice teachers' computer skills and confidence depending on whether they become computer literate based on theory or on theory and application integrated simultaneously with teaching methods?
3. During their first year of teaching, will there be a difference between the two groups' transfer rates?

METHOD

Subjects

The sample for this study consisted of 73 preservice teachers in an integrated elementary methods course prior to their student teaching experiences. The study was conducted during two semesters. The sample sizes for the fall and spring semesters were 40 and 33, respectively. All of the 73 teachers were contacted at the end of their first year of teaching to assess how frequently and for what purposes they were using technology as an instructional tool. Only 56 of the 73 preservice teachers had completed one year of teaching.

Description of Each Semester's Content

During each semester, the students could use a word processor to complete their lesson plans but were only required to do so during the fall semester. All of the required assignments during the fall semester ranged from using the word processor for lesson plans and spreadsheets for graphing to communicating with peers using e-mail and handing assignments in as e-mail attachments. The preservice teachers learned the capabilities of a spreadsheet while they completed content-based assignments. As an example of an interdisciplinary assignment, an observational experiment and graphing assignment was designed by the mathematics and science instructors. During the fall semester, the preservice teachers conducted an observational experiment as part of the science methods course and graphed the results as part of the mathematics methods course. They were not shown specifically how to use a spreadsheet. If they did not know how to use a spreadsheet, they could work with a partner or explore individually to learn basic spreadsheet skills as they completed the assignment. During the spring semester, the same assignment was given to the 33 preservice teachers in the methods courses. The preservice teachers in the second semester were introduced to spreadsheet use through a demonstration by the instructor and given one class period to explore the software on their own. Their exploration focused more on the mechanics of using a spreadsheet rather than deciding when to use a spreadsheet or practicing their skills through integrated, instructional tasks. They were not required to use a spreadsheet to complete any of the assignments. The purpose was to introduce the preservice teachers to a spreadsheet and let them discover the basic capabilities of the software and then assess whether they would transfer the skills into the classroom. At the conclusion of each semester, the postcourse questionnaire assessed how frequently each group used technology during the semester and their postcourse comfort levels using each of the computer applications in the classroom as part of their instruction.

Instrumentation

Pre- and postcourse questionnaires, with a reliability of .84, were administered to all of the preservice teachers completing the integrated elementary methods courses. The precourse questionnaire was designed to assess the preservice teachers' computer skills prior to entering the integrated block of methods courses. They were asked to look at the following computer applications and to check all that they felt comfortable using: word processor, spreadsheet, e-mail,

and Web browsers. To clarify to the preservice teachers what was meant by *comfort level*, they were asked to rate their abilities based on whether they were able to perform applications at the basic skill level, such as printing a letter in a word processor or sending an e-mail message, or at a more advanced level. For example, an advanced use of e-mail was sending and receiving attachments. This precourse information was used by two of the faculty to develop interdisciplinary instruction and assignments emphasizing the effective use of technology as instructional supplements to teach mathematics and science. As part of the course, each preservice teacher was given an e-mail account to use during the semester. During the fall semester, the preservice teachers were required to complete interdisciplinary teaching assignments using various technology applications, and during the spring semester, the teachers were introduced to each of the applications based on theory and isolated skills. Therefore, the first group was taught computer literacy through theory and practice simultaneously. At the end of each semester, the preservice teachers completed a postcourse questionnaire. They responded about their frequency of use of each of the computer applications during the semester and their comfort level using technology in the classroom. The follow-up questionnaire administered after their first year of teaching assessed how frequently they had used technology as an instructional tool, and a content analysis summarized how they were using technology as an instructional tool.

RESULTS

The preservice teachers' pre- and postcourse responses concerning their levels of comfort in using the various computer applications are given in Figure 1. As reported in the research, a majority (76%) of the 73 preservice teachers reported they were comfortable using a word processor when they entered the semester. However, only 31 (42%) reported they were comfortable using e-mail, and only 23 (31%) were comfortable using a Web browser. After completing the technology-integrated methods courses, the preservice teachers reported they were more comfortable using all three computer applications in the classroom.

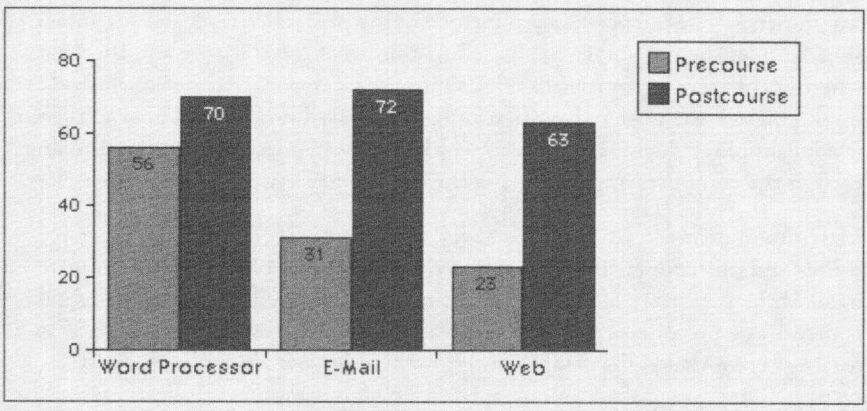

Figure 1. Preservice teachers' reported ability to use computer applications.

The preservice teachers' pre- and postcourse responses for using spreadsheets are given in Figure 2. The purpose for reporting the preservice teachers' use of spreadsheets separately was to compare their pre- and postcourse responses to their ability to transfer their skills for using spreadsheets for instructional purposes based on whether they had been required to become literate with this application of technology through an integrated or isolated learning approach.

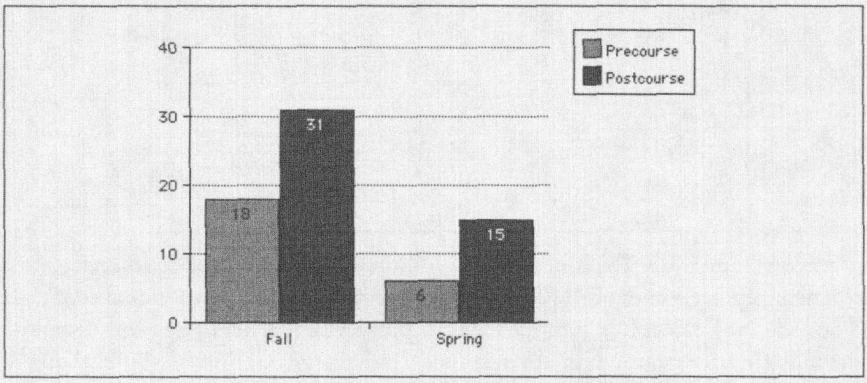

Figure 2. Preservice teachers' reported ability to use spreadsheets.

During the fall and spring semesters, 18 (45%) and 6 (18 %) of the preservice teachers, respectively, reported they were comfortable using a spreadsheet when they entered the course. By the end of the fall semester, in which the preservice teachers were required to complete integrated mathematics and science projects using a spreadsheet, 31 (78%) reported they were comfortable in their ability to use spreadsheets as an instructional tool, while only 15 (45%) responded in the same manner after having been taught how to use spreadsheets from the more traditional isolated approach. Of the preservice teachers during the spring semester, only 9 (27%) chose to use the spreadsheet as a graphing tool. The rest turned in hand-drawn graphs.

The preservice teachers were asked how frequently they used the computer applications during the semester (Table 1). It was not surprising that all of the preservice teachers reported they used e-mail and word processors often because (1) so much of their work required them to do so and (2) they entered the class with confidence using word processors. However, the preservice teachers' frequency of spreadsheet use supports the results previously reported. During the fall semester, the frequency of use was higher than during the spring when the use of a spreadsheet was optional and not integrated with the teaching of the subject matter. However, the preservice teachers who were not required to learn the use of spreadsheets through instructional methods did not transfer the isolated basic skills toward the use of spreadsheets in the classroom. These results indicated that the rate of transfer was not the same for the two models used to provide the preservice teachers with the computer literacy required to meet technology standards for instructional purposes. Web use was approximately the same during both semesters, considering that the primary use was to obtain lesson ideas and plans to use in the classroom.

Table 1. Frequency of Preservice Teachers Reported Use of Computer Applications

	None	Sometimes	Often
Fall			
Word Processor	0	3	37
Spreadsheet	5	6	29
E-Mail	0	0	40
Web	2	22	16
Spring			
Word Processor	0	0	33
Spreadsheet	7	18	8
E-Mail	0	0	33
Web	0	25	8

A content analysis was conducted to summarize each group of preservice teachers' reported uses of the computer applications as an instructional tool. The following categories summarized the preservice teachers' responses from the fall semester (more than one response could be given): instructional tool (95%), research and data analysis tool for students (53%), enrichment and remediation tool (45%); spreadsheets as a gradebook (39%), Web for lesson planning (98%), and e-mail to communicate with other teachers and for students to gather data (92%). The following categories summarized the preservice teachers' responses from the spring semester (more than one response could be given): instructional tool (13%), research tool for students (49%), Web for lesson planning (95%), and e-mail for communicating (85%). These results suggested that the preservice teachers responded based primarily on what they had experienced during the semester. However, using the specific computer applications for enrichment and remediation was not discussed during either semester. Therefore, the responses from the fall semester preservice teachers reflected their ability to begin thinking about how they could transfer their knowledge of technology into their classrooms.

One year later, each of the teachers from the fall and spring semesters was contacted to determine if they were using technology as an instructional tool in the classroom and for what purposes. Of the 73 preservice teachers, 56 had completed one year of teaching. The follow-up questionnaire asked the teachers if they were using technology in the classroom at least once a week as an instructional tool, and if so, to check the following applications that they had used: word processor, spreadsheet, e-mail, and the Web. Of these teachers, 31 (55%) reported they had used technology in the classroom at least once every week. Of the 25 reporting they had not used technology in the classroom, 19 reported that the barrier was a lack of computers in their school. The remaining six teachers reported time constraints as a barrier. An additional telephone interview indicated that each of the six teachers did have access to computers in their schools, but they did not feel as confident using the computers and indicated that more time was required to integrate the technology into their classroom. All six of these teachers were in the spring semester group, which was not

required to use technology to complete the assignments. A final question was asked to determine how the teachers were using word processors, e-mail, and the Web in their classrooms. The teachers were asked to list all of the ways that they had used each of the computer applications listed in Table 1. A content analysis was used to summarize their responses. The results are provided in Table 2.

Table 2. Frequency of Technology Use in the Classroom After First Year of Teaching

Responses	Fall Teachers (N = 32)	Spring Teachers (N = 24)
Spreadsheets for Student Projects	30 (94%)	8 (33%)
Spreadsheets as a Gradebook	25 (78%)	11 (46%)
Students Using E-Mail	27 (84%)	21 (88%)
Teachers Using E-Mail to Communicate with Colleagues and Other Professionals	15 (47%)	12 (50%)
Teacher-Prepared Reports to Parents	32 (100%)	18 (75%)
Lesson Planning Ideas from the Web	31 (97%)	24 (100%)
Student Research Projects Using the Web	32 (100%)	24 (100%)

The self-reported follow-up data indicated that the teachers from the fall semester began their first year of teaching with the confidence and knowledge to incorporate technology into the classroom as an instructional or professional tool. Of the 32 first-year teachers who had completed the methods courses during the fall semester when the use of spreadsheets was required for completing assignments, 94% reported using the spreadsheet for students' use, and 78% reported using the spreadsheet as a gradebook. These results were not as high for those teachers who were not required to use a spreadsheet to complete the assignment: 63% and 46%, respectively. These results support the hypothesis that teaching computer literacy simultaneously with the methods promotes self-confidence among teachers to transfer their computer skills into the classroom.

CONCLUSIONS

The results of this study indicate that the integration of computer literacy training into methods courses did provide future teachers with the confidence to transfer their computer skills into their classrooms based on their own exploratory experiences. These results can assist other preservice education programs as modifications to teacher education programs are made for integrating technology into the programs such that preservice teachers enter 21st century classrooms with the positive attitudes and confidence needed to teach problem-solving skills from a constructivist approach using technology. By observing the ways the teachers reported using the computer as an instructional tool, the data suggest that it was important to integrate the use of computer applications into the preservice methods courses already in existence to give the teachers the opportunity to experience exactly how technology can be an integral part of the daily operations of the classroom. Therefore, the teachers did not perceive the integration of technology as an isolated instructional resource that would re-

quire additional instructional time. On the contrary, computer literacy was used as a teaching tool for the subject content. Furthermore, the interdisciplinary approach provided the preservice teachers with the much-needed emphasis on the importance of teaching math, science, social studies, and language arts concepts as integrated topics. Even though the subjects used in this study were mathematics and science, the model can be applied across the curriculum.

These results are applicable not only to preservice education but also to inservice professional development programs as schools are seeking ways to train their inservice teachers in an effort to meet the technology standards outlined by ISTE. The training of preservice and inservice teachers should also be considered because of their differences in classroom experiences and computer skills. Because most preservice teachers have more computer experience and the inservice teachers have more classroom experience, the concept of training the two groups simultaneously has proven to be effective (Halpin, 1996). Therefore, using the integration of technology from a theory and application approach as described in this study with preservice and inservice teachers simultaneously could be beneficial.

A note should be made concerning the importance of having an accessible computer laboratory at the university for the preservice teachers to use during their courses. This was a major problem during the fall semester because the preservice teachers found the computer laboratory closed at 5:00 P.M. and was normally reserved for instructional purposes during the afternoons. For the spring semester, this problem was slightly improved when the computer laboratory extended the hours of operation until 9:00 P.M. and a public computer laboratory in the library was made available. However, the preservice teachers still commented that they did not have easy access to the computers during the afternoons. This was an important concern and should be addressed by preservice education programs before computer requirements are incorporated as an integral component of the curriculum. ■

Contributor

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