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ABSTRACT

In this study, preservice elementary teachers were networked via the Internet, using electronic mail, newsgroups, listservs, World Wide Web access, and electronic mentoring during their science methods class and student practicum. Electronic networking was introduced as a means to provide a social context in which to learn collaboratively, share and reflect upon science teaching experiences and practices, conduct tele-research effectively, and to meet the demands of student teaching through peer support. The study employed a quasi-experimental pretest-posttest control group design. Findings indicate that prospective teachers benefit from interactions with peers, science mentors, and science methods instructors during student teaching. (Contains 59 references.) (DDR)

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Abstract

Preservice elementary teachers' science teaching efficacy is an important determinant of whether and how they will teach science in their classrooms. Preservice teachers' understanding of science and science teaching experiences have an impact on their beliefs about their ability to teach science. This study had a quasi-experimental pretest-posttest control group design. Preservice elementary teachers in this study were networked via the Internet (using e-mail, newsgroups, listserv, world wide web access and electronic mentoring) during their science methods class and student practicum. Electronic networking was introduced as a means to provide a social context in which to learn collaboratively, share and reflect upon science teaching experiences and practices, conduct tele-research effectively, and to meet the demands of student teaching through peer support. It was hoped that the activities over the electronic networks would provide them with opportunities to address their beliefs and improve their learning and teaching experiences. Self-efficacy was measured using a 23-item Likert scale instrument, the Science Teaching Efficacy Belief Instrument, Form-B (STEBI-B). Analysis of covariance was used to analyze the data, with pretest scores as the covariate. Findings of this study revealed that prospective elementary teachers in the electronically networked experimental group had greater science teaching efficacy and personal science teaching efficacy as compared to the non-networked group of preservice elementary teachers. The science teaching outcome expectancy of prospective elementary teachers in the networked group was not greater than that of the prospective teachers in the non-networked group (at $p < .05$). Information about the experiences of the participants in this study was also collected through interview sessions. Findings revealed that prospective teachers benefited from the interactions with peers, science mentors, and science methods instructors during student teaching. Students who did not have access to computers noted that time was a constraint in the use of the electronic networks.

Introduction

Science literacy for all students is a major goal of science education at all levels. The goals set by the National Science Education Standards and Project 2061 reflects this. A science-literate individual possesses the knowledge and skills to solve problems, make decisions, and be willing to learn and change views based on experience and understanding of the world around him/her. Achieving science literacy for elementary students starts with achieving science literacy for prospective elementary teachers.

Currently preservice teachers come to the final phase of their professional development-the student teaching phase, still unprepared and diffident about teaching science (National Science Foundation, (NSF), 1996). It is widely accepted that the focus of traditional elementary teacher education programs needs to be rethought (Cochran-Smith, 1992; Darling-Hammond, 1989; Kaplan & Edelfelt, 1996). The extent to which preservice teachers are exposed to science content is questionable, although pedagogy is addressed to some extent. The report prepared by the NSF (1996) indicates that only about two-thirds of teachers of grades 1 through 8 have completed at least one college course in the biological, physical, or earth sciences. Whereas as 80% of the elementary teachers indicate that they felt qualified to teach reading, less than 30% said that they felt confident to teach science.

In addition to the issue of inadequate preparation in the sciences, there is very little attention given to issues of teacher motivation, belief systems and attitude toward teaching science, although research indicates their importance (Ashton & Webb, 1986; Czerniak & Chiarlelott, 1990; Koballa & Crawley, 1985; LaBoskey, 1993; Ramey-Gassert & Shroyer, 1992). These are important issues to be considered if we need to have effective science teachers who not only understand the meaning of scientific literacy, but also feel efficacious and motivated enough to teach it. Self-efficacy refers to an individual's belief in his or her ability to perform a task successfully. Teaching efficacy refers to teachers' belief in their ability to affect student learning. Also missing in these programs is an impetus toward the integration of technology into the curriculum.

Science teaching self-efficacy may be one area of importance that has been overlooked in the attempt to improve science teaching at the elementary level (de Latt & Watters, 1995; Ramey-Gassert, Shroyer, & Staver, 1996). A teacher's sense of self-efficacy has been shown to have a significant effect on teacher behavior and student achievement (Anderson, Greene, & Loewen, 1988; Ashton & Webb, 1986; Czerniak & Chiarlelott, 1990; Emmer & Hickman, 1991; Guskey, 1987; Riggs & Enochs, 1990; Stein & Wang, 1988; Watson, 1991)

Theoretical Background

The psychological construct of self-efficacy is grounded in social learning theory (Bandura, 1977a). The theory of self-efficacy posited by Bandura suggests that people develop a generalized expectancy based on their experiences, called outcome expectancy beliefs. Additionally, they develop beliefs concerning their abilities to execute courses of action, termed self-efficacy beliefs. Self-efficacy is a psychological construct that, more than any other teacher characteristic, has demonstrated a consistent relationship to student achievement and efficacy (Ashton & Webb, 1986). Applied to the teaching situation, self-efficacy refers to teachers' confidence in their own teaching abilities and outcome expectancy beliefs refer to teachers' beliefs that student learning can be influenced by effective teaching (Gibson & Dembo, 1984).

Teachers' science teaching efficacy is an important determinant of whether and how they will teach science in their classrooms. Efficacious teachers have a better attitude toward science and science teaching and believe that they can affect their students' achievement and learning processes (Ramey-Gassert & Shroyer, 1992). Self-efficacy has been shown to be a determinant of teacher behavior, and student behavior, and student achievement (Ashton & Webb, 1986). Prospective teachers need support and guidance during student teaching, and issues of isolation are real and it is important that these issues be tackled. Preservice teachers have feelings of inadequacies and concern regarding classroom management and their ability to teach effectively, before their field-placement phase, as well as during their placement period (Zeilinski & Preston, 1992). It therefore becomes pertinent to address the issue of teacher self-efficacy from within the context of teacher education programs.

Information about self efficacy is gathered in various ways. The strongest factor affecting efficacy is performance accomplishments (successful performance). Vicarious experiences (observation of others' success and failures), social influences and persuasion also play major roles in affecting self-efficacy (Bandura, 1977a). A number of approaches to enhance science teaching self-efficacy are described in the literature: open-ended inquiry, reflection (Ashton & Webb, 1986), support groups and cooperative learning situations (Scharmann & Hampton, 1995), fostering a non-competitive classroom atmosphere (Ramey-Gassert & Shroyer, 1992), hands-on experimentation, micro teaching, field experiences, and making science meaningful. Research has also shown that self efficacy beliefs may be associated with negative learning experiences and could be improved in situations where individual students received support and an appropriate learning environment (Watters & Ginns, 1995).

In an attempt to address teacher efficacy from within the teacher education program, it is important to understand how professional development shapes prospective teachers' efficacy. There have been some studies that have looked at the effects of specific strategies on the science teaching efficacy of prospective teachers. These strategies include well planned and supervised field experience (Cole, 1994; Vinson, 1995; Wilson, 1994), and increased and improved science content courses that will be helpful in future science teaching (Ashton, 1984; Ross, 1994). Other strategies include reflection (Volkman, Scheffler, & Dana, 1992), and providing performance feedback to prospective teachers about their teaching (Rosenholtz, 1989; Schunk, 1981). Vicarious experiences such as role modeling (Ashton, 1984; Moor, 1990) and cognitive modeling (Gorell & Capron, 1990), and sharing curricular materials and teaching strategies (Dutton, 1990; Volkman, et al., 1992; Watters, Ginns, Neumann, & Schweitzer, 1994) have also been shown to improve teaching efficacy.

It has been recognized that networking can provide a forum for reflection (McIntyre & Tlusty, 1995), collaboration (Bos, Krajcik, & Patrick, 1995; Naidu & Olsen, 1996), provide a context for moral and emotional support for preservice teachers (Merseth, 1991), curriculum guidance (Bull, Harris, Lloyd, & Short, 1989), and contact with content experts. An electronically networked setup is an effective medium for peer dialoguing (Stamper, 1996), and for interaction with subject matter experts (Falk & Drayton, 1997; Lenert & Harris, 1994). It can also be an effective way for providing mentor support (Kay, 1990; Odell, 1990) and is a quick and easy medium for communication with instructors and peers during student teaching (Sunal & Sunal, 1992). Since many of these strategies help improve self-efficacy, this study aims at incorporating electronic networking into preservice teachers' curriculum through structured activities. It is hoped that this will help address some of the issues that affect their science teaching self-efficacy. This study looks at the effect of infusion of electronic networks into the curriculum on prospective teachers' science teaching self-efficacy.

Purpose

The primary purpose of this study was to investigate whether using electronic networking for the purposes of reflection and collaborative learning, helped improve the science teaching self-efficacy of preservice elementary teachers. Of particular interest was whether increased opportunities to express concerns and experiences of the student teaching phase, and the provision of emotional and curricular support would impact their science teaching self-efficacy, personal science teaching efficacy, and science teaching outcome expectancy.

A secondary purpose of this study was to ascertain the feasibility of integrating electronic networked activities into preservice elementary teachers' science methods courses and student teaching practicum. Concerns regarding incorporation of networked technology include time constraints, technical support and equity issues (access to the technology being incorporated). It was also hoped that through this study educators would find that electronic networking technologies can improve upon traditional ways of teaching and learning. Electronic networking technologies can open up entirely new opportunities for communication, collaboration and knowledge building.

Definition of Terms

For the purpose of this study the following definitions were used :

Science Teaching Self-Efficacy: This refers to the belief teachers have in their ability to affect student performance in science (Ashton, 1984). Science teaching efficacy has two subconstructs: a) science teaching outcome expectancy and b) personal science teaching efficacy.

Science Teaching Outcome Expectancy (PSTE): This refers to teachers belief that student learning in science can be influenced by effective teaching.

Personal Science Teaching Efficacy (STOE): This refers to the confidence teachers have in their own abilities to teach science effectively.

Electronic Networks: This denotes computers that are connected, which allow access to the Internet.

Networked Activities: Networked activities in this study include assignments in the form of posting opinions, ideas and reflections, on a newsgroup. Also included were 'follow-up' postings to others' postings. In addition, students accessed web pages, as well as interacted with science mentors and the science methods instructor. Prospective elementary teachers also interacted with science mentors and students from other universities via the listserv PreSTO (Preservice Student Teachers Online).

Non-networked Environment: A setting where communication, reflection, and interaction would be through the more conventional modes (e.g., written or oral).

Research Questions

This study investigated the following research questions:

1. Do preservice elementary teachers in an electronically networked environment show greater science teaching self-efficacy than preservice elementary teachers in a non-networked environment?

2. Do preservice elementary teachers in an electronically networked environment show greater personal science teaching efficacy than preservice elementary teachers in a non-networked environment?

3. Do preservice elementary teachers in an electronically networked environment show greater science teaching outcome expectancy than preservice elementary teachers in a non-networked environment?

Research Design

The experimental design of this study was a quasi-experimental pretest-posttest nonequivalent control group design. This design was employed to investigate the impact of the experimental treatment on preservice elementary student teachers. The independent variable manipulated was electronic networking and the dependent variables were preservice elementary teachers science teaching self-efficacy, personal science teaching efficacy and science teaching outcome expectancy. Science teaching self-efficacy and its subconstructs were assessed using the Science Teaching Efficacy Belief Instrument Form B (STEBI-B).

Sample

Participant students in this study (N = 60) were enrolled in the science methods class. They were in the final year of their professional development program in a large Southwestern University. The science methods course spanned over the first three weeks of the semester in which this study was conducted, after which the students are assigned to schools where they taught. Students in both the control group (n = 29) and treatment group (n = 30) were pre-tested using STEBI-B at the beginning of the study. The sample (N=60) consisted of two males (3%) and the remaining were females. They were predominantly white (87%) and from the middle socio-economic level with an average age of about 22-23 years.

Sampling Technique

Since it was not possible to randomly select the sample from the target population, intact groups were assigned to each of treatment groups (i.e., experimental and control). This was because the students were already enrolled in various sections of the course at the beginning of the semester, and it was highly impractical to regroup them again. The research design of this study is therefore considered quasi-experimental in nature.

Instrumentation

Information about science teaching self-efficacy, personal science teaching efficacy and science teaching outcome expectancy was assessed using the Science Teaching Efficacy Belief Instrument, Form B (STEBI-B). The validity and reliability of this instrument have been demonstrated to be high in field tests (Enochs & Riggs, 1990). It consists of two subscales: the Personal Science Teaching Efficacy Belief subscale (PSTE) and Science Teaching Outcome Expectancy (STOE) subscale. STEBI B consists of 13 positively worded items and 10 negatively worded items. Scoring is accomplished by assigning 5 points to positively worded items receiving "strongly agree" down to 1 for "strongly disagree." Negatively phrased items had their scores reversed. The time required to administer this test was approximately 20 minutes. Information about students' experience using the electronic networks was collected through inventories. Students were also interviewed to get information regarding their confidence to teach science.

Procedures and Treatment

Preparation and Pretest

The study began by administering the pretest to the participants of this study using the STEBI B on the second day of class. In addition, information about student biodata, their science teaching philosophy, concerns regarding teaching science to elementary grades and computer related information was collected. Instructor and researcher constructed questionnaires were administered to collect these data.

Computer and Network Use Training

Prospective elementary teachers in the experimental group were introduced to the concept of electronic networking, 'sending and receiving e-mail, methods of posting on a newsgroup, and methods of posting on a listserv. Addressed also were any concerns that students might have had in learning to use the computer. Issues of access, setting up network connections with the university, purchase of the software required to set up connection with the university network and names of reliable vendors for purchase of new and used computer were some of the issues discussed. Computer dial-up accounts were free. The software needed to set up connection from off-campus locations could be bought for a nominal fee.

Handouts containing instructions on how to "telnet" (remote access from off-campus locations) to the university server as well as instructions on how to use the software PINE ("Pine Is Not Elm") for e-mail and posting on newsgroups, were distributed to the students. The demonstration and discussion took two hours and students were given the opportunity to work on what they had learned for the rest of the class period that was approximately one hour.

Posttest

A posttest was administered at the conclusion of the treatment period to both the experimental and control groups using STEBI-B to measure science teaching self efficacy. A few students from both the control and treatment groups were interviewed. These interviews offered a perspective on their experiences of communication and support. Before the interview process the researcher observed the science lessons of preservice teachers when they were teaching as part of their student teaching practicum. The issues addressed by researchers as pertaining to efficacious teacher characteristics in classroom teaching were used as the criterion for assessing student teachers. The experiences of the participants in the experimental group, using the electronic network was sought using a questionnaire constructed for this purpose.

Treatment

The treatment for the experimental group involved working on-line for the purpose of completing various class assignments and for communication. The control group did not use the electronic network for these activities, but used conventional methods.

Experimental Treatment - Electronic Networking

In the experimental group, preservice elementary teachers used electronic networks for communication, collaboration, support and reflection both during the three week science methods class as well as during the 12 week student practicum. The experimental treatment was part of the course requirement. Each subject in this group had to make individual postings on the basis of the instruction given by the instructor for the course, as part of the course assignment. During the science methods course, students had to post their reflections twice during a week on the newsgroup. The reflections were usually based on the concepts learned during a certain period of time (e.g., 2-3 days) or on some issue posed by the instructor or on some discussion initiated by students in class.

These issues ranged from their philosophy for science teaching, their perceptions of themselves as science learners, discussions pertaining to the scientific processes and scientific literacy and other issues that arose during the methods class. Since there were two intact classes that were assigned to the experimental group, two newsgroups were setup to avoid clutter.

Each individual also had to make a "follow-up" posting in response to one another classmate's reflective posting. This posting could be in the form of constructive criticism or a note of support, either emotional or academic. They also had to access the World Wide Web (WWW) to gather materials and information pertinent to science teaching. In addition they also had to post regularly over a listserv/mailing list set up specifically for preservice teachers called PreSTO (Preservice and Student Teachers Online). This mailing list gave them the opportunity to interact with other preservice teachers over the world to exchange teaching philosophies, teaching techniques and content. The postings over PreSTO occurred throughout the semester. In addition, three science experts were invited by this researcher to interact with the preservice teachers in the experimental group. The experts answered specific content related questions and any other issue they felt inclined to address.

During the student teaching practicum, the messages posted were mainly reflections on their experiences teaching science lessons, commenting on peers messages, exchanging lessons planning ideas, teaching ideas and class management issues. Specifically, preservice student teachers had to make five reflective postings based on their experiences teaching science in their classrooms. These reflections were to be based on, though not limited, to a set of questions specifically formulated by this researcher for the study. The questions were to be used to guide their reflections. In addition, they were to respond to at least two other reflections of their classmates in a prompt manner, to provide feedback on issues raised by them.

Student teachers were encouraged to interact with the teaching assistant (researcher) and the professor. Student teachers had access to the newsgroup and the mailing list and to each other due to the nature of the electronic networks.

Control Treatment

The students in the control group could interact with each other during the course of the class time. They were required to reflect each day as well, but the reflection was in the traditional paper and pencil format, and was due at the end of each week. In addition, they used mostly the library to gather information (academically related information) though they might have had access to the WWW. Not all students got a chance to see everybody else's work.

Data Analyses

Data were analyzed using statistical techniques on SPSS® for Windows, Release 7.5. The procedures used were General Linear Model (ANCOVA), ANOVA, and Paired-Samples t-test. An alpha value of 0.05 was used in all cases to determine statistical significance. 0.05 is the alpha level preferred by most statisticians because it reduces the chance of Type I and Type II error (Hays, 1988). Data was also collected through interviews and using questionnaires. The purpose of including qualitative techniques to collect data in this study was to increase the validity and reliability of the study. Including qualitative techniques increases the validity and reliability by: a) providing an enlarged contextual and procedural framework within which to analyze and interpret data, thus increasing the understanding of the phenomenon being studied; and b) helping to eliminate alternate explanations for findings in the weaker quasi-experimental designs (Goodwin & Goodwin; 1984). Interview data were analyzed for patterns and emerging themes. The information from interviews were used to complement the findings from the statistical analyses.

Results

Influence of Electronic Networking on Science Teaching Self-Efficacy

The first research hypothesis concerned the effect of electronic networking on the science teaching self-efficacy of preservice elementary teachers. This hypothesis can be stated as :

H_0 1: The mean scores on the Science Teaching Efficacy Belief Instrument (STEBI-B) of preservice elementary teachers in an electronically networked environment will be less than or equal to the mean scores of teachers in the non-networked environment.

The data collected from the pre- and posttest on the STEBI-B, from both the experimental and control groups were used to test the hypothesis stated by H_0 1. Table 1 displays the means and standard deviations for the pre- and posttest scores for each group, and the means and the t values for the gains made by each group. The network supported group had a lower mean score on the pretest, but a higher mean score on the posttest as compared to the preservice elementary teachers in the non-networked group.

Both groups showed a significant gain in their science teaching efficacy scores as measured by STEBI-B. The electronically networked group showed a $t\ (30) = 10.07$, $p < 0.05$; and for the control group, $t\ (28) = 3.35$, $p < 0.05$.

Table 2 summarizes the results from the analysis of covariance. The table shows that there was a significant difference between the experimental group and the control group, $F(1, 57) = .016$, $p < .05$. The electronically networked group also had higher adjusted mean scores as compared to the non-networked group (95.58 versus 91.59). The $H_0 1$ of no effect of electronic networking on preservice elementary teachers science teaching self-efficacy was rejected based on this result.

Influence of Electronic Networking on Personal Science Teaching Efficacy (PSTE)

The purpose of the second research hypothesis was to determine the effect of electronic networking on preservice elementary teachers personal science teaching efficacy. The personal science teaching efficacy belief was assessed by means of the PSTE sub-scale on the Science Teaching Efficacy Belief Instrument B (STEBI-B). The hypothesis is as follows:

H_0 2: The mean scores on the personal science teaching efficacy sub-scale of elementary teachers in an electronically networked environment will be less than or equal to the mean scores of teachers in the non-networked environment.

Table 1 Means and Gains for Data from the Science Teaching Efficacy Belief Instrument, (STEBI-B) of Students in the Experimental and Control Groups

	Pretest		Posttest		Gain[a]	
Treatment	M	SD	M	SD	M	t value[b]
Experimental[c]	81.39	8.57	95.52	5.78	14.13	10.07*
Control[d]	81.83	9.12	91.66	7.48	9.83	5.35*

Note. Maximum possible score = 115.
[a]gain = posttest - pretest.
[b]t value is a result from paired-samples t-test (t-test on gain scores).

[c]n = 31. [d]n = 29.
*p < .05, two-tailed.

Table 2 ANCOVA Summary for Data from the Science Teaching Efficacy Belief Instrument (STEBI-B) of Students in the Experimental and Control Groups

Source of Variation	SS	df	MS	F	Sig. of F
Covariate	351.35	1	351.35	9.04	.004*
Treatment	237.62	1	237.62	6.12	.016*
Residual	2214.94	57	38.86	-	-

*p < .05.

The data collected from the pre- and posttest on the PSTE sub-scale of the STEBI-B, from both the experimental and control group were used to test the hypothesis ($H_0 2$). Table 3 displays the means and the standard deviations for the pre- and the posttest scores of each group, and the mean and the t-values for the gains made by each group. The electronic network supported group of preservice teachers had a lower mean score on the pretest, but a higher mean score on the posttest on the PSTE, as compared to the preservice teachers in the control group. The experimental group as well as the control group showed a significant gain of PSTE scores, $t(30) = 10.53$, $p < 0.05$; and for the control group, $t(28) = 6.86$, $p < 0.05$.

To test whether there was a difference between the control and experimental groups on PSTE, ANCOVA was performed on the posttest data. Table 4 shows a significant difference between the two groups on the PSTE sub-scale scores, $F(1, 57) = 4.19$, $p < 0.05$. The experimental group also has a higher adjusted mean as compared to the control group (58.14 versus 55.95). The $H_0 2$ of no significant difference between the two group should be rejected based on the findings of this analysis.

Table 3 Means and Gains for Data from the Personal Science Teaching Efficacy Sub-Scale (PSTE) of Students in the Experimental and Control Groups

Treatment	Pretest		Posttest		Gain[a]	
	M	SD	M	SD	M	t value[b]
Experimental[c]	46.42	7.19	58.10	3.98	11.68	10.53*
Control[d]	46.79	7.19	56.00	5.06	9.21	6.86*

Note. Maximum possible score = 65.
[a]gain = posttest - pretest.
[b]t value is a result from paired-samples t-test (t-test on gain scores).
[c]n = 31. [d]n = 29.
*$p < .05$, two-tailed.

Table 4 ANCOVA Summary for Data from the Personal Science Teaching Efficacy Sub-Scale (PSTE) of Students in the Experimental and Control Groups

Source of Variation	SS	df	MS	F	Sig. of F
Covariate	210.13	1	210.13	12.19	0.001*
Treatment	72.19	1	72.19	4.19	0.045*
Residual	982.58	57	17.24		-

*$p < .05$.

Influence of Electronic Networks on the Science Teaching Outcome Expectancy (STOE)

The purpose of the third research hypothesis was to determine the effect of electronic networking on preservice elementary teachers' science teaching outcome expectancy. The science teaching outcome expectancy beliefs was assessed using the STOE sub-scale on the Science Teaching Efficacy Belief Instrument form B (STEBI-B). The hypothesis is as follows:

H_0 3: There will be no difference in the science teaching outcome expectancy of elementary teachers in an electronically networked environment as compared to teachers in the non-networked environment.

The data collected from the pre- and posttest on the STOE sub-scale of the STEBI-B form, from both the experimental and control group were used to test the hypothesis stated in H_0 3. Table 5 displays the means and the standard deviations for the pre- and the posttest scores of each group, and the mean and the t-values for the gains made by each group. The electronic network supported group of preservice teachers had a lower mean score on the pretest, but a higher mean score on the posttest on STOE, as compared to the preservice teachers in the control group. The experimental group showed a significant gain on the STOE scores, $t(30) = 3.11$, $p < 0.05$; while the control group only showed a small change, $t(28) = 0.65$, $p = 0.52$.

Table 5 Means and Gains for Data from the Science Teaching Outcome Expectancy (STOE) Sub-Scale of Students in the Experimental and Control Groups

Treatment	Pretest		Posttest		Gain[a]	
	M	SD	M	SD	M	t value[b]
Experimental[c]	34.97	5.14	37.42	4.39	2.45	3.11*
Control[d]	35.03	3.58	35.66	4.49	0.62	0.65

Note. Maximum possible score = 50.
[a]gain = posttest - pretest.
[b]t value is a result from paired-samples t-test (t-test on gain scores).

[c]n = 31, [d]n = 29.
*p < .05.

Table 6 ANCOVA Summary for Data from the Science Teaching Outcome Expectancy (STOE) Sub-Scale of Students in the Experimental and Control Groups

Source of Variation	SS	df	MS	F	Sig. of F
Covariate	204.84	1	204.84	12.46	0.001*
Treatment	48.13	1	48.13	2.93	0.093
Residual	937.26	57	16.44	-	-

*p < .05.

Table 6 reports the summary of the results from the analysis of covariance. Although preservice elementary teachers in the experimental group showed a higher adjusted mean score on STOE (37.43) than those in the control group (35.64), the difference did not reveal a statistical significance at the 0.05 level, $F(1, 57) = 2.93$, $p = 0.09$. The null hypothesis H_0 3 was not rejected.

Results from Qualitative Interpretations

Responses from interviews were analyzed to see if it corroborated with, and elaborated on, the information obtained from the statistical analyses of data (Goodwin & Goodwin; 1984).

Findings from Interviews

Information obtained from the interviews sessions were collected to complement the quantitative data. All students interviewed were volunteers from the control and experimental groups. Two 'high efficacious' students and two 'low efficacious' students from the experimental group were interviewed. From the control group only two high efficacious students were selected, as no students with low efficacy volunteered to be interviewed. Open-ended questions were asked so as not to influence the responses of the student teachers. Question 1 was asked of students from both the experimental and the control groups. Questions 2, 3, and 4 were asked only of student volunteers from the experimental group. Students' level of efficacy was based on their pretest scores on STEBI-B. The major themes that emerged on analyzing the data, and the conclusions drawn from these analyses are stated next.

1. At this point in time what are your feelings about teaching science?

Theme: Enjoy teaching Science :

The responses of students in both the experimental and control groups indicated that they had positive experiences teaching science. This was indicated by the low efficacious students in the experimental group as well. Students in the experimental group, however, volunteered to provide specific reasons to support their positive feelings about teaching science as seen in the response of one of the 'low efficacious' students: "...my experiences were made more enjoyable because of the support and feedback I received from my peers....I really enjoyed seeing the wonder and amazement on my students face when they discovered something on their own."

Theme: Confident Teaching Science:

The 'high efficacious' students in both the experimental and control groups indicated that they were more confident about teaching science than before. The 'low efficacious' students' responses suggested that they had made great strides as far as their belief in their ability to teach science went. The students in the control group indicated that they were confident in their abilities to teach right from the start.

The 'low efficacious' students in the experimental group noted the opportunities afforded by the electronic networks and the science methods course as contributing toward their confidence in their abilities to teach science.

> I now know that the help groups - science listservs and newsgroups, that people talk about as available on the Internet, is not something beyond my reach. I know where to look for help in the future. I was amazed to find out that there was a listserv set up specifically for teachers and the kind of help that was available online....It is so beneficial to have this help. I have something to compare my performance with and know where I am at.

Theme: Teach Science in the Future

Although the 'high efficacious' students in the control group indicated that they were not concerned about teaching science in the future, they did not show the enthusiasm and the planning that the students in the control group evinced. The 'low efficacious' students in the experimental group indicated that they felt more prepared to teach science now, knowing that they would always have help and assistance available online if other means are not available. One of the 'low efficacious' student had the following to say: "...my cooperating teacher had some good things to say. He feels that I will be able to handle higher grades as well. I know now that I can handle the lower grade science pretty well. I look forward to doing this again."

2. ***What are your thoughts/comments about using the electronic networks in the science methods class?***

Theme: Helped me see that I was not alone

Both 'high efficacious' and 'low efficacious' students in the experimental group indicated that they came to the methods class with fears and apprehensions about teaching science. Though the degree of this apprehension varied, most of them were skeptical about the future. Seeing others' postings on the newsgroup about their previous science background and experiences and their fears about teaching science, helped students realize that the problems that they were facing were not peculiar to themselves. Clearly, others in the class had similar experiences and were voicing it. Their poor science learning experiences was one of the major hindrances to science teaching, but there was help available and other students in the class were willing to help.

Low Efficacious student (LES) 1: "...I no longer felt like I was the only one who needed help with science pedagogy and content. That I was not stupid...and my problems were not peculiar to me. That we could help each other...."

LES 2: "...I realized that there was real help available here, because other folks would understand my confusion, and could help me from within that context."

High Efficacious student (HES) 1: "...nice to realize that there were others in the class who could help me with content and classroom management techniques.."

HES 2: "...at the end of the day there was a place to go to, and see that help was available. It was gratifying to know that others would listen and help... the classroom meetings were not the end of contact...this was especially true during student teaching, even though we were so tied up."

Theme: Source of Resources for Science Teaching:

Students who were interviewed indicated that they were able to locate and build up a list of resources on the Internet that would help them prepare science lessons during student teaching. Also, the ability to communicate with other students from various universities, helped expand their ideas about teaching science. The presence of the science mentor was also a big help in terms of finding help to teach science content and hands-on activities. It was also much easier to locate resources through the networks by communicating with others than struggling to find it alone in the library.

LES 1:"...helped me feel more confident about teaching science because of the resources that are available on the Internet. Now I know where to start...before this I did not even know about the ideas I am now reading about on the different web pages....It is just so nice to think that there are people available to help you when you need help...you know like the science mentors on PreSTO. your talk about different science newsgroups that exist on the Internet has also helped us realize that there are ample resources available on the Internet. next semester if I have a job I'll know where to start looking for help".

LES 2: "...especially when one does not have the time to go to the library or other places, to have this information over the Internet is incredible. Before this I did not know which books to look up. Now there are sites that refer you to books that can get you started. It is so reassuring to know that I can remain in touch with my science methods teacher even when I leave the university."

HES 1: "...so much out there. Yes! it requires time to sort through, but hey! knowledge and information does not come free and easy.... I feel that I will have some help out there without having to go too far. I will have to get on another server once I graduate, but now I know where to look for expert advice and I know that there are people out there who I can contact."

HES 2: "...felt better about having to teach science in the future after seeing that there was so much information available out there, ...and it was not difficult to access it. Helped me realize how I can link up with other teachers in other schools once I start working, even though this might me difficult in the beginning I'm sure I will get better at it... I am sure my students will enjoy this interaction."

<u>Theme : Misconception about Ease of Use:</u>

Some of the students both 'high efficacious' as well as 'low efficacious' indicated an initial hesitation and apprehension to use this networks. However, most of them indicated that by the end of their student teaching they realized the benefits of electronic networking, not only for science teaching but in other subject areas as well. One of the 'low efficacious' students who was interviewed also indicated that despite the limited access she had, she did her best to use it because she realized the benefits networking offered. Another 'low efficacious' student hoped that had known how to use the Internet before that semester, regretting what she had missed.

<u>LES 1</u>: "...I was skeptical initially, now, even with limited access to computer that I face at the moment, I will strive to use it because I know it is worth it."

<u>LES 2</u>: "...I was hesitant initially, but now I wish somebody had showed us earlier how easy it was to use this."

<u>HES 1</u>: "...I thought it was extra work initially, but this has helped me realize how I can link up with other teachers in other schools once I start working, even though this might me difficult in the beginning, I'm sure I will get better at it. I have experienced the benefits that it holds for me and my students."

<u>HES 2</u>: "...I tried getting on a few (newsgroups) myself...quite interesting discussions... and not at all complicated as I had anticipated. It has great advantages for a beginning teacher."

3. What are your thoughts/comments about networking electronically during student teaching?

<u>Theme: There was Help Available Always--Curricular Support</u>

Preservice student who were interviewed indicated their appreciation for the help that was available online, despite the time constraints some of them had in accessing the networks. They appreciated the suggestions they received in response to a query about teaching a particular unit. They also welcomed the feed back they received when they made a posting (based on their reflections about their classroom teaching). These students also liked the access they had to a science expert with whom they had developed a strong friendship through the networks. Students also appreciated the fact that they were required to reflect, because this helped them not to get overwhelmed by their setbacks, but to look for a way to make the situation work better next time.

LES 1: "...I knew that help was always around. I found our Newsgroup more comforting than PreSTO because I knew the people and I would say to myself, let me see what she has to say. But I did get some very useful information from PreSTO, when I was at a loss for ideas on science topics, like how to introduce diet/food topics and classroom management ideas and ideas on spelling lessons...the newsgroups you could log on to and see what others were doing, or I could see say let me see what she has to say about her first week of science teaching."

LES 2: "...I've come to realize how important it is to gain the feedback and support of fellow students while you are doing your student teaching, especially when a lesson doesn't go well, and in fact I found that I got the most responses on PreSTO and it was immediate. Also, it gave me responses from all over the US. The reflections we were required to do helped me focus on the issue at hand instead of getting overwhelmed by what did not work well, and address it to the class or the instructor and this helped me get a better hold of the situation that had arisen."

HES 1: "...even though I would have liked face-to-face interactions when I needed help, I realize that in the absence of this what we had was the next best opportunity for seeking help and assistance in teaching science. I got a lot of useful information by interacting with the members of my cohort over the newsgroups and with other teachers on the Listproc (PreSTO)."

HES 2: "...there was a lot of useful information shared through PreSTO and the newsgroup and e-mail. But my time was limited, so I didn't get to use it as much as I would have liked. It was nice hearing ideas for teaching not only science but for other subjects as well, and I was pleased with the responses I got from people on the Listproc."

Theme: Friends Available for Emotional Support

Peers helped student teachers realize that setbacks in a class or in a particular lesson were not always their fault. Often, all it required was suggestion about how to do things differently. Student teachers who were interviewed appreciated the emotional support that they received from their peers.

LES 1: "...I found help and support when my ideas were not working especially when I did not know if it was my fault that the students responded in that particular class like that or not."

LES 2: "...even though we had a lot to do during student teaching, it was a good thing to know that there was a way of keeping in touch with all your cohort members and the science methods teacher. Even though the best method I think is to meet people personally, this is the next best method, because you know that people would respond to you."

HES 1: "...I knew that I had a place to go to if I needed help."

HES 2: "...we all could do with some encouragement and support at the end of a hectic day, and this was possible by just logging on to the newsgroup and sending messages or reading somebody message to you."

Theme: Source of New and Workable ideas:

Prospective teachers who were interviewed indicated that the interactions they had with their peers on various issues relating to science teaching helped them look at a situation from a new perspective. Although they often did not get a ready-made answer to their question, they always found help to reach the goals they had set for themselves.

LES 1: "...there was always a way of working out the problems you had because someone or the other had a suggestion. The science mentors were really helpful always providing us with accurate science information, that I did not have the access to nor might have understood."

LES 2: "...even though I did not receive an exact answer to some of my questions, several were answered and I began to look at situations from a new perspective."

HES 1: "...this was a way of getting new ideas beyond what we were exposed to in our science methods class or the university setup."

HES 2: "...interactions provided for a means of negotiating ideas and coming up with better answers. two minds thinking was better than one. reflections helped because, when we needed to confide in you we could send you e-mail with our reflections and then address certain issues of our reflections to the class to get a feed back."

4. What role has Electronic Networking played in your development as a science teacher?

<u>Theme: Networking Important for Professional Growth</u>

All four student teachers who were interviewed indicated that they thought that it was important to interact with other professionals in their field and networking was the best substitute to face-to-face interactions. They felt that they could attribute a significant part of their growth as a science teacher to the help they received via the electronic networks. "...I think that I have become all the better for it. It required certain commitments from me, but the payback was immense....I feel that I can do a much better job with the help I got."

<u>LES 1</u>: "...I can bounce ideas of other educators and learn science in the process and improve as a science teacher I guess."

<u>HES 1</u>: "...it is important for teachers to communicate and interact with each other, especially in the area of science to exchange data and to find out what works with limited resources available in schools instead of giving up on teaching science in the absence of support from administrators."

<u>HES 2</u>: "...it was important for me to know what other students were learning in other universities. I always think it would be nice to know what other teachers are doing in other schools...communication important for improving, you know."

<u>Theme: Feel more confident about teaching new concepts in science</u>

The four student teachers who were interviewed indicated that they would take a chance at teaching new and difficult concepts, as this had not proven to be disastrous during their student teaching. They indicated that they were hesitant to try out new concepts initially (especially the 'low efficacious' students). However, the help they received not only from their cooperating teacher, but also from their peers as well as the science mentors, made it easier to teach new concepts. The 'high efficacious' students indicated that in addition to the science methods course, the resources available through the Internet helped them a great deal in teaching new concept and this made them more confident about teaching new concepts in the future.

LES 1: "...I have gained a lot of great ideas to teach science concepts.

LES 2: "...I was able to make science teaching a more enjoyable process both for myself and my students and I think I will continue to do this in the future.

HES 1: "...as a teacher of science I have so many more resources and this has helped me become more confident of wanting to teach in the future, different things than what I taught in the classroom during student teaching."

HES 2: "...I was exposed to some great ideas which was gained beyond our methods class that I will find useful in the future."

Theme: Reflecting Together

All the students who were interviewed indicated that reflecting over the network really helped them to address various issues that troubled them. They indicated that it forced them to address their teaching practices and not succumb to feelings of helplessness or anxiety. This helped them address the issues that lead to the outcome in class, rather than assigning some unforeseen cause to it or blame it on their deficiencies. They also indicated that despite initial apprehensions, most people were very civil and helpful over the networks. One 'high efficacious' student however preferred to send some parts of her reflective thoughts (especially about her cooperative teacher's teaching practices) privately via e-mail to the instructor, whereas, she did not mind sending her reflections about her teaching experiences to the newsgroup.

LES 1: "...reflections were useful, it forced me to think. I liked to see how others looked at themselves as they were developing... as a science teacher. But since I did not have a computer at home, and hence could not respond to or receive responses very promptly. But this was better than nothing."

LES 2: "...even though sometimes I thought of skipping it, I found it useful in general, especially those 'guiding questions' you gave us to help reflect...kind of forced us to question ourselves and our classroom practice, my philosophy of science teaching. Did the students really learn?"

HES 1: "...reflecting helped me see how to handle the situation the next time over. I do that all the time, and it was good to see what others had to say about their experiences...and to realize that they had analyzed their experiences and were informing us (at least I hope so)."

HES 2 : "...I would have personally liked to send you an e-mail every week reflecting on my personal development as a teacher. I would be very uncomfortable to have the whole class see my differences with my cooperating teacher, just because someone in my school might read it. But I definitely liked sharing how or why something did not work and how I would try it differently or why something worked the way it did. I would definitely like my cohort members to benefit from my success."

Secondary Findings

An additional goal of this study was to determine the feasibility of incorporating and integrating electronic networking into the teacher education program successfully. Concerns of educators regarding incorporation of technology included issues of equity (access to the technology), time constraints, and technical support. This study allays those concerns. Computers are widely available today, and the majority of the preservice teachers owned, or had access to a personal computer. Nearly 90% of the students in the networked group had access to computers and were computer literate. Some of the students who did not own a computer bought computers and the necessary software seeing the support, in terms of technical and personal help, available. Also, students who were new to the use of networking were quick to learn the necessary techniques.

A minority of the students cited time constraints as a factor. These were, invariably, those who were new to the use of this technology or those who did not have a computer at home. Even though students had a hectic schedule, responses obtained from most students through an inventory and interviews indicated that they appreciated the help that was available through the networks. They indicated personal benefits to them in the form of greater confidence and ideas to teach and hence the willingness to put up with the 'extra work.' Clearly, implementing a networked approach should not be limited by concerns about accessibility, equity, time constraints or (lack of) technical support.

Conclusions and Discussion

Science Teaching Efficacy

1. The findings of this study supported the hypothesis that preservice elementary teachers networked electronically would show better science teaching self-efficacy as compared to preservice teachers in a non-networked environment.

2. Both groups (networked and non-networked), exhibited significant improvement in their science teaching self-efficacy from the pretest to the posttest.

Discussion

A number of different activities can positively affect self efficacy; networking provides a stage for many such activities. The research results described above bear out the premise that networking can improve self-efficacy. Several studies have found that when preservice teachers work in a networked environment they have many benefits that their non-networked partners do not experience, or experience to a lesser extent both in a methods course as well as during student teaching (Waugh & Rath, 1995). As described earlier, these benefits include: emotional support from peers, feedback on pedagogical and teaching techniques, promotion of reflection and effective peer dialogue journaling, quick and easy means of communication with methods instructor and supervising teacher, enhancement of collaboration, support from subject matter experts, and access to resources on the Internet.

The findings from interviews and the inventory support the reports of the findings identified above. Students in the networked environment also reported being able to interact with peers, subject matter experts and methods instructors through postings and reflections. Some of their comments are noted below:

> I have found our cohort newsgroup and PreSTO to be very helpful. Not only did I get great ideas for my science lessons but for other subject areas as well. Whenever I posted a question, I received many responses from people all over the US. This also motivated me to respond to other teachers' questions.

Others noted that:

> "I enjoyed the social aspect of it because we don't get to see each other ..."
>
> "... reading about each others school experiences was really great."
>
> "... I've come to realize how important it is to gain the feedback and support of fellow students while you are doing your student teaching especially when a lesson doesn't go so well."

Clearly, they acknowledged the fact that networking had helped in their growth as a teacher, as well as in enhancing their confidence to teach science effectively. Research has shown that self-efficacy is improved by successfully executing a task (performance accomplishment), seeing others perform a task successfully (vicarious experiences), hearing others' success stories, as well as feeling reduced anxiety about teaching science (Bandura, 1977b; Bandura, 1986). The networked environment also enables the prospective teachers to 'observe' what their peers are doing in their classes. Often this has been a motivation for them to try or consider trying those activities:

> Wow! You taught an owl pellet lesson to first graders! ... L. I'm impressed that you did this activity with such a young group. I guess I just thought of it as an activity for older students and you've proven it otherwise ....

> I loved your science activity on the crime scenes. I think that is a wonderful idea. I am glad to hear someone else that is not afraid of putting in a lot of preparation work into a lesson or unit ....

> Your lesson sounded awesome. What a great hands on activity having to do with lubricants. I didn't know it was possible for lubricants to be so interesting. ... Great lesson plan, I might have to steal it!

> I enjoyed reading your lesson teaching about reptiles. I especially liked how you introduced the concept of cold-blooded versus warm-blooded. What a simple and effective way to introduce body temperature!

Reflection on teaching practices and teaching philosophies has also been show to improve self-efficacy (Ashton, 1984). Studies into staff development have shown that cooperative and collegial relations aid teachers' efforts to improve their teaching practice (Anderson, et al., 1988). Teacher cooperation has been cited as providing opportunities for resolving an individual teacher's difficulties in the classroom (Smylie, 1988). Networking provides a perfect environment for teachers to interact with and support each other. This support system is especially critical given the difficulty experienced by preservice teachers in meeting at the same time at one place.

Research studies have shown that prospective teachers' self-efficacy beliefs improve as a result of experiencing the methods class and their student teaching experience. The control group exhibited an increase in science teaching self efficacy indicating the importance of the methods class and field experiences in improving efficacy. However, the science teaching self-efficacy of the networked group was greater than was the non-networked group on posttest scores. Clearly, the difference in the mean scores on posttest on STEBI-B, supports the hypothesis that the networked environment has a positive impact on the science teaching self-efficacy of preservice elementary teachers.

Personal Science Teaching Efficacy

1. Preservice elementary teachers in an electronically networked environment demonstrate better personal science teaching efficacy as compared to preservice elementary teachers in a non-networked environment.

2. Both groups (networked and non-networked), exhibited significant improvement in their personal teaching self-efficacy from the pretest to the posttest.

Discussion

Personal science teaching efficacy is defined as a teacher's belief in his/her own ability to teach science effectively. Successful field experiences have been cited as contributing to improvement in prospective teachers' personal science teaching efficacy (Cole, 1994; Ross, 1994; Spector, 1990; Vinson, 1995; Wilson, 1994). The positive impact of field experiences can explain the gains made by both the groups in personal teaching efficacy.

The networked group, in addition, demonstrated a greater improvement in PSTE as compared to their non-networked counterparts. Networking can provide opportunities for reflection and feedback as well as opportunities for discussion of reflective thoughts with peers. Group interaction and sharing of ideas improves efficacy (Dutton, 1990). Dutton (1990) also describes the positive effects of feedback and discussion with colleagues. Social interactions are important in improving personal efficacy (Watters & Ginns, 1995). Clearly, preservice elementary teachers in the networked environment may be expected to develop greater confidence in their ability as they teach. The networked activities included posting about their classroom projects and environment. Quite apart from the benefits of reflection associated with this, is the opportunity afforded for evaluation of their own performance. Also, seeing similar others succeeding, or improving their skills can convey a vicarious sense of self-efficacy that they can learn as well (Schunk, 1985). The accomplishments of those with similar personal attributes such as gender, race, and academic background, are often viewed as indicators of one's capabilities (Rosenthal & Bandura, 1978). The additional advantages of a networked environment may explain the better personal efficacy scores in the experimental group.

Science Teaching Outcome Expectancy (STOE)

1. Preservice elementary teachers in an electronically networked environment do not demonstrate better science teaching outcome expectancy as compared to preservice elementary teachers in non-networked environment.

2. An analysis of the gain made by each group revealed that only the networked group had a significant improvement in the science teaching outcome expectancy scores. The gain made by the non-networked group was non-significant and small.

Discussion

Science teaching outcome expectancy refers to the expectation or belief that specific teaching techniques will result in desirable outcomes in students (science achievement of students). Previous research reported that outcome expectancy remained unchanged or decreases as a result of student teaching or field experience (Spector, 1990; Woolfolk & Hoy, 1990). This, consistently observed decline in STOE, is postulated to have occurred because prospective teachers are inexperienced in classroom management techniques that lower their ability to teach effectively. However, Zeichner (1990) showed that when student teachers were taught using an inquiry oriented approach, their science teaching outcome expectancy did not decrease. Both the experimental and control groups experienced hands-on, minds-on science methods courses. This may be one reason why their science teaching outcome expectancy did not decline in either group.

The increase in science teaching outcome expectancy for the networked group may be attributable to the reflection and social interaction occurring over the electronic network. Reflection plays an important role in enabling teachers to analyze their inefficacy (Ashton, 1984). Ashton notes that operating from an analytical perspective, teachers would be less likely to succumb to a state of helplessness. Feelings of helplessness have been shown to be caused by poor outcome expectancy ('universal helplessness') and personal efficacy ('personal helplessness') (Ashton & Webb, 1986). Feelings of helplessness arise due to an inability to isolate factors that contribute to feelings of inefficacy. Contact with expert teachers improves outcome expectancy (Ross, 1992). Participants in this study interacted with students and mentors on the listserv. The networked environment provided a forum for discussion of ideas, and providing feedback on ideas that worked and did not work. Moreover, the science mentor who was available throughout the period of this study, provided valuable insight into scientific concepts, and ideas for science teaching. Mentors often offer students support, explain why certain situations occur and suggest better ways of doing things in the classroom (Kay, 1990; Odell, 1990) Clearly, such information, if assimilated, will improve science teaching outcome expectancy.

Conclusions from Interview Data

Analysis of interview data revealed themes that indicate that for the networked group there were several advantages that was otherwise not available to prospective teachers (during their science methods course as well as student teaching). These include constant access to peer support (both emotional and curricular), access to resources on the Internet (such as lesson plan ideas and age appropriate hands-on activities). They also had online help and mentorship from science experts as well as their science methods teacher. Prospective teachers indicated that they regarded electronic networking as a means to ensure professional development as well as maintain a support system for the future. Time was considered a constraint for those who did not have access to a computer at home.

Students with low efficacy in the experimental group indicated their willingness to persevere to teach science better in the future. They indicated a confidence in their ability to teach science. For these teachers, the electronic networking was not only a means for their educational success, but also a means to improve their students' learning process. The ability to reflect over the electronic networks and receive feedback and constructive criticism was indicated by both the 'high' as well as the 'low efficacious' as contributing significantly to their development as a science teacher.

Implications

The findings of this study show that an electronic networked approach improves the science teaching self efficacy and personal science teaching efficacy in preservice teachers. The experimental group in this study demonstrated an increase in outcome expectancy that is contrary to previous findings that indicate that outcome expectancy declines through student teaching. It is thus important to look at ways of providing preservice elementary teachers with support and a means of communication during student teaching.

An important goal of any teacher education program is the training of effective teachers. Clearly, rather than provide teachers with "ready-made" solutions, teachers should be equipped to solve problems that arise in their classrooms. The implication here is that providing prospective teachers with the tools and the resources to help them teach science effectively is of utmost importance. It is evident from this study that electronic networking offers numerous resources for the prospective teacher. Therefore, incorporating a networked approach to student teaching and the methods classes seem logical and essential given prospective elementary teachers' negative attitudes towards and concerns about teaching science.

The networking activity in this study promoted a collaborative and cooperative attitude among participants and provided a forum for interaction with mentors, subject matter experts and supervisors. Bringing about long term and effective change to teacher education programs will require the collaboration of diverse groups of stakeholders across the post secondary educational sectors. By using electronic networks, it is possible to maintain a collaborative and interactive program that involves post-secondary science faculty, science educators, various methods teachers, and practicing teachers, who interact with and guide prospective teachers.

Time is a significant constraint on the activities that may be undertaken in a student teaching semester. Therefore, it is preferable that students enter the science methods and student teaching course understanding and feeling comfortable with the basics of networking (i.e., e-mail, accessing the web, and posting on newsgroups and mailing lists). It is thus imperative that teacher educators implement the use of telecommunications at an early stage of preservice training and integrate its use throughout their professional development program. Programs that incorporate activities over the networks should provide ample time for students to interact. Initiating network based activities at least a semester before their final semester should provide ample time for students to feel comfortable using the technology.

For preservice elementary teachers, a planned and well thought out set of activities over the networks (as provided in this study) would be a model in terms of experiencing the benefits of technology integration in an academic setting. Prospective teachers are more likely to incorporate the technology of the networks into their curriculum and classroom activities after having experienced the benefits of electronic networking for themselves, and the access to resources on the 'Net,

Colleges of Education are increasingly incorporating technology of electronic networking and telecommunications into their programs and technical help and support is no longer a major issue. The need of the hour is to support teacher educators in gaining an understanding of the importance of this technology, and the skill to integrate it successfully into their programs. The fear of being overburdened and lack of time, can be successfully overcome by careful planning, through appropriate training in the use of technology in the educational setting. A corollary to this is preparing prospective teachers (students) to use this technology, as well as inculcating in them the understanding that they need to be active rather than passive learners.

Recommendations

It is important to see how preservice elementary teachers' sense of efficacy relates to their teaching practices and classroom behaviors. The present study did attempt to look at student teachers' teaching strategies in relation to their efficacy scores. However, this was not a detailed attempt. Conducting such a study with preservice teachers can provide valuable information about their efficacy beliefs and how these are translated into teaching behaviors. Observation of teaching behavior and examining how these behaviors change over time as efficacy change will offer tremendous insight into the construct of efficacy and its importance from an educational standpoint.

Self efficacy is a construct that consists of the subconstructs of personal teaching efficacy and outcome expectancy. Outcome expectancy and personal teaching efficacy are postulated to be independent subconstructs. It is not very clear how similar scores on overall efficacy, composed of differing scores on outcome expectancy and personal teaching efficacy, translate into teaching behavior and motivation. A qualitative study can trace the impact of the sub-constructs of personal teaching efficacy and outcome expectancy on teacher behavior and motivation.

There have not been any longitudinal studies analyzing how teachers' efficacy evolves through the first years of their teaching careers. Such a study may track the same students through their methods course and after they start their careers. A comparison with students who do not have the benefit of a networked environment will also be useful to understand the impact networking really has on efficacy. Following novice teachers through the first few years of their teaching careers to see the impact of real classroom experience on teachers' sense of self-efficacy and the role of networking during the induction years is important.

Delimitation

The generalizability of the results of this study is limited by the sample selection. Majority of the sample consisted of females, who were predominantly white and from the middle to high socio-economic class. Because of this specificity of gender, race and socio-economic status, caution should be used in generalizing the findings of this study.

Future studies should be conducted to see if gender, race and socio-economic status will make a difference on the effect of electronically networking preservice elementary teachers, to improve their self-efficacy and attitude toward teaching science.

The experimental group also had the advantage of having extra "activities" on-line, in the form of discussion, feedback and mentor support, due to the easy accessibility of these resources through the Internet. These resources were not accessed by the students in the control group to the *same extent*, due to the restrictions imposed by 'conventional' interactions. This could have caused some differences in the extent of help and support that both groups may have received and may have manifested in their posttest scores on the measures of self-efficacy and attitude toward science.

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