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Preservice Early Childhood Teachers' Self-efficacy and Outcome Expectancy for ICT Integration in Science Instruction

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Although research on the integration of information and communication technology (ICT) with science instruction has identified significant benefits to students and teachers, K-12 teachers tend to underutilize ICT in their science instruction. This study used a quasi-experimental design to measure preservice early childhood teachers' attitudes (self-efficacy and outcome expectancy) toward the integration of technology into their science instruction before and after curricular intervention during their science methods course. Both the treatment and control groups showed significant positive change in their self-efficacy scores at the end of the course. Only the treatment group, however, showed a significant positive change in outcome expectancy. Previous research has shown that outcome expectancy is resistant to change as a result of instruction. In light of the results of this study, implications for the instruction of preservice teachers in the use of educational technology to teach science are discussed, as are considerations for future research.

Introduction

ICT Integration

The link between ICT (Information and Communication Technology) and science education is salient. A review of the literature suggested that appropriate ICT integration in science classrooms may improve student learning outcomes (Chandra & Lloyd, 2008), facilitate data collection and encourage interaction

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and communication (Gillespie, 2006), and expand tools and resources available to science teachers (Osborne, 2003). For example in a controlled study, Chandra and Lloyd (2008) found that most boys and lower-achieving girls in the treatment group, who were taught science via a traditional instructional approach in year one and via a blended, e-learning approach in year two, performed better on their end-of-term unit tests than similar students in the control group, who received traditional instruction both years. After reviewing multiple studies on ICT integration in science education, the British Educational Communications and Technology Agency (2003) stated that ICT use “can make science more interesting, authentic and relevant, allow more time for observation, discussion and analysis, and increase opportunities for communication and collaboration” (p. 1).

Despite the great potentials and increasing availability and support of ICT in schools, relatively few teachers are keen to fully incorporate ICT in their instruction (Marcinkiewicz, 1993; Wang, Ertmer, & Newby, 2004). Teachers’ integration of ICT tools in science classrooms is especially insufficient (Cox & Webb, 2004; Cox, Abbott, Webb, Blakeley, Beauchamp, & Rhodes, 2004). Teacher education programs have faced the challenge to prepare students as competent, confident and critical ICT users. In the past decade, various strategies such as technology courses, workshops/training, and technology integration and modeling in all courses (Kay, 2006) have been utilized in teacher preparation programs to introduce ICT to preservice teachers. The cumulative effects of these strategies have resulted in effectively improving pre-service teachers' ICT skills (Polly, Mims, Shepherd, & Inan, 2010). However, increased teacher technology skills may not necessarily lead to effective and meaningful classroom technology integration (Wang, 2002; Zhao & Bryant, 2005). In 1993, Oliver (cited in Albion, 1999) argued that beginning teachers with formal ICT training and veteran teachers without ICT training did not differ in their use of computers for teaching. Almost 20 years later, the same picture was presented in a recent study (The Richard W. Riley College of Education and Leadership at Walden University, 2010), which reported new teachers, even though they might be proficient ICT users, were not more likely to translate their skills into teaching than veteran teachers.

So what has been preventing teachers from ICT integration? Ertmer (1999) categorized barriers to teacher use of ICT in science classrooms as “extrinsic” and “intrinsic”. He referred to “extrinsic” as first order issues including technology access, time, training and support, and “intrinsic” as second order issues consisting of teachers’ attitudes and beliefs. He argued that technology integration was unattainable with first order barriers existing. However, even if first order obstacles are removed, teachers do not automatically integrate technology into their pedagogy. There are an increasing number of studies suggesting that teacher beliefs in and attitudes toward their capacity of using technology effectively may significantly impact their classroom ICT integration (e.g. Albion, 1996; Marcinkiewicz, 1993; Oliver & Shapiro, 1993).

Self-Efficacy and Outcome Expectancy

Self-efficacy theory describes the interrelationships among behavior, self-efficacy and outcome expectancy (Bandura, 1997). According to Bandura (1977), an individual’s behavior is largely influenced by two constructs: self-efficacy and outcome expectancy. Bandura defines self-efficacy as an individual’s belief in his or her capability to accomplish a specific task, while outcome expectancy refers to a person’s expectation that accomplishing a task will produce a certain outcome (Bandura, 1977, 1982, 1997). People who possess both high outcome expectancy and self-efficacy would act in a confident manner and persist longer on a task (Bandura, 1977).

Following this theoretical framework, teaching behaviors may be predicted based on teaching self-efficacy and teaching outcome expectancy, with teaching self efficacy defined as a teacher’s belief in his or her ability to teach a particular topic or employ a specific strategy and teaching outcome expectancy defined as a teacher's belief that student learning can be positively impacted by effective teaching (Enochs, Smith & Huinker, 2000). Gibson and Dembo (1984) suggested that "teachers who believe student learning can be influenced by effective teaching [outcomes expectancy beliefs] and who also have confidence in their own teaching abilities [self efficacy beliefs] should persist longer, provide a greater academic focus in the classroom, and exhibit different types of feedback than teachers who have lower expectations concerning their ability to influence student learning" (p. 570). Haney, Lumpe, Czerniak, & Egan (2002) found that science teachers with high self-efficacy were more likely to design lessons that promote student-initiated inquiry, encourage collaboration among students, and include significant, worthwhile, and relevant content.

This study examined the impact of low-level instructional intervention in the use of interactive software to teach early childhood science on the self-efficacy of preservice teachers. The following research question was addressed: Does the participation in two 2-hour instructional sessions enhance the self-efficacy and outcome expectancy of early childhood preservice teachers for integrating technology into their science instruction?

Method

Subjects

Subjects were enrolled in one of two sections of a science methods course for early childhood teachers at a medium-sized, Midwestern university in the United States. Determination of treatment and control group status was based on availability of the researchers to provide the treatment protocol. Prior to their participation, all subjects completed two required courses in classroom technology and two content science courses as part of their teacher preparation program. The experimental group was composed of 27 females and 1 male, all self-identified as White, non-Hispanic. Two students held four-year university degrees and 1 had completed a master's degree. The control group included 24 females and 2 males, with 23 self-identified as White, non-Hispanic, 2 African American and 1 Hispanic. Two students held two-year degrees and 7 had completed a four-year degree.

Treatment

All subjects completed two course assignments that required the use of technology to teach a science concept. Assignment 1 required students to work in small groups to produce a virtual field trip to a community resource to teach about a science concept of their choosing. Assignment 2 required students to individually demonstrate the use of an interactive feature or lesson for a SMART Board to teach a science concept, or to demonstrate the use of an interactive Web 2.0 tool to teach a science concept.

Students in the experimental group received 2 hours of instruction that highlighted free or commonly available technologies that can be easily integrated into early childhood science instruction. Instruction, which consisted of demonstrations and student interactions with the technology, was provided by two of the authors (Li and Herman) during a regularly scheduled science methods session. These students also received a handout of useful resources. Approximately two weeks later, students in the treatment group had a second 2-hour session in which they received additional instruction and were able to ask questions specific to a technology with which they were working. These students were not allowed to work on their technology assignments during these instructional sessions, only receive instruction on how to utilize the different technologies.

Students in the control group received no technology instruction during their science methods course. Instead they engaged in teacher-facilitated hands-on activities to learn how to implement inquiry-based science teaching. These students did, however, receive the handout of useful resources distributed to the treatment group to refer to as they worked on their technology assignments outside of class.

Data Collection and Analysis

On the first and last day of class, all subjects completed the Technology Integration in Science Belief Instrument (TISBI), which is a modified version of The Science Teaching Belief Instrument for Preservice Teachers (STEBI-B) (Enochs & Riggs, 1990). The instrument consists of 23 statements scored on a 5-point Likert scale (Strongly Agree, Agree, Uncertain, Disagree, Strongly Disagree). The statements were organized into two scales, randomly distributed: Self-Efficacy scale (SE) and Outcome Expectancy scale (OE), which consisted of 13 items and 10 items, respectively.

Modifications to the STEBI-B statements to develop the TISBI typically consisted of substituting “teaching” with “integrating” and “science” with “technology”. For example, the original instrument included the statement, “Even if I try very hard, I will not teach science as well as I will most subjects.” The TISBI modification was, “Even if I try very hard, I will not integrate technology in science as well as I will in most subjects.”

Although the modifications to the STEBI-B are substitutions of terminology rather than wholesale statement substitutions, such changes can affect an instrument’s reliability (Bleicher, 2004); hence, item analyses were conducted of the survey items in the SE scale and items in the OE to determine if the elimination of one or more items would obtain a better measure of each scale. The reliability of the TISBI and its subscales was determined by Cronbach’s alpha. Negative survey items were reverse scored to enable proper analysis. Two-tailed t-tests, with alpha set at 0.05, were performed to examine pre- and post-treatment scores for within- and between-group differences before and after treatment. All analyses were performed using SPSS 17.0.

Results

Based on the results of the item analyses, the elimination of question 7 produced a better measure of the OE scale; therefore, only 9 items in the OE scale were included in subsequent analyzes. Using Cronbach's alpha, the overall reliability or internal consistency of the TISBI was $\alpha = .743$, with the SE scale scoring $\alpha = .809$ and the OE scale scoring $\alpha = .686$. Table 1 summarizes the overall TISBI mean scores and the mean scores of the SE and OE scales for the treatment and control groups. Although the alpha values for both scales of the TISBI are slightly lower than those computed for the STEBI-B by Enochs and Riggs (1990) and Bleicher (2004) (SE scale = .90 and .87, respectively; OE scale = .76 and .72, respectively), the values are similar and the trend is identical. Therefore, the TISBI was considered acceptably reliable for this study.

No significant difference in the pre-treatment scores were found between the treatment and control groups on the overall TISBI (t = -1.892, df =53, p = .064), the SE scale (t = -1.709, df = 54, p = .093) or the OE scale (t = -1.102, df = 53, p = .275). Likewise, after the treatment was administered, no significant differences were found between the treatment group and control group on the overall TISBI (t = -.471, df =53, p = .640), the SE scale (t = -.858, df = 53, p = .395) or the OE scale (t = .252, df = 53, p = .802).

On the other hand, when pre- and post-treatment scores were examined within each group, both the treatment group and the control group showed significant gains in the overall TISBI score (treatment group: t = -7.113, df = 27, p = .000; control group: t = -6.865, df = 24, p = .000) and on the SE scale (treatment group: t = -5.652, df = 27, p = .000; control group: t = -4.231, df = 24, p = .000). However, only the treatment group showed a significant gain on the OE scale (treatment group: t = -2.018, df = 27, p = .047; control group: t = -.322, df = 24, p = .750).

Table 1. *Pre-and post-treatment means on both scales of the Technology Integration in Science Belief Instrument for the treatment group*

	Pre-treatment *M*		Post-treatment *M*		Change	
	Treatment	Control	Treatment	Control	Treatment	Control
Total TISBI Score	75.39 (*n*=28)	82.36 (*n*=25)	87.04 (*n*=28)	90.88 (*n*=25)	11.57** 14.68%	8.52** 10.34%
SE TISBI Score	45.86 (*n*=28)	48.69 (*n*=26)	52.32 (*n*=28)	53.39 (*n*=26)	6.46** 14.09%	4.69** 9.63
OE TISBI Score	33.04 (*n*=28)	33.92 (*n*=25)	34.71 (*n*=28)	34.20 (*n*=25)	1.68* 5.1%	.28 .83%

**p<.000; *<.05

Discussion

This study used a quasi-experimental approach to investigate the impact of content-specific instruction in the use of interactive software on preservice early childhood teachers' self-efficacy and outcome expectancy to integrate technology into their science instruction. The findings indicated both groups showed significant gains in self-efficacy (SE), but only the treatment group showed a significant gain in outcome expectancy (OE).

The work of Bandura (1977, 1982, 1997) has clearly established that self-efficacy and behavior are highly correlated and self-efficacy is a robust predictor of behavior. Meanwhile, an increasing number of researchers have argued that self-efficacy and outcome expectancy may be self-sustaining and they both may have separate influence on behavior (Gao, Xiang, Lee, & Harrison, 2008). For example, Maddux, Sherer, & Rogers (1982) and Maddux & Rogers (1983) studied the relationship between self-efficacy and outcome expectancy and the effects of both factors on individuals' intentions to perform a behavior. The findings of their studies indicated that outcome expectancy had significant effects on behavior intention and influenced participants' self-efficacy beliefs.

These findings are supported by the study of Schwarzer and Fuchs (1995), which suggested for men, outcome expectancy (instead of self-efficacy) might play a more important role to motivate cancer screen behaviors. For women's cancer screen behaviors, although outcome expectancy seemed to play a minor role, low self-efficacy could be compensated by a high level of outcome expectancy. Maddux and Rogers (1983) further concluded that "outcome expectancy may have two avenues of influence on behavior change: (1) by directly causing changes in intentions and behavior and (2) by causing changes in self-efficacy expectancy that subsequently influence behavior" (p. 477). That is to say, both self-efficacy and outcome expectancy may be significant predictors of teaching behaviors (Ramey-Gassert & Shroyer, 1992).

Outcome expectancy is an important predictor of whether a person's behavior will change (Williams, 2010). However, the results of previous studies indicate that OE is resistant to positive change. For example, in a study on the effects of curricular intervention on the attitudes of middle school science teachers, Haney, Wang, Keil & Zoffel (2007) found that teachers' self-efficacy improved significantly from pre- to posttest; however, they did not see a statistically significant change in outcome expectancy. Plourde (2002) found that the student teaching experience produced a negative change in outcome expectancy in preservice science teachers.

Implications

The fact that, in this study, even modest instructional intervention in the use of technology integration in science instruction produced significant positive change in preservice teachers' outcome expectancy suggests that systemic approaches to technology integration in science methods courses may lead to more frequent and more effective integration of technology in early childhood classrooms. This may be accomplished through authentic, content-specific integration exercises within educational technology courses for preservice teachers and through additional instruction and integration experiences in subsequent methods courses.

Limitations and Future Studies

As interesting as the findings are, the limitations of the study should be noted. First, this study utilized a quasi-experimental design. Students were assigned to either the control group or the treatment group based on the classes in which they were enrolled. Random selection of participants was not employed. Therefore, this study may be weak in controlling threats to internal validity, specifically selection. Before they participated in the study, the control and treatment groups may not have been equivalent in certain characteristics such as academic performance level, technology skills and motivation. These preexisting group differences may have influenced the research results. It is important to note, however, that in order to control these possible differences, all students had a minimum cumulative G.P.A of 3.2 or higher and had completed two courses in educational technology and science content. Furthermore, no significant between-group differences were found for the three subscales on the pre-treatment administration of the TISBI. Future studies should involve random selection of participants, using a control group, to better understand the impact of technology integration modeling on early childhood preservice teachers' perceptions of technology-related self-efficacy and outcome expectancy.

Another limitation lies in the population used in this study. Participants were early childhood pre-service teachers enrolled in one of two sections of a science methods course. Findings of this study may not be generalized to other populations, such as student teachers or practicing teachers. In addition, findings of this study may not be generalized to other courses or content areas. Future studies are needed to address whether the findings of this study are observed in other populations and settings.

This study focused on self-efficacy and outcome expectancy. Future studies should include a wider spectrum of participant attitude surveys to determine science and technology points of view. Additionally, a number of internal or external factors, such as technology background, skills, and usage habits should be factored into the analysis

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