Preservice Elementary-school Teachers' Beliefs Related to Technology Use in Mathematics Classes

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Abstract:
The beliefs of preservice elementary-school teachers regarding the use of basic calculators and *Illuminations* activities were investigated. The goals of the study were to describe preservice teachers' beliefs, identify the sources of those beliefs, and determine which interventions successfully modify them. Participants included 210 undergraduates majoring in elementary education or special education. Results indicate that many preservice teachers oppose the use of calculators during mathematics instruction. Teachers report that this belief is related to their own elementary-school experiences and to their own computational abilities. Other teachers believe that calculators and computers can be used as teaching tools but caution that they should not be over used. An introductory methods course positively affected the beliefs of preservice teachers. Researcher-designed calculator interventions did not significantly affect their beliefs. Preservice teachers who have use *Illuminations* activities have very favorable beliefs about them and plan to use them in their classes.

The No Child Left Behind Act drew increased attention to student achievement (Smith, Arbaugh, & Fi 2007). Because of this increased attention, numerous studies have been conducted to identify factors associated with higher achievement. These studies have indicated that one of the teaching practices associated with student achievement is the use of technology (Ellington 2006, 2003; Smith et al.). Because of the correlation between technology use and achievement, many organizations recommend that technology be used during instruction (e.g. National Council of Teachers of Mathematics [NCTM] 2000; United States Department of Education 2004). The use of both calculators and computers in mathematics instruction has been found to improve students' attitudes (Ellington 2004), problem solving skills (Ellington 2003), and standardized test scores (Smith et al.). Calculator and computer use in high school is commonly accepted, but children as young as preschoolers can also effectively use both calculators (Huinker 2002) and computers (Clements & Sarama 2007).

In spite of state and national policies that encourage the use of technology in mathematics education, many teachers rarely use it (Barron, Kemker, Harmes, & Kalaydjian 2003). Teachers who do use technology during instruction often use it for drill-and-practice (Smith et al. 2007), which is not the practice recommended by teacher educators (Van de Walle 2004) or correlated with higher achievement (Smith et al.). Because teachers' beliefs affect their teaching practices (Brinkerhoff 2006), many teacher educators have stated that one of the purposes of professional development is to impact teachers' beliefs (e.g. Lim & Chan 2007). However, teachers' beliefs are the cumulative result of many years of schooling (Ball, Lubienski, & Mewborn 2001; Lortie 1975), and can, therefore, be difficult to change (Pajares 1992). This research was conducted to describe the beliefs of preservice elementary-school teachers regarding calculator and computer use in mathematics instruction, identify the sources of those beliefs, and to determine which methods-course activities most successfully modify them.

Literature Review

Research has shown that calculator and computer use can increase U.S. student achievement (Tarr, Uekawa, Mittag, & Lennex 2000; Smith et al. 2007) and improve student attitudes (Ellington 2004). However, technology seems to be under-used in the U.S. For example, 37% of fourth-grade students rarely or never use a calculator during mathematics instruction (Grouws et al. 2004) and in only 11% of secondary-education mathematics classes do students use computers frequently (Becker 2001). Teachers' beliefs may be one of the causes of the under-use of technology (Albion & Ertmer 2002; Brinkerhoff 2006). Therefore, many professional development efforts have been aimed at modify teachers' beliefs about the use of technology during instruction. These professional development efforts seem to be successful with some, but not all, teachers. The reasons for this have not been fully investigated.

Purpose

The study had four purposes: (1) to describe the beliefs of preservice elementary-school teachers regarding calculator and computer use, (2) to investigate the effects of four 30-minute, researcher-designed interventions on the beliefs of preservice elementary-school teachers regarding calculator use, (3) to determine the sources of preservice elementary-school teachers' beliefs about calculator use, and (4) to describe the reactions of preservice elementary-school teachers to the applets featured on the NCTM-sponsored *Illuminations* website (http://illumination.nctm.org).

Methods

This study was conducted during the spring semester of 2007 at a large urban university in the south-eastern United States. Participants were divided into three groups, two types of experimental groups and one control group. Participants in the control group completed researcher-designed surveys on beliefs about calculator use at the beginning and end of the semester. Participants in the first experimental group completed these surveys and also engaged in four 30-minute researcher-led interventions designed to familiarize teachers with expert-recommended uses of four-function calculators (Huinker 2002; Coburn 1988). Participants in the second experimental group completed researcher-led investigations of six applets featured on the NCTM-sponsored Illuminations website (http://illuminations.nctm.org).

Participants

Participants included 210 undergraduates majoring in elementary education or special education. Seven sections of mathematics methods courses participated. Participants in five of the seven sections (n=146) were enrolled in an introductory mathematics methods course; participants in the other two sections (n=63) were enrolled in an advanced methods course. Almost all of the participants were female juniors or seniors. About 85% were traditional college age and about 80% were Caucasian.

Five sections of the introductory course participated. Three of these were designated as control sections (n=85) and two were designated experimental sections (n=61.) Although the researcher has taught the course in the past, none of the participating sections of the introductory course were taught by the researcher. The five sections were taught by four instructors including two professors and two doctoral students. One of the doctoral students taught one experimental and one control section.

Two sections of the advanced course participated. Both sections were taught by the researcher and participants in both sections engaged in the *Illuminations* interventions described below. Seven of the 63 teachers in the advanced class were male.

Interventions

Interventions Used in the Introductory Course

Participants in the two experimental sections completed four researcher-led interventions intended to familiarize teachers with calculator activities that promote active learning and higher-level thinking (Huinker 2002; Coburn 1988). During the interventions, participants were encouraged to share and discuss their beliefs regarding the use of calculators during mathematics instruction. Participants in the two control sections were assigned to read the textbook (Van de Walle 2004) and participated in class discussions regarding the use of technology in elementary-school mathematics instruction, but did not participate in the researcher-led interventions.

Interventions Used in the Advanced Course

Participants enrolled in the advanced methods course completed in-class, researcher-led investigations of six applets on the NCTM-sponsored *Illuminations* website (http://illuminations.nctm.org). The six *Illuminations*

applets used in the study were *Cubes*, *Cube Nets*, *Fire*, *Shape Sorter*, *Turtle Pond*, and *Random Drawing Tool – Individual Trials*. These six applets were chosen to match the mathematical content covered in the advanced methods course (Geometry, Measurement, and Probability.) Participants in the advanced course investigated two applets during each of three class periods. Exploration of each applet lasted about 15 minutes, for a total of about 90 minutes. Following each of the three class periods in which participants investigated *Illuminations* applets, participants wrote answers to three open-ended questions. Examples of these open-ended questions appear in the next section. Near the end of the semester, participants then completed a seven-item, researcher-designed Likert-scale survey designed to measure their beliefs regarding the usefulness of *Illuminations* activities and the teachers' perceptions of their ability to guide elementary-school students through *Illuminations* activities. This Likert-scale survey is also described below.

Instruments and Data Analysis

Instruments Used in the Introductory Course

Participants in the introductory course completed two types of surveys. These participants complete a survey at the beginning and end of the semester; these surveys were used to calculate gain scores. Participants in the experimental sections also completed a short survey after each of the four researcher-led calculator interventions; these surveys were meant to measure the effectiveness of each of the four calculator interventions.

Beginning- and End-of-Semester Calculator and Computer Surveys

Participants enrolled in the introductory course completed researcher-designed surveys at the beginning and end of the semester to determine their beliefs about the use of four-function calculators and computers during mathematics instruction. The surveys were designed in consultation with a measurement specialist and a faculty member in Mathematics Education. The survey used at the beginning of the course included 20 items, 17 Likert-scale and three open-ended. The survey used at the end of the semester contained the 20 items from the beginning-of-semester survey and also contained an additional six items meant to investigate teachers' perceptions of their changes in beliefs. Numerical values were assigned to each of the Likert-scale responses. Each participant received two scores, one based on each of the two surveys. Gain scores were computed by subtracting each participant's score on the first survey from her score on the second survey.

One of the open-ended items asked participants to "Write any comments you may have about any changes in your beliefs and opinions that may have occurred over the course of the semester." Another open-ended item asked participants to write a statement about their beliefs regarding the use of calculators in elementary-school mathematics. A third asked participants to write about the *source* of their views on the use of calculators in elementary-school mathematics. A fourth asked "To what extent do you believe computers should be used to teach math in elementary school? Please explain." The researcher identified common responses and calculated the percentage of participants responding with each of these responses.

Calculator Intervention Surveys

Participants in the two experimental sections participated in four researcher-led calculator interventions in which the researcher presented research on the effects of calculator use and activities from Huinker (2002) and Coburn (1988). Following each of these interventions, participants in the experimental sections completed a short survey designed to measure the effect of the intervention on teachers' beliefs. Each survey contained five Likert-scale and one open-ended question. For example, the first Calculator Intervention presented methods of using basic calculators with students in first and second grades (ages 6 and 7.) The Likert-scale prompts on the Calculator Intervention Survey that followed this intervention asked participants to "Circle the response that matches your feelings and opinions about each item." One of the items read "Suggestions of specific ways to use calculators with first and second graders." Participants were asked to indicate whether hearing about these suggestions had no effect on their opinion, a small effect, a large effect, or circle "I doubt whether the activities would work with first and second graders."

Instrument Used in the Advanced Course

Near the end of the semester, participants in the advanced course completed a researcher-designed survey intended to summarize teachers' reactions to *Illuminations* applets. This survey contained seven Likert-scale items. Participants were asked to circle one of five responses ranging from "strongly disagree" to "strongly agree." An example of an item on the *Illuminations* survey is "*Illuminations* activities would help elementary-school students understand concepts more deeply or in a different way than completing worksheets or working out of a textbook." Another item on the survey was "I plan to use *Illuminations* activities with my elementary-school students."

Results and Discussion

Teachers' Beliefs Regarding Calculator and Computer Use

The most common beliefs expressed by preservice teachers upon entrance into their first mathematics methods course included the following: (1) students should learn the "basics" before using or in addition to using calculators, (2) calculators can be used effectively during mathematics instruction, and (3) students should not rely on calculators to find the answers to mathematics problems. Most preservice teachers seemed to be open to occasional or restricted calculator use but also feared that calculator use had the potential to harm students' computational skills. Many participants emphasized the importance of computational skills. For example, one participant wrote "I think it is very important for kids to learn the basics like +, -, x, & ÷. I would have students memorize the [multiplication] tables." This is consistent with other researchers' finding that teachers fear that calculator use will prevent students from learning "the basics" (Bright 1994).

At the beginning of the introductory methods course, the preservice teachers were generally favorable to the use of computers during instruction, but also cautioned that computer use should not replace traditional instruction and that students should not rely on computers. In response to the question "To what extent do you believe computers should be used to teach math in elementary school? Please explain" about half of the respondents stated computer use should not replace traditional instruction. For example, one teacher wrote "I think once a week students should be able to do math 'labs' on the computer, but I don't think it should be the sole means of learning for them." Another teacher wrote "Computers should be used to enhance a lesson not teach one."

Effects of an Introductory Methods Course

The mean gain scores in all five sections of the introductory course were positive. This indicates that an introductory methods course helps align the beliefs of preservice teachers to NCTM recommendations regarding technology use in mathematics classes. This is true regardless of whether or not the methods course focused on the use of technology. Participants in both the control and experimental sections indicated that the textbook (Van de Walle 2004) and class discussion influenced their beliefs. For example, one participant wrote, "The textbook's viewpoint, as well as what we've discussed in class makes a lot of sense. NCTM has good info on it as well. Because of all of this, I have a better understanding of how helpful calculators can be." Another participant wrote, "When I first started to take MAE 4310 I was against [the use of calculators in mathematics classes.] I felt it made students lazy. Now that I have taken this course I see the benefits of using a calculator."

Effects of Four Calculator Interventions

Neither of the means of the experimental sections was significantly different than the gain scores of the control groups. One of the experimental sections had a mean gain score higher than any of the mean gain scores of the control sections, although the difference was not statistically significant. However, the other experimental section had a mean gain score that was lower than the gain scores of two of the control sections. In the control sections, 84% of the participants' gain scores were positive. In one of the experimental sections, 64% of the gain scores were positive whereas in the other experimental section, 91% of the gain scores were positive. Classes in which the mean gain score was high also tended to have higher standard deviations in the gain scores. In the experimental group with the lowest average gain score, the instructor reported that some of the teachers may have resented an outsider (the researcher) coming into the class to conduct the calculator interventions. Because the calculator interventions were led by someone other than the class instructor, the teachers seem to have felt that the interventions were unrelated to

class content. Based on these results, the researcher cannot state whether four 30-minute interventions can have an effect on the beliefs of preservice teachers. It may be the case that specific circumstances of this study prevented the interventions from being more effective, or it may be the case that short-duration professional-development efforts are generally ineffective. Although the four calculator interventions did not significantly raise the average gain score, individual participants seem to have benefitted. For example, one teacher wrote "I learned calculators do not make children lazy. Rather, they allow the child to get easy computation they already know done easily so the rest of their attention can go towards learning the new task at hand."

Sources of Teachers' Beliefs

Besides the methods course, the largest influences on teachers' beliefs about calculator use seem to be teachers' own elementary-school experiences and teachers' computational weaknesses. 49% of the participants indicated that their own elementary-school experiences affected their opinions. For example, a participant wrote, "I think I believe that calculators should not be used solely to solve problems because when I was in elementary school, I wasn't allowed to use calculators. Students should not rely on something to do the work for them. They need to know how to do it on their own."

Many participants indicated that their own computational weaknesses are linked to their beliefs about the use of calculators. For example, a participant wrote, "I believe students shouldn't use them because it hindered my learning process. Once I became comfortable with using a calculator, I stopped practicing my concepts of math and somewhat forgot how to do them." Another participant wrote, "I believe [that calculators should not be used too often] because I actually experienced it first hand. We were allowed to use a calculator I think too often. I am now very dependent on a calculator and a lot of the time wish I wasn't."

Teachers' Reactions to *Illuminations* Activities

Results indicate that a large percentage of preservice teachers who have used *Illuminations* applets enjoy using them and believe they help students learn. A smaller percentage of teachers state that they plan to use the activities in their classrooms. Of the 63 participants enrolled in the advanced methods course, 47 completed the *Illuminations* questionnaire. Each of the 47 participants responded to all seven prompts. The first prompt read "The activities on the Illuminations website are a valuable resource for elementary-school teachers." Of the 47 respondents, 43 (91%) circled either "agree," or "strongly agree." Another prompt read "I plan to use Illuminations activities with my elementary-school students." Of the 47 participants, 27 (57%) circled either "agree" or "strongly agree."

Implications for Practice

Teacher educators should recognize that teachers enter professional development programs with an established set of beliefs (Pajares 1992). These beliefs affect teachers' responses to the professional development. Teachers often hold beliefs that are inconsistent with the recommendations and standards issued by national (NCTM 2000) and international (ISTE 2007) education organizations. When teachers' beliefs are inconsistent with the recommendations and standards of organizations, teacher educators should help modify teachers' beliefs. Addressing teachers' beliefs through class discussion and reflection are effective ways to modify them. Researchers and teacher educators should continue to focus on the role beliefs play in teacher learning.

Implications for Research

Many studies have sought to show that a particular teacher education program is effective, which is usually interpreted to mean that it has an effect on the average teacher or on most teachers. Too little research has focused on the individuality of teachers and recognized that teachers respond differently to professional development. This study has indicated that teachers' reactions to professional development can vary widely and that their reactions may depend on their relationship with the teacher educator. Future research should determine whether these finding hold true in other situations as well and identify other variables that affect the ways teachers react to professional development.

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