

Inservice and Preservice Teachers' Attitudes Regarding the Use of Graphing Calculators to Support Inquiry Learning in Mathematics

Iris Johnson

Abstract The purpose of this study was to examine and compare the beliefs of inservice and preservice teachers regarding the use of graphing calculators to support inquiry-based learning of mathematics. Data were collected from approximately 80% ($n = 135$) of the inservice teachers who were participating in a graduate level mathematics course designed to enhance their mathematical content and pedagogical content knowledge during the summer of 2005. A random sample of 31 of the 108 questionnaires completed by the inservice teachers who taught grades 6-8 were analyzed in this study. A random sample of 31 out of 65 questionnaires completed by preservice teachers from an earlier, related study (DeLoach Johnson, 2004) was also analyzed.

Analysis of data from the two-part questionnaire yielded significant differences between the two groups favoring the inservice teachers on two variables: proponents of inquiry as a way of learning mathematics ($F(1,60) = 16.092, p < .001$) and proponents of the use of graphing calculators to support that learning ($F(1,60) = 18.603, p < .0001$). A significant difference between the two groups favoring the preservice teachers was found with regards to participants' support for statements that were less in favor of the use of graphing calculators ($F(1,60) = 8.507, p < .01$). Fisher's PLSD confirmed the likelihood of the significance of these differences with $MD = 11.097, p = .0002$; $MD = 10.516, p < .000$; and $MD = -4.516, p = .0050$, respectively.

Although there were significant differences between the groups with regards to the variables mentioned above, the overall response to graphing calculator use to support learning mathematics by inquiry was not as strong as desired (e.g., typical per-item mean on these variables ranged from 2.089 to 2.874 on a 0.00-4.00 Likert-style scale). Both preservice and inservice teachers indicated a preference for learning mathematics best without using the graphing calculator (mean 2.891 where 4.0 was associated with "strongly agree"). Statistically significant differences between the two groups also revealed that preservice teachers were more inclined to indicate a preference for learning a mathematics concept that is taught first without a graphing calculator and checked later with the graphing calculator ($F(1,60) = 105.005, p < .0001$).

Introduction

Although graphing calculators were certainly not available in the 1920s, one might argue that responses to the roles of technological innovations in the classroom haven't changed much since then. With the introduction of the motion picture, the portable radio, teaching machines, educational television, and the microcomputer society's responses seem to be fairly consistent—failing to benefit from previous experiences with such innovations. Beginning with an announcement of the technological innovation as a great gift to education with virtually limitless potential, soon the assessment changes to regard the same innovation as a suspect tool capable of detracting from learning more so than enhancing it. "The cycle always began with big promises, backed by the technology developers' research. [However,] in the classroom, teachers never really embraced the new tools, and no significant academic improvement occurred" (Oppenheimer, 2003, p. 6).

Is it possible that society often looked to these new tools to radically change or *replace*, rather than merely enhance or supplement, previously accepted modes of learning? Support for appropriate use of calculators in the mathematics classroom was given by the National Council of Teachers of Mathematics (1989) almost 20 years ago when they stated that calculators should be "available to all students at all times" (p. 124). However, confusion about the terms of availability and use methods of may have helped to fuel some myths and hence may have prompted NCTM to offer three separate statements regarding the importance of technology in mathematics education. These three statements are provided in the Technology Principle (NCTM, 2000), the position statement on "The Use of Technology in the Learning and Teaching of Mathematics (NCTM, 2005a), and the position statement on "Computation, Calculators, and Common Sense" (NCTM, 2005b). The last of these statements, adopted in July, 2005 emphasizes balance "between the use of electronic aids and paper-and-pencil computation" (NCTM, 2005b, p. 6). The statement goes even further to reveal that the balance is not just between two entities—electronic or not—but also includes estimation and mental mathematics skills.

Of the many studies that investigated various variables related to the teaching and learning of mathematics using graphing calculators since the publication of the first NCTM (1989) *Standards* the

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findings typically support appropriate calculator usage (Allison, 2000; Blume & Heckman, 1997; Brawner, 2001; Bridgeman, Harvey, & Braswell, 1994; Burton, 1996; Cassity, 1997; Ellington, 2000; Graham & Thomas, 2000; Harskamp, Suhre, & Van Streun, 2000; Hubbard, 1998; Rodgers, 1995). Results of these and similar studies also tend to be associated with better student achievement scores; decreased or no gender/ethnic differences in academic performance; better understanding of numbers, variables, functions, algebraic reasoning and problem solving; and improved student attitudes toward mathematics. Yet the body of classroom teachers who still shy away from using the graphing calculator appropriately on a regular basis still persists (Dunham, 1999). We continue to wait for the majority of classroom teachers of grades 6-16 to embrace this tool, and to guard against some of the common myths about calculator usage (Pomerantz, 1997).

Although the importance of the role of the classroom teacher in supporting appropriate usage of technology has been noted previously (Ball & Stacey, 2005; NCTM, 2000), the more recent NCTM (2005b) position statement might clearly point to the necessary and sufficient conditions for bringing the graphing calculator to its proper place in the mathematics classroom: the existence and nurturing of skillful teachers who know

...how to help students develop ... abilities in a balanced program that focuses on mathematical understanding, proficiency, and thinking.... [who] help students learn when to use a calculator and when not to, when to use pencil and paper, and when to do something in their heads. ... [These teachers help] students ... become fluent in making decisions about which approach to use for different situations and [become] proficient in using their chosen method to solve a wide range of problems. (NCTM, 2005b, p. 6).

Most of the participants of this study were working towards this goal, increasing their skill in these areas. Thus, the researcher wanted to investigate whether the inservice teachers who had more experience in the mathematics classroom and had also participated in a recent professional development designed to address some of the areas described above (e.g., pedagogical content knowledge, increased content knowledge, and experiences rich in mental mathematics and estimation) might respond differently to the questionnaire than preservice teachers. This interest led to the following research question:

Is there a statistically significant difference between inservice and preservice teachers with regards to their beliefs regarding the use of graphing calculators to support learning mathematics by inquiry?

Method

Sample There were two groups of participants in this study: preservice and inservice teachers of middle school mathematics. The 95 preservice teachers were enrolled in a middle childhood mathematics program (for Grades 4-9) in a Midwestern university with approximately 16,000 undergraduate students on its main campus (of four campuses—with two stateside regional campuses and one international campus). The 135 inservice teachers taught mathematics (for Grades 4-9) in southwestern Ohio, representing approximately 150 schools and 70 charter, parochial, private, and public school districts. Teacher participants had elementary, middle childhood, or secondary certification/licensure and had 2-15+ years of teaching experience.

Preservice participants were required to take three inquiry-rich mathematics courses and three regular mathematics courses during the four years of their undergraduate program in middle childhood mathematics education. The first inquiry-rich course taken after Calculus I focused on the structures of arithmetic and algebra. This course required regular use of the graphing calculator, but also employed other calculation techniques such as paper-and-pencil, mental math, and estimation. Students typically took this course during the second semester of the freshman year or the first semester of their sophomore year. The second inquiry-rich course was a geometry course, which involved regular use of Geometer's Sketchpad, infrequent use of a graphing calculator, and other techniques such as paper-and-pencil and estimation. This course was typically taken during the sophomore or junior year, along with a course in statistics or discrete mathematics. The third inquiry-rich course typically occurred in the senior year as a capstone experience bringing together the concepts and processes learned in the six mathematics courses taken previously.

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During the summer of 2005, approximately 135 classroom teachers participated in a professional development experience that exposed them to activities of The Rational Number Project (Cramer, 2003) and other standards-based activities. All participating teachers were given a pre- and post-test of mathematics content knowledge and pedagogical content knowledge, but only 108 (80% of 135) completed the questionnaire regarding the use of the graphing calculator to support inquiry learning. Of this number, 60 taught grades 6-8.

To respond to the research question a questionnaire was adapted from a previous study (DeLoach Johnson, 2004) and administered to these two groups. Data analysis was carried out with a random sub-sample from both groups: 31 preservice teachers and 31 inservice teachers.

Survey

Survey items were taken from salient points made in the literature as well as survey questions of previous studies (Damjanovic, 1999; DeLoach Johnson, 2004; Heflich, Dixon, & Davis, 2001; Fey & Smith, 1999; Forster & Taylor, 2000; Nicol, 1999; Simonsen & Dick, 1997; Tharp, Fitzsimmons, & Ayers, 1997). The two-part survey permitted investigation of several components of the teachers' beliefs and attitudes in alignment with inquiry-rich experiences and use of graphing calculators in the mathematics classroom to support such learning.

Survey questions were grouped together to form composite variables to identify beliefs that may be closely associated with characteristics of inquiry learning (inquiry), traditional learning/teaching (non-inquiry), and use of graphing calculators (proponent (pro) or non-proponent (con)). Table 1 shows the mean values for the composite variables and per-item means.

Table 1

Analysis of Survey (Parts I and II) – Composite Variables (Mean and SD)

Composite Variable	Number of Survey Items	Range of Possible Highly Positive Scores (all 3s-all 4s)	Mean Value (SD) for Respondents	Per-Item Mean (SD) Value for Respondents
Pro-Inquiry	27	91-108	74.422 (11.613)	2.708 (0.364)
Con-Inquiry	11	33-44	32.031 (4.486)	2.874 (0.339)
Pro-Graphing Calculator	22	66-88	57.188 (10.165)	2.515 (0.403)
Con-Graphing Calculator	16	48-64	33.125 (7.083)	2.089 (0.724)

Results

Analysis of data from the two-part questionnaire yielded significant differences between the two groups favoring the inservice teachers on the two variables: pro inquiry as a way of learning mathematics ($F(1,60) = 16.092, p < .001$) and pro use of graphing calculators to support that learning ($F(1,60) = 18.603, p < .0001$). (See Table 2.) A significant difference between the two groups favoring the preservice teachers was found with regards to participants' support for statements that did not favor the use of graphing calculators ($F(1,60) = 8.507, p < .01$). (See Table 2.) Fisher's PLSD confirmed the significance

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of these differences with $MD = 11.097, p = .0002$; $MD = 10.516, p < .0001$, and $MD = -4.516, p = .0050$, respectively.

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Table 2

ANOVA Results Comparing Inservice and Preservice Middle School Mathematics Teachers Regarding Attitudes about Learning Mathematics by Inquiry, Using Graphing Calculators to Support that Learning, and Learning Concepts First Without a Graphing Calculator and Checking With a Graphing Calculator

		<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F-Value</i>	<i>p-Value</i>
Pro-Inquiry	Group	1	1908.645	1908.645	16.092	.0002
	Residual	60	7116.710	118.612		
Pro-Graphing Calculator	Group	1	1714.129	1714.129	18.603	<.0001
	Residual	60	5528.581	92.143		
Con-Graphing Calculator	Group	1	316.129	316.129	8.507	.0050
	Residual	60	2229.548	37.159		
Learn First w/o Graphing Calculator	Group	1	311.629	311.129	105.005	<.0001
	Residual	60	178.065	2.968		

Of the 62 respondents, 25 indicated they lacked confidence and skill with graphing calculators, 40 indicated they were learning more about how to use a graphing calculator, yet 51 indicated they would like more training in the use of graphing calculators. These responses were in alignment with those made by teachers in previous studies who cited the need for continuous and effective professional development to help them feel comfortable with the use of graphing calculators in the class (Tharp, Fitzsimmons, & Ayers, 1997; Simonsen & Dick, 1997). Teachers in previous studies who became more skillful after receiving such professional development typically supported a more balanced program as described in the 2005 position statement (Forster & Taylor, 2000; Heflich, Dixon, & Davis, 2001; NCTM, 2005; Tharp, Fitzsimmons, & Ayers, 1997; Simonsen & Dick, 1997).

Conclusions, Limitations, and Implications

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Results of this study—not yielding overwhelmingly positive results—appear to indicate that classroom teachers whose mathematics content knowledge and pedagogical content knowledge has been updated in a professional development experience may tend to feel more favorable about the use of graphing calculators to support learning mathematics by inquiry than preservice teachers. A desirable scenario for both groups would include experiences with a stronger emphasis on the appropriate uses of graphing calculators in addition to such methods as paper and pencil, estimation, and mental mathematics. Future research should document the types of graphing calculator functions experienced and the degree to which a balance of presentation (i.e., sound pedagogy, strength in content, use of other means of finding results) accompanied those experiences.

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