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Mathematics Education Doctoral Students' Attitudes Toward Statistics

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Abstract

This study examines mathematics education doctoral students' perspectives of statistics. Several studies have been conducted regarding undergraduate students' attitudes toward statistics during their experiences in introductory statistics courses (e.g, Gal, Ginsburg, & Schau, 1997; Wise, 1985). Far fewer studies have been conducted regarding teachers' attitudes toward statistics (e.g, Begg & Edwards, 1999; Greer & Ritson, 1994). One area of research that has not been explored concerns mathematics educators' and mathematics teacher education faculty members' attitudes toward statistics. This area of research is especially important given the impediments statistics educators have encountered when trying to increase the depth and quality of statistics education in the K-12 setting. Results show there is a need to emphasize statistics more broadly in the preparation of mathematics education doctoral students.

Keywords: statistics education, attitudes, statistics, doctoral education

1. Introduction

This study examines mathematics education doctoral students' perspectives of statistics. Several studies have been conducted regarding undergraduate students' attitudes toward statistics during their experiences in introductory statistics courses (e.g, Gal, Ginsburg, & Schau, 1997; Wise, 1985). Far fewer studies have been conducted regarding teachers' attitudes toward statistics (e.g, Begg & Edwards, 1999; Greer & Ritson, 1994). One area of research that has not been explored concerns mathematics educators' and mathematics teacher education faculty members' attitudes toward statistics. This area of research is especially important given the impediments statistics educators have encountered when trying to increase the depth and quality of statistics education in the K-12 setting.

The fight to include statistics in the K-12 curriculum has been a challenging effort for statisticians and statistics educators. As Shaughnessy stated almost twenty years ago, "Teachers' backgrounds are weak or nonexistent in stochastics and in problem solving. This is not their fault, as historically our teacher preparation programs have not systematically included either stochastics or problem solving for prospective mathematics teachers" (1992, p. 467). This concern still exists for Shaughnessy (2007), as "Most K-12 teachers in the United States have very little background in statistics" (p. 995). Over the past several years, statistics educators have called for courses focused on the teaching and learning of statistics to be included in teacher preparation programs (e.g., Author, Year; Kader & Perry, 2002). However, research regarding teacher preparation programs reveals that statistics is still not a major component of preservice teachers' coursework (Author, Year).

Mathematics educators' attitudes may be one of the obstacles to the inclusion of statistics in the K-12 setting as well as in teacher preparation programs. Mathematics educators are generally former teachers of mathematics from a variety of levels. Research concerning teachers' attitudes toward statistics reveals that teachers hold a negative disposition toward the subject (e.g., Author, Year; Begg & Edwards, 1999; Greer & Ritson, 1994). Perhaps, one of the major causes for teachers' views toward statistics is that they do not really understand the nature of statistics and the process of statistical thinking. This study investigated mathematics education doctoral students' attitudes toward statistics during a doctoral seminar focused on statistical literacy, reasoning, and thinking.

2. Method

2.1 Participants

Eleven graduate students studying for their doctorate of philosophy with an emphasis in mathematics education participated in this study. Seven of the participants were in their first year, two in their second, and two in their third year of doctoral study. All participants expressed an interest in preparing future teachers upon the completion of their degree. Of the participants, 10 were female and 1 was male. Furthermore, 8 of the participants were Caucasian, 2 were African American, and 1 was Asian.

2.2 The Statistics Education Course

The goals of the course were to investigate research and theoretical perspectives related to teaching and learning statistics as well as to examine the importance of statistical (quantitative) reasoning in the K-12 setting. The class met once a week for three hours over a 16- week semester. Readings were centered on issues associated with statistical literacy, reasoning, and thinking (Ben-Zvi & Garfield, 2004). After establishing a theoretical framework regarding the definitions of statistical literacy, reasoning, and thinking, topics extended to students' reasoning related to: 1. Data analysis; 2. Graphs and distributions; 3. Average; 4. Variation; and 5. Samples and inferences. The course concluded with discussion of issues and research on assessment of statistical ideas, teachers' understandings of statistics, and professional development aimed at improving teachers' understandings. As a requirement of the course, doctoral students had to propose a research study to explore a topic related to statistic education and situate their study within relevant literature.

2.3 Measures

The primary instrument used in this study was the Attitudes Toward Statistics (ATS) Scale developed and validated by Wise (1985). This survey consists of 29 items with two subscales: Attitudes Toward Course and Attitudes Toward Field. Participants rated the items on a scale from strongly disagree (1) to strongly agree (5). The Attitudes Toward Course items are phrased in terms of being enrolled in a statistics course. The Attitudes Toward Field items measures attitudes toward the discipline of statistics in general. Reliability and validity of these scales were re-examined by Schultz and Koshino (1998). In their re-analysis of the instrument, they determined that the reliability for the Attitudes Toward Course subscale was 0.59 and 0.71 when used with undergraduate and graduate students, respectively. The values for the Attitudes Toward Field subscale were 0.72 and 0.76 for undergraduate and graduate students, respectively.

In addition to the ATS, three qualitative writing [?] prompts were provided to the doctoral students at the end of the course: 1. How did you feel about statistics before the course? How do you feel now? 2. In relation to the five content standards, where did you put statistics in order of importance for the K-12 curriculum before the course? Where do you place it now? and 3. As a future mathematics educator, how do you feel the course influenced the way you will prepare future teachers to teach statistics?

2.4 Analysis

Attitudes Toward Statistics. The 29 item ATS survey contained 20 items in the Field subscale and 9 items in the Course subscale. Each participant's responses were totaled for a prestest and posttest score in each subscale. Items with negative stems were reverse-coded as described by Wise (1985). The Shapiro-Wilk test for normality was used to determine if a dependent *t*-test was appropriate to explore differences between the pretest and posttest data. This test, as well as exploration of the graph of the normal probability plot and frequency distribution histogram, revealed that the data violated the normality assumption. Therefore the Wilcoxon Signed-Rank Test, the non-parametric equivalent to the *t*-test, was used to analyze the data.

Qualitative Prompts. An inductive analysis strategy (Hatch, 2002) was chosen because it begins with the specifics of participants' words and moves to "looking for patterns across individual [words], then arguing for those patterns as having the status of general explanatory statements" (Potter, 1996, p. 151). The data were systematically analyzed to look for patterns in the responses to each question.

3. Results

3.1 Attitudes Toward Statistics

Descriptive statistics and results from the Wilcoxon Signed Ranked Test for each subscale of the ATS are displayed in Table 1.

Table 1. ATS Pretest and Posttest Analysis

	Pre		Post			
Subscale	*M*	*SD*	*M*	*SD*	*Z*	*p*
Course	23.4	5.43	18.7	3.17	-2.38	0.017*
Field	60.8	7.01	72.4	3.08	-2.94	0.003**

Note: *Significant at the 0.05 level; **Significant at the 0.01 level

3.2 Qualitative Prompts

How did you feel about statistics before and after the course? Two changes in students' thinking emerged from the data regarding participants' feelings toward statistics: 1. Statistics is different than mathematics; 2. Statistics is a

problem-solving process focused on concepts and reasoning rather than a set of procedures to carry out. Representative comments from participants are provided for each conclusion.

Statistics is different than mathematics.

- Readings about these topics changed my thinking. I had never considered statistical thinking as something necessarily different from numerical thinking. However, I now perceive statistical-related thinking/literacy/and reasoning as associated with variation whereas mathematics tends to act as if variation does not necessarily exist within the real world.
- I didn't realize statistics is different from mathematics; it was taught to me with a major emphasis on the mathematical calculations so I never realized it was anything other than that. The articles we read, and some of the discussions helped me to understand how mathematics is a tool for statistics.
- Now, I see statistics as something related to mathematics. Statistics is a much broader content area than what I thought. It encompasses every aspect of our lives – as students, as professionals, as consumers.

Statistics is a problem-solving process focused on concepts and reasoning rather than a set of procedures to carry out.

- I think being aware that statistics is not the same as mathematics is important for me, but also realizing that the types of thinking and reasoning necessary for success in statistics are similar to what's necessary for success in mathematics is key. I do not think I ever really thought about teaching statistics to all students (we sometimes forget it when we rattle off the things children should learn) but now I will not forget it.
- The course has been very helpful in making us believe that statistics is not knowing about the definition and procedure of certain statistical concepts. It is much more than that.
- I view statistics as more than a course taught in a classroom. It's a way of thinking and reasoning about the data around us…thrown at us from every angle in newspapers, magazines, business reports, etc. Students should question the world around them and be able to intelligently critique, analyze, and interpret data, problems, and solutions.

In relation to the five content standards, where did you put statistics in order of importance for the K-12 curriculum?

Nine of the 11 participants responded to this prompt. Prior to the course, 7 of the 9 indicated that they would rate statistics last among the five content standards whereas the other 2 participates rated it in the middle or second from last. After the course, ratings changed dramatically. Three of the 9 rated statistics as the most important content students should learn, 3 rated it as the second most important, and 3 rated it in the middle.

As a future mathematics educator, how do you feel the course influenced the way you will prepare future teachers to teach statistics?

The students communicated two ways that the course had influenced their perspectives. First indicated that there is a deficiency in terms of statistics that must be addressed through teacher education, and second that here is a need to show preservice teachers that statistical thinking is different than mathematical thinking. They noted that this thinking can encourage problem-based learning and problem solving and help change the way we teach mathematics. Representative comments from participants are provided for each of the conclusions .

There is a deficiency in terms of statistics that must be addressed through teacher education.

- I have realized for some time now how much teachers can be apprehensive about teaching mathematics. With statistics, it is added pressure and anxiety. As a future mathematics educator, this course made me even more aware of this problem. I am already thinking of ways to help preservice teachers to understand statistical concepts to be able to teach them effectively.

There is a need to show preservice teachers that statistical thinking is different than mathematical thinking. This thinking can encourage problem-based learning and problem solving and help change the way we teach mathematics.

- I will use the research I've been introduced to help show the difference between making students think and analyze versus just crunching numbers and getting a numerical value as an answer. I will show

teachers at all levels how to incorporate problem-based learning and items from the media instead of having their students create a bargraph or figure out the mean, median, and mode for a given set of numbers.

- I think learning about statistics, and the thinking and reasoning involved with that, will help make stronger mathematics students. So it's important to me to prepare future teachers to understand what statistics really is, what the statistical problem solving processes are, and what implications that has for children and young adults.
- Statistical thinking and problem solving are essential. We need to work on getting this type of thinking into our elementary, middle, and high school curriculum. Overall, mathematical teaching needs to focus on conceptual understanding rather than rote memory.

4. Discussion

The quantitative results reveal that the doctoral students' attitudes toward the field and statistics courses were significantly influenced by their exposure to theoretical foundations and research associated with statistical literacy, reasoning, and thinking. The 11 participants revealed varying positive shifts in their dispositions toward statistics. The results revealed that the doctoral students entered the course with a slightly negative disposition toward statistics; however that disposition changed once their conceptions of statistics were problematized by the content in the course.

The qualitative comments made by the doctoral students reveal a clear shift in their definitions and thinking of statistics, impression of the importance of statistics in the K-12 curriculum, and ideas associated with the importance of preparing teachers to teach statistics. The last shift is fundamental as most teacher preparation programs only allot 1-2 weeks toward methods associated with teaching statistics (Author, Year).

Results from this study have implications for the statistics and mathematics education communities. First and foremost, a larger study should be conducted of mathematics education doctoral students' and mathematics education faculty' attitudes toward statistics to determine if similar dispositions exist. A study of this kind would provide a snapshot of attitudes toward statistics to help determine whether the negative disposition toward statistics evident in these 11 doctoral students is pervasive among mathematics educators and prospective educations. Second, mathematics educators should work toward including more literature from the statistics education community in doctoral programs in order to help them understand what the statistics communities mean by statistical reasoning, thinking, and literacy. Third, the statistics and statistics education communities should generate a list of potential readings for mathematics education doctoral programs to inform the dispositions of mathematics educators. Increasing insights and perspectives about statistics during doctoral programs may lead to significant changes in the way teachers are prepared to teach statistics.

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