The effect of statistical coursework on preservice secondary teacher understanding of, and efficacies and attitudes toward, statistics learning: The case of Betty

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statistics, preservice secondary teachers, efficacy, attitudes

Contributed Research Report

ABSTRACT

In this qualitative study, I describe the characteristics of Betty, a senior undergraduate mathematics education major, who has never completed a full course in statistics either in high school or at the undergraduate level. To investigate and to provide perspective on Betty's characteristics, Betty and five of her cohorts were administered a series of instruments, which measured statistical understanding, self-efficacy, and attitudes. The participants also developed and presented a statistics lesson and were then interviewed to investigate their confidence in the implementation of their statistics lesson. The results indicate that the lack of a complete statistics course may have contributed to Betty's confidence in her ability to learn statistics, her low confidence levels in her ability to currently perform statistical analyses, her weak understanding of statistical concepts, her unwillingness to take risks on statistical knowledge instruments, and her lack of confidence in her lesson plan.

INTRODUCTION

The role of statistics in the secondary school curriculum has been increasing (NCTM, 1989, 1992, 2000; NCRMSE, 1994) thus increasing the need for secondary school teachers to be prepared to successfully teach statistics topics.

There is evidence that teacher content knowledge and teacher pedagogical content knowledge affect teacher beliefs with respect to method of delivery of lessons (Cooney, 1994; Llinares, 2002; Simon, 1995). Teacher pedagogical content knowledge is dependent on content knowledge (Vacc & Bright, 1999) and teacher pedagogical content knowledge is important in its own right (Ball, Lubienski & Mewborn, 2001). Teacher content knowledge directly affects teacher success. This is true both for mathematics in general (Hill, Rowan, & Ball, 2005) and statistics in particular (Mickelson & Heaton, 2004; Sorto & White, 2004). Examples of this need are ability to respond to surprise questions, unanticipated responses, and unintended outcomes during statistical investigation (Mickelson & Heaton, 2004).

With regard to statistics education, both teacher beliefs and teacher pedagogical content knowledge are dependent on teacher statistical content knowledge. This is cause for concern when paired with evidence that teachers tend to have weak statistical concept skills (Mickelson & Heaton, 2004). Even when statistical reasoning skills are present, teachers tend to perform better in the use of pure statistical knowledge than in application to teaching (Sorto & White, 2004).

Does the absence of a complete course in statistics affect teacher characteristics related to statistics teaching, such as content knowledge, pedagogical content knowledge, willingness to embrace more progressive teaching styles such as discovery learning, various attitudes toward statistics, and confidence in lesson development and execution?

METHODS

The research question was, "What are some unique characteristics of a preservice secondary teacher's knowledge of, and attitudes toward, statistics (as a subject to learn and as a subject to teach) in the case that the preservice secondary teacher has not taken a complete course in statistics?"

The data were collected over a one-semester span in 2007. The six participants were enrolled in a capstone Mathematics Content for Teaching course at a major university in the Midwestern United States. The objective of the course involved identifying, and pedagogically addressing, concepts that are known to be difficult for secondary students to learn. This material was assimilated from all levels mathematics content typically taught from 7^{th} to 12^{th} grades.

The mathematics teaching content course involved four weeks (out of 15) of statistics content. The statistical content covered in the course included concepts that secondary students are likely to have difficulty learning, such as identifying and dealing with outliers. The course objectives included having the students discuss ways to address such content pedagogically. The culmination of the statistics content involved each student choosing a particular statistics topic that would pose difficulties for secondary students, to write a lesson plan to teach this topic while addressing particular concerns about content learning, and to implement the lesson in class using cohorts as the students. Students participating in the study also completed an interview that addressed their statistics lesson shortly after the lesson was presented.

Near the end of the statistics content, the participants completed a survey consisting of five separate instruments. The instruments measured (1) general attitudes toward statistics as a field of study (ATS-F), (Wise, 1985), (2) attitudes toward the statistics material in the current course, (3) self-efficacy toward current ability to perform statistical procedures (CSSE), (Finney & Schraw, 2003), (4) current self-efficacy to learn statistics in the future (SELS), (Finney & Schraw, 2003), (5) statistical reasoning using the ARTIST scales (StatReas), (delMas, Garfield, Ooms, Chance, 2005), and (6) the SCI statistics knowledge instrument (A Stone, K Allen, TR Rhoads, TJ Murphy, 2004). Each of the instruments has been tested for reliability and validity (see references). The knowledge instrument was designed for higher scores to correlate with better statistical knowledge. All other instruments were Likert-type with higher scores correlating to more positive attitudes or self-efficacy. Each of the 6 instruments had a ratio level of measurement, so a score of zero was possible.

The SCI instrument included 38 questions. The SCI instrument includes a wide range of content and difficulty levels ranging from introductory statistics content to upper-level undergraduate statistical content. Hence some of the material was beyond the training of the preservice secondary teachers in the cohort. This condition provided opportunity to observe student willingness to attempt statistical problems that the participant might have little confidence in answering correctly.

I quantitatively compared the results of each instrument between participants and of each participant between instruments. I transcribed the audio-recorded interviews to text and analyzed the transcriptions. During qualitative analysis of the interviews, I searched for comments indicating levels of participant confidence in (1) the choice of statistical concepts to present, (2) the preparation of the lesson plans, (3) the administration of the lesson, and (4) toward statistics in general.

RESULTS AND DISCUSSION

For the ARTIST statistical knowledge instrument, Betty scored 32.5% correct. The range of scores for her cohort was 32.5% to 67.5% correct with a mean of 51.7%. The scores were 32.5, 41.6, 49.4, 53.2, 66.2, 67.5. Betty had the lowest score on this statistical knowledge instrument. For the SCI instrument, Betty attempted only 12 problems out of 38. The number of problems attempted by each person in the cohort was 12, 25, 27, 32, 36, 38. Betty correctly answered 7 of the 12 problems she attempted. The number of correct responses in the cohort was 7, 11, 11, 13, 16, 20. Although Betty correctly answered much fewer problems than the rest of the cohort, she correctly answered 58.3% of the problems she attempted which was the highest percentage in the cohort for problems correct out of problems attempted.

In each of the four affective measures, confidence to perform statistical analyses (CSSE), confidence in ability to learn statistical concepts (SELS), attitudes toward statistics as a field of study (ATS-F), and attitudes toward the statistics addressed in the current course (ATS-C), Betty scored at an extreme level compared to her cohorts. The CSSE scores were 32, 32, 41, 43, 56, 57. Betty's score was 32. Betty was tied for the lowest level of confidence in her current statistical abilities. The SELS scores were 58, 63, 68, 72, 77, 84. Betty's score was 84. She had the highest level of confidence in her ability to learn statistical concepts. The ATS-F scores were 73, 74, 76, 81, 83, 84. Betty scored 84. Betty had the highest score for positive attitudes toward the importance of statistics as a field. The ATS-C scores were 30, 32, 35, 37, 38, 38. Betty's score was 38. Betty had the highest score for positive attitudes toward the statistics being studied in the current course.

When preparing the statistics lesson plan, Betty spend much time visiting with the professor, discussing her ideas and asking for advice on how to develop the lesson. Betty appeared to recognize her weakness in statistics and even admitted on multiple occasions that she lacked the knowledge and confidence that she would have preferred to have before presenting such a lesson. Her post-lesson interview reaffirmed these traits. She admitted that she lacked confidence in her ability to prepare a statistics lesson, though she felt more confident by the time her lesson was administered due to her preparation with the course instructor on the lesson plans. She admitted that she did not feel confident that she could prepare and present a statistics lesson on her own.

CONCLUSIONS

In the case of Betty, the absence of a full course in statistics was accompanied by multiple personal characteristics related to statistics education, each of which are not desired in a preservice secondary teacher. Betty scored much lower on each of two separate statistical knowledge instruments compared to her cohorts, each of whom had completed at least one full course in statistics. In one of the instruments, Betty attempted much fewer problems than her cohorts, indicating that she was less comfortable taking chances on problems that she felt she might not answer correctly. Although Betty had the lowest score of her cohorts regarding current self-efficacy to perform basic statistical analyses, she had the highest confidence levels toward (1) her ability to learn statistics in the future, (2) her attitudes toward statistics as a field, and (3) her attitudes toward the statistics work in the course. She also showed the most uncertainty of the cohort in her ability to create and deliver her statistics lesson.

There were consistent differences between Betty's results and the results from the cohort in each of the instruments administered. The level at which the lack of a complete statistics course affected these results is unclear. However, when comparing results across all cohort participants, no similar consistencies appear for any particular participant except that the student who ended up with a much higher course grade than all the other participants also had by far the highest scores on both the knowledge instruments. Yet even this person had self-efficacies and positive attitude scores that were each in the midrange of the scores of the six cohort participants. No cohort participant consistently scored in the extreme high or low range of all the instruments except for Betty.

Does a lack of statistical training create unjustified confidence in ones ability to learn statistics? There has been a comparable precedent to this claim. Begg and Edwards (1999) found similar results with primary level teachers who tended to be highly confident in their ability to teach statistics concepts even though there was evidence that the teachers did not have the statistical knowledge levels needed to successfully teach some statistical concepts.

More can be discovered concerning the answers to the research question. A quantitative study could be conducted using a cohort with at minimum 40 participants in each of two subgroups; one groups that has not taken a complete statistics course, and a group in which every member has taken at least one statistics course.

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