

A STUDY OF PRESERVICE TEACHERS' ATTITUDES TOWARD THEIR ROLE AS STUDENTS OF STATISTICS AND IMPLICATIONS FOR FUTURE PROFESSIONAL DEVELOPMENT IN STATISTICS

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I analyze data from the attitudes of 56 preservice primary teachers related to their role as continuing students of statistics. The variables investigated include preservice primary teachers' (1) attitudes toward future professional development in statistics, (2) current knowledge of statistics, (3) current statistical self-efficacy, and (4) current self-efficacy to learn statistics in the future. My results suggest that (1) current self-efficacy to learn statistics in the future is a moderate predictor of preservice primary teacher beliefs that future professional development in statistics will help their classroom teaching, and (2) current self-efficacy to learn statistics in the future can vary for preservice primary teachers throughout their preparation program.

INTRODUCTION

The role of statistics in the primary school curriculum has been increasing (NCTM, 1989, 1992, 2000; NCRMSE, 1994), thus increasing the need for primary school teachers to be prepared to successfully teach statistics topics. A number of factors affect teacher ability to deliver successful lessons. Preservice teacher educators seek to address these factors. Students learn statistics more effectively in settings where collaboration is encouraged and problem solving is the focus (Gal 2002; Lajoie, 1999). Such strategies include the use of progressive teaching methods such as discovery learning. To successfully implement such strategies, teachers must possess the necessary beliefs structures pertaining to K-8 learning of statistics (Wilson & Cooney, 2002).

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). Some studies report that teacher content knowledge affects teacher success, for mathematics in general (Hill, Rowan, & Ball, 2005) and statistics in particular (Mickelson & Heaton, 2004; Sorto & White, 2004). Examples of this need are the teachers' ability to respond to surprise questions, unanticipated responses, and unintended outcomes during statistical investigations (Mickelson & Heaton, 2004).

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 understanding of statistical concepts (Mickelson & Heaton, 2004). Even when statistical reasoning is present, teachers tend to perform better in the use of pure statistical knowledge than in application to teaching (Sorto & White, 2004).

Such concerns about teacher statistical content knowledge and pedagogical content knowledge can be addressed in both preservice training programs and continuing professional development. Heaton (2000) concludes that it is not realistic to try to teach teachers the necessary statistics and pedagogy within a single program. Certain types of knowledge—including an understanding of how students learn specific statistical concepts—are difficult for teachers to obtain in preservice teacher programs. These knowledge types are best obtained in continuing professional development after the teacher has at least two years of experience in the classroom (Heath-Camp & Camp, 1990; Hill & Ball, 2004). So, continuing professional development has a necessary role separate from that of the preservice teacher program. Continuing professional development has been shown to help teacher statistical knowledge (Gal, 2002; Garfield, 1995; Smith, 1998) and to directly improve K-12 statistics instruction (Chadjiapadelis, 1999; Friel & Bright, 1998; Gould & Peck, 2005).

Continuing professional development is an important strategy to remedy the lack of teachers' statistical content and pedagogical content knowledge. A special concern, however, arises with primary level teachers. How do we encourage these teachers to return for continuing professional development? Even those primary level teachers who are interested in furthering their development as teachers may choose from topics such as literacy or science rather than mathematics. Research indicates that the attitudes a person has toward a subject affect that person's willingness to participate in activities related to that subject (Bandura, 1986, 1997; Pajares, 1996). Attitudes toward continuing professional development in statistics of preservice primary teachers are the emphasis of this study. Preservice mathematics teacher educators play an important role in the development of attitudes toward statistics that preservice primary teachers take with them into the teaching field (Lave & Wenger, 1991). If we can identify affective factors that preservice teachers associate with both statistics learning and the importance of continuing professional development in statistics, then we can address those feelings/attitudes/beliefs during preservice teacher training to attempt to increase the likelihood that those preservice teachers will eventually return for continuing professional development.

Do preservice primary teachers have fears of statistics that might limit their interest in continuing professional development in statistics? Research results exist concerning various teacher attitudes toward statistics (Begg & Edwards, 1999; Estrada, Batanero, Fortuny, & Díaz, 2005; Tempelaar, 2003). However, there is little research concerning teacher attitudes as future students of statistics or how such attitudes correlate to other attitudes toward statistics.

METHODS

Due to the lack of existing literature specific to teacher attitudes toward statistics as students of statistics, I needed to conduct a broad investigation. I had no indications about which attitudes, knowledge, or environmental issues might correlate with teacher attitudes toward statistics as students of statistics. To find answers to the questions posed, I used existing instruments that measure a variety of attitudes. I also used an existing statistics knowledge instrument. I designed the study to investigate preservice primary teachers at the beginning and at the end of their prescribed training in statistics. For comparative purposes, the study included participants who were in an introductory mathematics course with preservice primary teachers but were not primary level education majors.

The data were collected over a two-semester (Fall then Spring) span. All participants were enrolled in a major university in the Midwestern United States. Participants came from two sources; a mathematics content course that focused on primary level teaching content and an introductory, freshman level, mathematics course that is a prerequisite for the content course. From the introductory mathematics course there were 81 participants including 12 primary teaching majors and 69 students who were not primary teaching majors. There were 44 participants from the mathematics content course. They came from two sections, one in the Fall (22 participants) and one in the Spring (22 participants). An inexperienced instructor taught the Fall course (Course 1). An experienced instructor taught the Spring course (Course 2). Together, the 44 mathematics content course participants and the 12 primary teaching majors in the introductory course provided 56 preservice primary teacher participants.

The mathematics teaching content course involved three weeks of statistics content that included basics of probability, tree diagrams, simulations, conditional probability, statistical graphs, measures of central tendency and variation, and abuses of statistics. The statistics content in the introductory mathematics course was similar to the teaching content course. Six groups were defined for the study; the 69 participants who were not preservice primary teachers (GenMathNon), the 12 preservice primary teachers in the introductory mathematics course (GenMath12), all 81 of the participants from these first two groups (GenMath), Content 1, Content 2, and the combined participants from Content 1 and Content 2 (Content).

Near the end of the statistics content in each of the respective courses, the participants completed a survey consisting of five separate instruments. The instruments measured (1) general attitudes toward statistics (ATS), (Wise, 1985), (2) self-efficacy toward current ability to perform statistical procedures (CSSE), (Finney & Schraw, 2003), (3) current self-efficacy to learn statistics in the future (SELS), (Finney & Schraw, 2003), (4) statistical reasoning using the

ARTIST scales (StatReas), (delMas, Garfield, Ooms & Chance, 2005), and (5) attitudes toward the pursuit of continuing professional development in statistics (AttPDstat), (author). The instrument measuring attitudes towards statistics contained two integrated categories of questions. The different categories were not revealed to the participants. One category was attitudes toward statistics as a field of study (ATSfield). The other was attitudes toward the statistics material in the current course (ATScourse). The ATS scores equaled the sum of ATSfield and ATScourse.

The instruments from Wise and from Finney and Schraw have all been tested for reliability and validity (see references). The statistical reasoning scale from ARTIST is recently developed and is under investigation for reliability and validity. The AttPDstat scores were based on results from a single Likert-type question, "Do you believe a continuing professional development program in statistics would help you in your classroom teaching?"

The knowledge instrument was designed so higher scores correlate with better statistical knowledge. All other instruments were Likert-type. Higher scores correlated to more positive attitudes or self-efficacy. The data were entered into an SPSS spreadsheet. Variables were assigned to each participant for course, major, and section. ANOVA tests were conducted to seek potential differences in means for each test across the participant groups. Regression analyses were conducted within groups to search for correlations between variables.

For each variable, three separate one-way ANOVA were generated for the participant sets: Content 1, Content 2, and GenMath12; Content 1, Content 2, and GenMathNon; and Content 1, Content 2, and GenMath. The separate ANOVA were necessary because of the overlap of participants in the groups GenMath, GenMath12, and GanMathNon. For each significant ($p < 0.1$) result from the ANOVA, follow-up t-tests were performed for the specific pair of participant groups involved. Separate t-tests were also performed for the pairs GenMath12 and Content, GenMathNon and Content, and GenMath and Content.

Before the ANOVA was performed, ANOVA assumptions were checked. For each category of variable and participant group, a boxplot was generated, and these were compared for relatively consistent variability across participant groups. The variability remained sufficiently consistent for each variable. One AttPDstat data point was removed as an outlier from the Content 1 data. Other outliers were investigated but retained. Normality tests were performed via Q-Q plots. The data were closer to normal for the larger group GenMathNon ($n=69$), but all Q-Q plots indicated relative normality (Lancaster, 2007).

Regression analyses were conducted using the dependent variables SELS and AttPDstats. SELS was chosen based on interesting ANOVA results. AttPDstats was chosen to answer the primary research question, "What cognitive or affective factors, if any, correlate to preservice teacher attitudes toward participation in continuing professional development in statistics?" For the SELS model, the factors tested were: ATSfield, ATScourse, CSSE and StatReas. For the AttPDstats model, the factors tested were: ATSfield, ATScourse, SELS, CSSE and StatReas. In each analysis, stepwise regression was performed. Each model suggested by stepwise regression was checked for multicollinearity between the factors. Coefficients were checked for statistical significance. When these tests were satisfied, a scatterplot comparing the dependent variable with each factor in the model was generated to check for potential nonlinear regression patterns. When such patterns existed, quadratic models were investigated.

RESULTS AND DISCUSSION

Significant differences were found in SELS means between certain groups. SELS was the predictor variable for a regression model that predicts AttPDstat scores. Another regression model was found that predicts SELS scores using the predictor variables CSSE and ATScourse. Additional results from the study can be investigated by referencing Lancaster, S., (2007).

Comparisons of the Means Across Data Sets

After ANOVA, follow-up t-tests indicated differences in the means for self-efficacy to learn statistics in the future between the groups GenMathNon and Content 1 ($p=0.048$) and between the groups GenMath12 and Content 1 ($p=0.057$). These differences were not

significant for the GenMathNon compared to the Content 2 data and for the GenMath12 compared to the Content 2 data. The means for these groups are provided in the boxplots in Figure 1. Why the means are significantly lower for the mathematics content course participants with the inexperienced teacher but not lower for the participants with the experienced teacher is unclear.

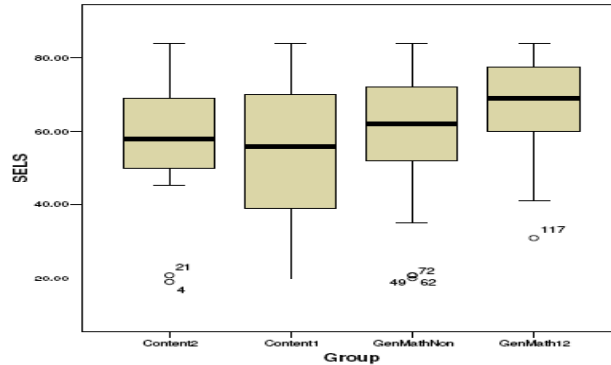


Figure 1. Boxplots for the Variable Self-Efficacy to Learn Statistics in the Future

Linear and Nonlinear Regression Models

Two useful linear models were found: $E(\text{SELS}) = 4.958 + 0.538(\text{CSSE}) + 0.955(\text{ATScourse})$ and $E(\text{AttPDstat}) = 1.217 + 0.029(\text{SELS})$. The first model explained 68.3% of the variance in the SELS scores for the Content participants. This suggests that the confidence possessed by these preservice teachers to learn statistics in the future is somehow associated with both their confidence in their current ability to reason statistically and their attitudes toward the course in which they are currently learning statistics. The second model accounted for 47.3% of the variability in the AttPDstat scores of the Content 2 participants (see Figure 2). This suggests that self-efficacy to learn statistics in the future is moderately tied to participant attitudes toward professional development in statistics.

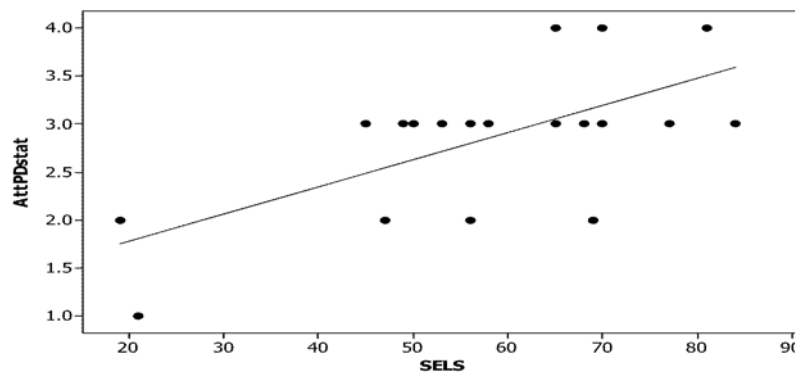


Figure 2. Scatterplot Comparing AttPDstat Versus SELS Scores

CONCLUSIONS

This study indicates that preservice primary teachers' current statistical self-efficacy to learn statistics in the future may affect preservice primary teacher attitudes toward the value of continuing professional development in statistics for improving classroom teaching. The study also indicates that preservice primary teachers' self-efficacy to learn statistics may be affected by a combination of current statistical self-efficacy and attitudes toward the current statistics course. The study suggests that self-efficacy to learn statistics in the future can vary between courses and instructors. These results imply that improvement of preservice primary teacher self-efficacy to learn statistics may improve teacher attitudes toward the value of continuing professional development in statistics. It would also indicate that this self-efficacy could be

improved by improving preservice teacher attitudes toward the statistics content course they are in and their self-efficacy to perform statistics while in that course. It appears that the latter two of these attitudes do not affect attitudes toward professional development unless the change in self-efficacy to learn statistics occurs as well.

The low sample size for each of the three groups of preservice primary teachers restricts the inferences that can be drawn from this study. These results are more suggestive than conclusive. The small number of participants increases the chances that a participant group could yield anomalous results with respect to one or more variables.

The study was not designed to detect evidence of why any differences in means or correlations exist. A subsequent study could be conducted to verify these suggestive results and to explain why any verified results exist. Such a study should reduce the number of variables based on evidence from this study, investigate instructor characteristics qualitatively, and increase the number of participants, instructors and sections involved. The study should be longitudinal and allow for data to be gathered on at least one group of students in three different phases of their training: previous to the introductory mathematics course, during the introductory mathematics course, and during the last content course that addresses statistics topics.

These conclusions do have limitations with regard to teacher preparation, primarily the limited amount of time available for the preservice teacher educator to affect change in the preservice teacher. Many programs have no more than 2 to 3 weeks on statistics material. However, if this is the only exposure preservice teachers have to statistics, even this brief period of engagement may have lasting effects on teacher attitudes.

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