The Influence of Undergraduate Statistics and Statistics Anxiety on Graduate Statistics Success

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Abstract
The purpose of the present study was to investigate the influence of an undergraduate statistics course, statistics anxiety, and attitude towards statistics on success in a graduate statistics course. A total of fifty-three graduate students from a public university in the southeastern United States participated in the study. All participants were working towards their non-STEM Master's degree. Participants were categorized into one of two groups; participants who completed an undergraduate statistics course, and participants who did not complete an undergraduate statistics course. All participants completed a statistics knowledge task on the first day of class (Time 1) and the last day of class (Time 2). Participants also completed the Statistics Anxiety Rating Scale. To determine the unique contribution of an undergraduate statistics course on test performance, an Analysis of Covariance (ANCOVA) was conducted. The independent variable was completion of an undergraduate statistics course (Yes, No), while the dependent variable was performance on a statistics test at the end of the graduate statistics course (Time 2). The covariate variable was performance on a statistics test on the first day of the graduate statistics course (Time 1). After adjusting for the Time 1 statistics test, there was a statistically significant difference at Time 2 between the individuals who had completed an undergraduate statistics class and those who did not complete an undergraduate statistics class, $F(1, 52) = 33.661$, $p < .005$, partial $\eta^2 = .402$. To determine unique contributions of statistics anxiety, a multiple regression, forced entry method, was conducted. The predictor variables were the Anxiety and Attitude subscales of the STARS, while the criterion variable was performance on the statistics test at Time 2. Results revealed that the predictor variables explained a significant proportion of the variance in statistics test performance at Time 2, R=.494, R^2 =.244, Adjusted R^2 = .209, $F(2,43)$=6.942, p< .005. Theoretical and practical implications are discussed.

Key Words: Graduate statistics; education; academic performance, statistics anxiety,

1.0 Introduction

In Fall 2015, for the second time since 1986, graduate applications surpassed two million (Okahana, Feaster, & Allum, 2016). As the desire to attend graduate school grows, educators need to ensure students are well prepared for the rigors of a graduate program. An increasing focus in graduate programs is that of research methodology, which generally includes at least one statistics course (Onwuebuzie & Wilson, 2003). This focus of research may be due in-part to the increased competition between higher education institutions. Research productivity has been associated with an institutions favorable reputation (Dundar & Lewis, 1998). Institutions of higher education may be incorporating a research component in graduate programs as a way of training future academic researchers, as well as generating increased research productivity within the institution. However, this focus on graduate student research may be a challenge for students in non-STEM programs. For example, in non-STEM programs, statistics courses are often viewed by students as among the most anxiety inducing of courses (Chew & Dillon, 2014). This anxiety can influence a student's attitude towards a course (Orobia & Arinaitwe, 2013), as well as an avoidance of courses during undergraduate studies (Ashcraft, 2002). As a result, it's not uncommon in non-STEM programs, for a graduate statistics course to have a mix of students who have and have not completed an undergraduate statistics course. This variability in previous coursework can make teaching and student learning difficult.

How can educators better assist graduate students in the learning of statistics? To explore this question, the present study investigated the relationship between previous statistics experience, anxiety, and attitude, on the act of learning. Specifically, how does previous statistics experience, statistics anxiety, and attitude towards statistics influence the act of learning in a graduate statistics course? This is an important question as graduate programs further emphasize the field of research, knowledge of statistics becomes a critical component to student success.

1.1 Review of the Literature

Experience and the act of learning. There is ample neurological evidence that learning occurs as neurons make new connections and strengthen existing networks within the brain (Hairston et al., 2005; Leuner et al., 2004). These existing networks are formed from previous experience which then forms our knowledge, and are the substrate for constructing new understanding (Zull, 2002). Essentially, we learn by attaching previously learned information with new information.

There is empirical evidence to the importance of experience to the act of learning. A researcher exploring the influence of previous math experience, found in a sample of 246 college students that previous math experience was related to specific aspects of statistics anxiety (Baloglu, 2003). Specifically, an increase in math experience caused a decrease in statistics anxiety. In another study of 1,684 undergraduate students, researchers found that taking more math courses had significant positive impact on student performance in business and economics statistics courses (Green, Stone, Zegeye, & Charles, 2009). Expanding the review to another academic field, Gwazdauskas and McGilliard (2014) explored the influence of previous coursework on pretest and posttest performance in a graduate physiology course. In the sample of 309 students, previous coursework had a significant impact on pretest and posttest performance.

Anxiety and the act of learning. Onwuegbuzie and Wilson (2003) estimate that as many as 80% of graduate students in the social and behavioral sciences experience statistics anxiety. Math including statistics anxiety, can be described as a feeling of tension, apprehension and fear that interferes with performance (Ashcraft, 2002). Possibly one of the most unfortunate outcomes of statistics anxiety, is the avoidance of statistics courses and curriculums that require statistics courses. Generalized to math, when compared with individuals who have low math anxiety, highly math anxious individuals tend to take fewer math courses in high school and college. There is also evidence that math anxiety is negatively correlated with motivation and math self-confidence with correlations ranging between -.47 and -.82 (Ashcraft, 2002). There is additional evidence that math anxiety compromises the functioning of working memory. Specifically, Ashcraft and Kirk (2001) found a significant correlation of -.40 between math anxiety and working memory capacity. That is, as math anxiety increased, performance on a working memory capacity task decreased. Ashcraft and Kirk (2001) suggest that when math anxiety is aroused, it drains working memory resources.

Attitude and the act of learning. Psychologist William James noted, “It is our attitude at the beginning of a difficult task which, more than anything else, will affect its successful outcome” (Bird, 1986 pp. 171). Evidence for this statement can be found experimentally. In a study of 2,400 students, attitude towards mathematics had a significant effect on mathematics achievement (Ajaji, Lawani, & Adeyanju, 2011). Another study found a significant positive correlation between students’ attitude towards learning and academic achievement, and attitudes towards learning and achievement motivation (Bakar et al., 2010). Li (2012) explored the relationship between attitude, self-efficacy, effort, and academic achievement in research methods and statistics courses. Results revealed positive correlations between all four variables.

1.2 The Present Study

The purpose of the present study was to investigate the influence of an undergraduate statistics course, statistics anxiety, and attitude on the act of learning. The act of learning was determined by performance on a statistics test. The study included participants who completed a graduate statistics course. Participants were categorized into one of two groups; participants who completed an undergraduate statistics course, and participants who did not complete an undergraduate statistics course. All participants completed a statistics task on the first day of class (Time 1) and the last day of class (Time 2). Participants also completed the Statistics Anxiety Rating Scale (STARS). Two research questions were explored. *(RQ_1) Does the previous completion of an undergraduate statistics course influence performance in a graduate statistics course? (RQ_2) How does anxiety and attitude influence performance in a graduate statistics course?*

2.0 Method

2.1 Participants

A total of fifty-three (N=53) graduate students from a public university in the southeastern United States participated in the study. All participants were either 1st or 2nd year students working towards their non-STEM Master’s degree. Students and degree programs included 13 students in Higher Education studies, five in Sociology, three in Exercise Science, 15 in Counseling, 15 in Curriculum and Instruction, and two in other programs. The sample included 36 females and 17 males. One participant identified themselves as American Indian / Alaska Native, two as Asian / Pacific Islander, 19 as Black, eight as Hispanic, and 23 as White. A total of 27 participants had not completed a statistics course in the last five years, while 26 had completed a statistics course in the last five years.

2.2 Materials

All materials were created in Qualtrics survey software and completed on desktop computers in a standard classroom. Participants were asked about their gender, ethnicity, and major. The statistics knowledge task is a four item multiple response task of 50 items obtained from a general undergraduate statistics book (Aron, Aron, & Coups, 2008). The topics in the task include; probability, central tendency, variability, standard scores, error, confidence intervals, statistical power, effect size, statistical significance, correlation, regression, t-tests, and analysis of variance (ANOVA). The task includes items that capture understanding of equations, computations, and data interpretation. All questions were populated on the screen to allow participants to scroll the entire task to answer questions in the order they desired. Performance on the task was based on number of items correct out of 50. To document previous statistics course experience, one item asked the following, “Within the past five years, I completed an undergraduate statistics course with a grade of C or better.” The response options were yes or no.

The Statistics Anxiety Rating Scale is a 51 item Likert type scale questionnaire that measures statistics anxiety and attitude towards statistics. The questionnaire includes six subscales; worth of statistics, interpretation anxiety, test and class anxiety, computational self-concept, fear of asking for help, and fear of statistics teachers. There are 23 items with a response option on a five point scale ranging from No Anxiety to Strong Anxiety. Participants are asked to rate items on how much anxiety they experience. Sample items include, Studying for an examination in a statistics course, Doing the coursework for a statistics course, and Waking up in the morning on the day of a statistics test. There are 28 items with a response option on a five point scale ranging from Strongly Disagree to Strongly Agree. Participants are asked to rate their level of agreement on items such as, I feel statistics is a waste, I do not understand why someone in my field needs statistics, and Most statistics teachers are not human. A recent study suggests that three of the subscales; interpretation anxiety, tests and class anxiety, and fear of asking for help, assess statistics anxiety, while the subscales of; worth of statistics, computational self-concept, and fear of statistics teachers, assess statistics attitude (Papousek et al., 2012).

2.3 Procedure

The research protocol was approved by the university Institutional Review Board (IRB). The statistics knowledge task and questionnaires were completed in a classroom where all participants had access to desktop computers. The graduate statistics course is offered in three modalities; traditional 16 week course, online over a 16 week period, or a five week accelerated format. The 16 week traditional course entails students meeting two or three times a week. The accelerated course entails students meeting for five consecutive Saturday’s from 8:30am to 4:30pm. The participants in the present study completed the five week accelerated course.

On the first day of class, participants were instructed to logon to Blackboard and access a series of web links to the task and questionnaires. The participants were instructed to complete the task and questionnaires to the best of their ability and that they had as much time as they needed to complete the tasks. All participants completed the statistics knowledge task first and then the questionnaires. On the last day of class, the participants completed the same statistics knowledge task, but items were randomized.

3.0 Results

All data was exported from Qualtrics into SPSS. The STARS subscale of Anxiety was based on the sum of the 23 anxiety items. The Cronbach’s for the subscale was .945. The STARS subscale of Attitude was based on the sum of the 28 attitude items. The Cronbach’s for the subscale was .955. were computed based on item inclusion as identified by Cruise, Cash, and Bolton (1985). Table 1 presents the Cronbach’s alpha (α) internal consistency reliability coefficients for each of the original six subscales along with the confidence intervals (CI). A criterion value of .70 was set as a cut-off point of acceptable reliability. The confidence intervals were calculated by a method offered by Feldt, Woodruff, and Salih (1987). As can been seen, all subscale scores showed good internal consistency.

Table 1. Cronbach's alpha value, and confidence interval for STARS results

Scale	N	Alpha Value	95% CI
Worth of Statistics	16	.932	.90 - .96
Interpretation Anxiety	11	.902	.85 - .94
Test and Class Anxiety	8	.931	.89 - .96
Computational Self-concept	7	.862	.78 - .92
Fear of Asking of Help	4	.871	.79 - .92
Fear of Statistics Teachers	5	.808	.70 - .89
Total Scale Score	51	.975	.96 - .98

(RQ_1) Does the previous completion of an undergraduate statistics course influence performance in a graduate statistics course? To determine the unique contribution of an undergraduate statistics course on performance in a graduate statistics course, An Analysis of Covariance (ANCOVA) was conducted. The independent variable was completion of an undergraduate statistics course (Yes, No), while the dependent variable was performance on a statistics test at the end of the graduate statistics course (Time 2). The covariate variable was performance on a statistics test on the first day of the graduate statistics course (Time 1). Prior to conducting the analysis several assumptions were validated. The four methodological assumptions included, dependent variable being continuous, the independent variable being categorical, the covariate variable being continuous, and independence of observations were all validated. Additional assumptions were explored by various analyses. There was a linear relationship between Time 1 and Time 2 statistics tests for each level of the independent variable, as assessed by visual inspection of a scatterplot. There was homogeneity of regression slopes as the interaction term was not statistically significant $F(1, 53) = 3.060$, $p = .087$. Standardized residuals for each level of the independent variable were normally distributed as assessed by Shapiro-Wilk's test ($p > .05$). There was homoscedasticity, as assessed by visual inspection of the standardized residuals plotted against the predicted values. There was homogeneity of variances as assessed by Levene's test of homogeneity of variance ($p = .129$). Finally, there were no outliers as assessed by no cases with standardized residuals greater than +/- 3 standard deviations.

Descriptive statistics were reviewed to explore the overall impression of the data. As illustrated in Table 2, participants who completed an undergraduate statistics class outperformed participants who did not complete an undergraduate statistics class.

Table 2. Performance on Statistics test, based on completing an undergraduate statistics course

	Undergrad Statistics	Mean	SD	N
Time 1	No	14.81	4.105	27
	Yes	23.42	5.693	26
	Total			53
Time 2	No	27.15	6.150	27
	Yes	41.15	5.002	26
	Total			53

After adjusting for the Time 1 statistics test, there was a statistically significant difference at Time 2 between the individuals who had completed an undergraduate statistics class and those who did not complete an undergraduate statistics class, $F(1, 52) = 33.661$, $p < .005$, partial $\eta^2 = .402$.

(RQ_2) How does anxiety and attitude influence performance in a graduate statistics course? To determine unique contributions of statistics anxiety, a multiple regression, forced entry method, was conducted. The predictor variables were the Anxiety and Attitude subscales of the STARS, while the criterion variable was performance on the statistics test at Time 2. The assumptions of independence of observations, linear relationship between the Criterion and each of the predictor variables, homoscedasticity, and multicollinearity were all validated. Results revealed that the predictor variables explained a significant proportion of the variance in statistics test performance at Time 2, R=.494, R^2 =.244, Adjusted R^2 = .209, $F(2,43)$=6.942, p< .005.

4.0 Discussion

There is neurological and empirical evidence as to the value of experience in the act of learning (Baloglu, 2003; Leuner et al., 2004; Hairston et al., 2005). Researchers also find anxiety and attitude to be associated with the act of learning (Ashcraft, 2002; Ajaji, Lawani, & Adeyanju, 2011). With the increase in graduate school attendance, educators need to continually explore activities that will help ensure students are well prepared for graduate school. The present study provides evidence to the value of previous coursework and self-concept on the successful completion of a graduate statistics course.

With respect to the first research question *(RQ_1), does the previous completion of an undergraduate statistics course influence performance in a graduate statistics course?* The results were expected. At Time 1, the participants who completed an undergraduate statistics course had an average score of 23.42 (SD = 5.69) or 47%, while the participants who did not complete an undergraduate statistics course had an average score of 14.81 (SD = 4.105) or 30%. At Time 2, the participants who completed an undergraduate statistics course had an average score of 41.15 (SD = 5.002) or 82%, while the participants who did not complete an undergraduate statistics course had an average score of 27.15 (SD = 6.150) or 54%. Unfortunately, while the participants who completed a previous statistics course demonstrated good knowledge of the material at Time 2, the participants with no undergraduate statistics course experience clearly struggled to gain an acceptable knowledge of the material. This is an important finding as more graduate programs include a statistics course, the present study shows the value of an undergraduate statistics course to graduate statistics course success.

Further evidence to the value of undergraduate statistics can be found in medical school research. Wu et al. (2015) conducted a cross-sectional survey of perceived learning of statistics among graduate and undergraduate medical school students. Interestingly, 62.58% of the graduate students felt it was very hard to learn statistics while only 27.2% of the undergraduate students felt it was very hard to learn statistics. This suggests students may be more willing to learn statistics at the undergraduate level than the graduate level. In another study of 121 first year graduate entry medical students, researchers found a strong relationship between the completion and perception of performance in previous mathematics courses, and attitude towards statistics (Hannigan, Avril, & McGarth, 2014). Here the study suggests a value of undergraduate coursework to graduate statistics success.

With respect to the second research question, *(RQ_2) How does anxiety and attitude influence performance in a graduate statistics course?* The results were a expected. The two subscales of the Statistics Anxiety Rating Scale (STARS) being anxiety and attitude explained a significant proportion of the variance in statistics test performance (Adjusted $R^2 = .209$). Future research could explore factors that impact attitude and anxiety such as self-concept. It is possible that self-concept may serve as a mediator between anxiety, attitudes, and course success.

Some strengths and limitations should be noted. A strength of the research is its generality to the broader ethnic population which lies in the diversity of the present sample which consisted of 36% Black, 15% Hispanic, 43% White, and 5% American Indian / Alaska Native, or Asian / Pacific Islander. However, there were a limited number of male participants (28%) in the study. In addition, only graduate students from a public, Southern university were included in the present research.

4.1 Summary

In general, graduate programs are an extension of an undergraduate program. Students in graduate programs expect to take more advanced courses than they experienced in their undergraduate studies. It's a progression of coursework for example; taking an introductory college math course, then an undergraduate statistics course or courses, and for those attending graduate school, advanced courses in statistics. This progression allows for the steady learning of more complex topics. Unfortunately, students taking a graduate statistics course may not have followed a typical progression of courses. For example, non-STEM undergraduate programs such as Education, typically do not include a statistics course as a required program component. However, students in graduate programs in Education, often times will be required to complete a graduate statistics course. The present study provides evidence that students entering masters and doctoral level programs who did not complete an undergraduate statistics course, may be at a disadvantage when it comes to the graduate statistics requirement. In this instance, the student may not have the knowledge to successfully comprehend the content of the graduate statistics course.

The present study has practical and theoretical implications. Practically, graduate program developers should consider including an undergraduate statistics course as a prerequisite for acceptance into graduate programs, particularly the programs that include a statistics course. Theoretically, researchers could explore various aspects of undergraduate statistics courses. It is possible that specific content, student performance, and amount of time between the undergraduate and graduate statistics course may influence graduate statistics performance. Additionally, researchers could further explore the relationship between factors such as anxiety, and attitude on success in a graduate statistics course.

In summary, as educators, our priority should be the development of curriculums that maximize the students' potential for success. A detailed evaluation of the students past experiences, and development of appropriate prerequisites, particularly for math based courses like statistics, should play a more prominent role in graduate curriculum development.

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