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Reducing Anxiety and Increasing Self-efficacy within an Advanced Graduate Psychology Statistics Course

Abstract

In this study we assessed the usefulness of a multifaceted teaching framework in an advanced statistics course. We sought to expand on past findings by using this framework to assess changes in anxiety and self-efficacy, and we collected focus group data to ascertain whether students attribute such changes to a multifaceted teaching approach. Statistics anxiety significantly decreased and students' current statistics self-efficacy increased. Further, course performance was positively correlated with self-efficacy and a strong negative relationship between statistics anxiety and self-efficacy was documented. Focus group data suggested students appreciated aspects of this teaching framework and that they thought it served to reduce anxiety. In addition to this teaching framework, two instructional techniques were used to teach two specific statistical concepts. These techniques did not result in significant performance differences; however, students reported enjoying the activities and encouraged their use in future classes. Overall, this study suggests a multifaceted teaching framework may be useful in helping graduate students overcome anxiety and increase self-efficacy when completing an advanced statistics course. The research presented here adds to the growing literature concerning the importance of non-cognitive factors when teaching statistics. Limitations and directions for future research are discussed.

Dans cette étude, nous avons évalué l'utilité d'un cadre pédagogique à plusieurs facettes dans un cours de statistiques de niveau avancé. Nous avons cherché à accroître les résultats de nos recherches passées en utilisant ce cadre pour évaluer les changements en matière d'anxiété et d'auto-efficacité et nous avons recueilli des données de la part de groupes cibles pour vérifier si les étudiants attribuaient de tels changements à une approche pédagogique à plusieurs facettes. L'anxiété vis à vis des statistiques avait beaucoup diminué et l'auto efficacité actuelle des étudiants en matière de statistiques avait augmenté. De plus, le rendement des cours était lié de façon positive à l'auto efficacité et une forte relation négative a été documentée entre l'anxiété vis à vis des statistiques et l'auto efficacité. Les données recueillies des groupes cibles suggèrent que les étudiants ont apprécié les divers aspects de ce cadre pédagogique et qu'ils ont pensé que celui-ci permettait de réduire l'anxiété. Outre ce cadre pédagogique, deux techniques d'instruction ont été utilisées pour enseigner deux concepts de statistiques spécifiques. Ces techniques n'ont pas donné lieu à des différences significatives, toutefois les étudiants ont rapporté qu'ils avaient aimé les activités et qu'ils encourageaient leur emploi dans d'autres cours à l'avenir. En général, cette étude suggère qu'un cadre pédagogique à plusieurs facettes peut être utile pour aider les étudiants des cycles supérieurs à surmonter l'anxiété et à augmenter l'auto efficacité dans les cours de statistiques de niveau avancé. La recherche présentée ici s'ajoute à la documentation de plus en plus vaste qui existe déjà sur l'importance des facteurs non cognitifs dans l'enseignement des statistiques. L'article présente également une discussion sur les limites et les directions à suivre pour des recherches futures.

Keywords

statistics anxiety, statistics self-efficacy, teaching statistics, statistics education

Statistics courses are often among the key requirements for many graduate social science university programs. In fact, Onwuegbuzie and Wilson (2003) report that an increasing number of social science graduate students now have to take at least one statistics course as a program requirement. These courses help students learn the skills necessary to conduct their own research and to interpret and critically evaluate real-world concepts (Gal, 2002). Yet, statistics courses have also been found to be among the most anxiety-inducing for graduate students and non-math-oriented students (Zeidner, 1991). It is not unusual for some students to dread taking these courses or even delay their registration because of high levels of anxiety and stress (Onwuegbuzie, 1997, 2004). Students who have high levels of anxiety have also been found to rate their own statistical self-efficacy as low, which can impact one's ability to learn statistical concepts and excel in these courses (Finney & Schraw, 2003). Connors, Mccown, and Roskos-Ewoldsen (1998) have outlined four specific challenges that instructors of statistics face, one of which is the anxiety students bring into the course. Given the negative outcomes that such anxiety can produce, we implemented a course curriculum that we thought would target student anxiety while simultaneously increasing self-efficacy.

Pan and Tang (2004) explored the effectiveness of a multifaceted teaching framework at reducing the statistics anxiety of social science graduate students. The purpose of the current study was to further examine the effectiveness of this framework with a group of students taking an advanced statistics graduate course. The primary goal was to determine whether this teaching framework would reduce students' statistical anxiety and increase statistical self-efficacy; the previous work by Pan and Tang (2004) only focused on one dependent variable, anxiety, whereas, in addition to this variable, we also collected course performance and self-efficacy data. Importantly, we also conducted focus groups with students to determine if a multifaceted teaching framework serves to reduce anxiety because previous work relied on a single group pre-test post-test design, which makes it difficult to interpret the reasons for observed reductions in anxiety (Pan & Tang, 2004). A secondary goal of this study was to explore the usefulness of two active-learning tasks that were used to teach two specific statistical concepts. Previous work on one of these tasks (the mixer developed by Segrist & Pawlow, 2007) focused on performance differences whereas the current study assessed changes in performance and anxiety. As such, the research presented here adds to the growing literature concerning the importance of non-cognitive factors when teaching statistics. Before further outlining the teaching framework and the techniques used, a review of the relevant literature is provided.

Statistics Anxiety

Statistics anxiety has been defined as any anxiety that results when encountering statistics, irrespective of the type or complexity of the statistical analysis being carried out (Onwuegbuzie, Daros, & Ryan, 1997). It is defined by affective, cognitive, and physiological aspects such as worry, intrusive thoughts, mental disorganization, and tension when working with statistics (Zeidner, 1991). Onwuegbuzie and Wilson (2003) have found that up to 80% of post-secondary students appear to have bothersome levels of statistical anxiety when enrolled in a statistics course. Not surprisingly, the students who most often struggle with this anxiety are those enrolled in non-mathematics programs. These are also the students who likely have the least statistical experience and little interest in the topic. This type of anxiety does not only influence college and university students, but also those pursuing graduate degrees (Onwuegbuzie & Daley, 1999). This is particularly concerning, as many of these students have

large research projects (e.g., theses, dissertations), which likely require some type of statistical analysis or at least statistical comprehension.

Statistics anxiety is related to several negative consequences. For instance, it has been found to be negatively related to overall course performance (Lalonde & Gardner, 1993; Zeidner, 1991). This may ultimately influence a student's ability to attain a scholarship or pursue further courses in that area of study. Statistical anxiety also impacts a student's ability to learn important concepts that may be needed to carry out their own research projects. Also, students with such anxiety have been found to delay registering for required statistics courses until later in their degree, which may interfere with their progress or even contribute to a failure to complete their degree (Onwuegbuzie, 1997, 2004). The consequences of statistical anxiety have been recognized as such a serious concern that several scales have been created to measure anxiety and attitudes about statistics. The current study used a revised version of the Statistical Anxiety Rating Scale (STARS) to examine graduate students' statistical anxiety levels (Cruise & Wilkins, 1980).

Statistics Self-Efficacy

A related concept to statistical anxiety is one's self-efficacy in statistics. One variable proposed to influence academic performance is self-efficacy (Lane, Hall, & Lane, 2004). Self-efficacy is defined as the levels of confidence individuals have in their ability to execute a course of action or attain specific performance outcomes (Bandura, 1977). Several researchers have found that self-efficacy is a good predictor of performance, effort, persistence, and future enrollment in courses within a specific domain (Choi, 2005; Pajares & Kranzler, 1995). Specifically, Devonport, Lane, Milton, & Williams (2003) examined the relationship between self-efficacy and coping ability when completing a dissertation. It was found that highly efficacious students tended to set attainable goals and seek out numerous resources to achieve their goals. Those students who were low in efficacy would delay starting the project and would not obtain the same resources. Therefore, one would hypothesize that students with high statistical self-efficacy would have the confidence and drive to tackle difficult concepts, while those low in efficacy may avoid the challenges that statistics courses pose.

While researchers have typically focused their work on mathematical self-efficacy (e.g., Pajares & Kranzler, 1995; Usher & Pajares, 2009), Finney and Schraw (2003) have recently begun exploring statistical self-efficacy. They conducted a study exploring changes in statistical self-efficacy and simultaneously validated two statistical self-efficacy scales. The Current Statistics Self-Efficacy (CSSE) scale measures "confidence in one's abilities to solve specific tasks related to statistics," whereas the Self-Efficacy to Learn Statistics (SELS) scale measures "confidence in one's ability to learn the skills necessary to solve specific tasks related to statistics" (p. 164). Results demonstrated that both instruments were reliable and were related to statistical performance. Specifically, students who had positive self-efficacy and positive attitudes towards statistics did better on specific statistics problems and overall in the course. Perhaps not surprisingly, it was also found that there was a moderate negative relationship between one's current statistical self-efficacy and statistical anxiety, whereby those with lower self-efficacy also had a higher rating of anxiety. A revised version of the CSSE was used in this study to document changes in self-efficacy with regards to statistics.

Techniques for Teaching Statistics

Given the anxiety and self-efficacy struggles of many students when learning statistics, it can be quite a challenging topic for instructors to teach. This is likely also the case when teaching an advanced multivariate statistics course, as it was in the current study. A plethora of information exists for statistics educators, some of which is dedicated to techniques for teaching graduate students and research professionals (Zieffler, Garfield, Alt, Dupuis, Holleque, & Chang, 2008). Much of this research has focused on exploring the effectiveness of various pedagogical techniques used to improve the teaching and learning of statistics.

For instance, one technique involves the introduction of humour into the classroom as a strategy to enhance student engagement and learning (Neumann, Hood, & Neumann, 2009). Neumann, Hood, and Neumann (2009) found humour to be effective for students who held previous negative attitudes towards statistics, but for those who already were motivated and engaged in statistics, the humour was seen as distracting and irrelevant at times. However, other researchers have found that making statistics fun, through humour, cartoons, or songs, can be an effective teaching tool (Lesser & Pearl, 2008).

Dalgleish and Herbert (2002) completed a study examining the effectiveness of a specific teaching framework on anxiety and attitudes towards statistics in a multivariate statistics course. These researchers included a variety of teaching techniques throughout the course including the use of humour, enthusiasm, real-world examples, and the integration of theoretical knowledge and practical skills. They also had students use data that were relevant to their own specific thesis topics. The results showed a significant decrease in anxiety. Similarly, Williams (2010) examined instructors' immediacy (i.e., communicative behaviours that can make a person more approachable) and found that the use of these behaviours with students led to a significant effect of decreasing students' anxiety regarding graduate statistics.

Another example, similar to the current study, was completed by Pan and Tang (2004) examining two specific instructional methods and their impact on reducing statistical anxiety for graduate students. Students were asked to write brief essays to non-statistics-oriented people using layperson language about what they had learned in class. They also had to write an essay critiquing a quantitative journal article. Their results demonstrated that, after controlling for individual differences, statistical anxiety was significantly reduced. These researchers argued that the use of a systematic approach, including multiple techniques, was the best way to help reduce students' anxiety. In other words, Pan and Tang (2004) used several strategies (e.g., optional grading system, flexible office hours, orientation letter) in conjunction with the specific classroom instructional methods, in an attempt to reduce anxiety and improve learning. A similar approach was used in the current study.

In the current study we also examined whether the use of two specific learning activities in the classroom would decrease anxiety and improve student learning. A previously developed cooperative learning exercise, known as the mixer, was used to introduce students to the topic of factor analysis (Segrist & Pawlow, 2007). The developers of this activity found that it was useful in teaching students about factor analysis. We wanted to extend the work on this learning activity by determining if it would reduce student anxiety about statistics in addition to improving one's understanding of factor analysis. Cooperative learning exercises designed for statistics classrooms are thought to make statistical concepts concrete and can improve attitudes toward learning statistics (Connor, 2003; Perkins & Saris, 2001). As such, it is possible that a learning activity like the mixer can facilitate understanding while reducing anxiety. Similarly, a think-

pair-share activity developed by the course instructor comparing mediation and moderation was also assessed for its usefulness in promoting student learning and decreasing anxiety. This writing and active learning task was designed based on the work of Pan and Tang (2004) and Radke-Sharpe (1991).

Related work (Carlson & Winquist, 2011) that has explored the usefulness of an active learning approach to teaching statistics has demonstrated positive results. In an introductory statistics class that relied on a workbook-based curriculum, researchers found that students who were exposed to this curriculum reported a better understanding of statistics and greater enjoyment of statistics than a comparison group. The current study differs from previous work in the evaluation of two specific active learning tasks because it examines the effect of these tasks on actual performance and student anxiety. While Carlson and Winquist (2011) noted that examining students' attitudes can provide meaningful information about the effectiveness of active learning tasks, we thought it was important to supplement such information with actual performance results in the current study.

While various challenges exist for students enrolled in advanced statistics courses, especially those who are not statistically-inclined, there are pedagogical techniques that seem to help reduce statistical anxiety, improve confidence, and potentially improve course performance. A multifaceted teaching framework, including two specific classroom activities, was explored in the current study. The study was conducted over one term with an advanced statistics graduate class. The students had 13 classes to attend that were predominantly lecture based, and during two of these classes active learning tasks were used to develop the students' understanding of factor analysis and mediation and moderation. Students completed five assignments that required them to conduct different statistical analyses on data from projects that they, or their advisors, carried out. These assignments were given grades of acceptable, unacceptable, or acceptable with indication of excellent work being completed. These assignments comprised the method of evaluation for the course; no exams were administered. It was hypothesized that the multifaceted teaching framework, in combination with the active learning tasks, would reduce anxiety and enhance self-efficacy in the advanced graduate statistics course.

Method

Participants

Twenty-eight graduate students who were enrolled in an advanced graduate statistics course offered by a psychology department at a large university in Canada completed the study. This psychology statistics course is considered an advanced course because students have already completed basic statistics courses at the undergraduate and master's level prior to enrolment. Participation in the study was voluntary; no incentives were offered, and 90% of students in the course participated. These students were provided with identification numbers to ensure confidentiality. Participants ranged in age from 24 to 38 years ($M = 27.15$, $SD = 3.85$), and there were 23 females and 5 males. Four participants identified themselves as visible minorities and the remainder of the sample was Caucasian.

Participants rated their approximate grade point average (GPA) on a 12.0 scale. A total of 17.9% of students had a perfect 12.0 GPA rating (A+), 42.9% scored between 11.5-11.9 (A), 17.9% scored between 11-11.4 (A), 7.1% scored between 10.5-10.9 (A-), and 14.2% did not answer the question. Lastly, participants indicated how much time had passed since their most

recent statistics course. A total of 46.4% students stated it had been more than 1 year, 10.7% said approximately about 1 year, 35.7% said less than 6 months, and two students chose not to report this information.

Measures

Statistical anxiety rating scale (STARS)¹. The STARS was selected as the measure of anxiety for this study because of its frequent use within the teaching statistics literature and also because it has received the most empirical scrutiny of the measures available to researchers (Keeley, Zayac, & Correia, 2008; Onwuegbuzie & Wilson, 2003). The original STARS consists of 51 items in total, with 23 items specific to statistical anxiety and 28 items addressing one's positive and negative attitudes towards statistics (Cruise & Wilkins, 1980). The statistical anxiety items are each rated on a 7-point Likert scale ranging from 1 (no anxiety) to 7 (strong anxiety). Four statistical anxiety constructs are assessed: (1) interpretation anxiety—"Interpreting the meaning of a table in a journal article"; (2) test and class anxiety—"Enrolling in a statistics course"; (3) fear of asking for help—"Asking one of your lecturers for help in understanding output"; and (4) fear of statistics teachers—"Going to ask my statistics teacher for individual help with material I am having difficulty understanding." Similarly, the attitudes towards statistics are also rated on a 7-point Likert scale, but the response options range from 1 (strongly disagree) to 7 (strongly agree). The attitudes towards statistics items tap two domains: (1) the value of statistics in general—"Statistics takes more time than it is worth," and (2) computation self-concept—"I'm too slow in my thinking to get through statistics" (Cruise, Cash, & Bolton, 1985). Higher overall STARS scores are associated with higher degrees of statistical anxiety. Overall, researchers have found strong internal consistency of the items ranging between $\alpha = 0.64$ to 0.96 (Baloglu, 2002; Nasser 1999).

Due to time constraints in the classroom, we reduced the original 51 item STARS (Cruise et al., 1985) to an 18 item STARS-revised (STARS-R). Eighteen items, most relevant to psychology students learning multivariate statistics, were selected from the original 51 scale items such that each of the original six content domains were represented, as the STARS measures interpretation anxiety, test and class anxiety, fear of asking for help, fear of statistics teachers, the value of statistics in general, and computation self-concept. Although not necessary, we also changed the Likert scale from seven to five points (1 – no anxiety to 5 - strong anxiety) as it has been demonstrated that results from a 5-point Likert scale are highly correlated with results from a 7-point scale (Colman, Norris, & Preston, 1997). Higher scores on the STARS-R were still associated with higher degrees of statistical anxiety (possible range 18 - 90). The internal consistency reliability was high for these 18 items both pre-course ($\alpha = .88$) and post-course ($\alpha = .87$). Also, correlations between the pre-course STARS and CSSE scale showed a significant negative correlation ($r = -.55$, $p = .003$), which demonstrates strong discriminant validity. The same was shown with the post-course correlations between these scales ($r = -.79$, $p < .001$).

Current statistics self-efficacy (CSSE). The original CSSE scale was designed to assess a respondent's perceived confidence to complete or understand various undergraduate level statistical concepts and procedures. Each of the 14 items is rated on a 6 point Likert scale ranging from 1 (no confidence) to 6 (complete confidence) (Finney & Schraw, 2003). Sample items

¹ More information on the STARS-R and revised CSSE is available by contacting the first author.

include: “identify the scale of measurement for a variable” and “distinguish between the information given by the three measures of central tendency.” The CSSE has demonstrated discriminant validity ($r = -.57$ with statistical test anxiety) and convergent validity ($r = .49$ with general math self-efficacy). The scale also has strong internal consistency ($\alpha = .93$) and the factor analysis revealed a unidimensional solution and all factors meeting the inclusion criteria with the lowest coefficient at .55 (Finney & Schraw, 2003).

Given that the original CSSE (Finney & Schraw, 2003) focuses on introductory level univariate statistical concepts, it was necessary to modify the original CCSE to reflect multivariate statistics concepts and procedures given that our participants were graduate students enrolled in a multivariate statistics course at the time of the study. For example, the item “interpret if a distribution is skewed” became “interpret plots to determine skewed and kurtotic data.” A total of 15 items (one more than the original scale) were used pre- and post-course (possible range of 15-75). The rationale for the selection and modification of these items was done with the course instructor to ensure that each learning domain within the course was represented. The internal consistency reliability was high for the revised 15-item CSSE scale pre-course ($\alpha = .91$) and post-course ($\alpha = .92$). As mentioned, negative correlations between the CSSE and STARS suggest discriminant validity for this scale.

Factor analysis performance test (FAPT). We created this test to act as an outcome measure. It assessed students’ knowledge of this concept with six multiple choice items. For example, a sample item was: “In which analysis are the factors estimated based only on the common variance?” This test was administered after the experimental and control group received either the concept-specific instructional technique or the control activity. The maximum score on this test was 6.

Mediation moderation performance test (MMPT). We created this test to act as an outcome measure. It assessed students’ knowledge of these concepts using seven multiple choice items. A sample item was: “A researcher is looking to make some cause-and-effect statements about his area of research. It is best that he uses which of the following analyses?” This test was administered after the experimental and control group received either the concept-specific instructional technique or the control activity. The maximum score on this test was 7.

Teaching technique questionnaire. We created this questionnaire to determine the extent to which participants agreed or disagreed from 1 (not at all) to 7 (very much) with the following three items: (1) “Did you enjoy this exercise?” (2) “Was it stressful?,” and (3) “Should your instructor continue to use this method in future classes?”

Study and course satisfaction questionnaire. We created a final questionnaire that included three items assessing study and course satisfaction using the following statements ranging from 1 (not at all) to 7 (very much): (1) “I enjoyed the specific experimental techniques used throughout the course,” (2) “It was worthwhile participating in this experimental study,” and (3) “I am satisfied with this course.”

Procedure

Students enrolled in the advanced statistics course were informed at the beginning of the semester of the opportunity to participate in this study. All students were also provided with an orientation letter from the instructor that outlined the requirements of the course, addressed the issue of anxiety and confidence with statistics, and informed students about the dataset they would need to use in the course. At this point, the 28 students who chose to participate in this

study completed an online pre-course assessment that included the statistical anxiety measure (i.e., STARS-R), the statistical self-efficacy measure (i.e., revised CSSE), and a demographic questionnaire.

During the first class of the semester, the instructor used several strategies hypothesized to calm student anxiety and foster confidence (Pan & Tang, 2004). These included addressing the challenges of advanced statistics, using humorous cartoons, showing a statistical music video made by previous students, presenting research on persistence in math, and sharing personal anecdotes related to difficulties with statistics. Also, the course assessment was selected with the purpose of limiting statistical anxiety for students. There were no formal tests, but rather students submitted assignments, whereby they analyzed data from their own respective area of psychology. Data analysis guides developed by the instructor were provided as an additional resource beyond the course textbook. Lastly, the instructor addressed student questions and concerns before and after class, as well as through flexible office hours.

In addition to these pedagogical strategies, two specific instructional techniques were used in the classroom. To examine the effectiveness of these techniques, participants were randomly assigned to either the experimental group (who would receive this classroom instructional technique) or a control group (who would concurrently be reading from their textbook in a separate classroom with the first author). The second author facilitated the first active learning instructional technique entitled “the mixer” with the experimental group (Segrist & Pawlow, 2007). The purpose of this activity was to have students “act out” the steps involved in factor analysis using a cocktail party atmosphere. Each student received one item from a pool of questionnaire items and then spoke to other students about her or his item. Students formed groups based on items that shared similar content. Students were then given time to discuss the exercise, their understanding of factor analysis, and the challenges that it can pose. Both the experimental and control groups completed the STARS-R, the FAPT, and the Teaching Technique Questionnaire. The control group subsequently returned to the classroom and received the same instructional technique, simply to ensure that the experimental group did not have a learning advantage over the control group throughout the course.

This procedure was repeated with the second instructional technique that involved a think-pair-share and writing activity comparing mediation and moderation. The experimental group had to brainstorm a theoretical model representing mediation and moderation analyses, share it with a classmate, and explain it in writing to a person outside the course (e.g., friend, family member). This writing activity was designed based on the work of Pan and Tang (2004) and Radke-Sharpe (1991). As with the first technique, the control group read from their textbook in a separate classroom. Both groups completed the STARS-R, the MMPT, and the Teaching Technique Questionnaire. Subsequently, the control group received the same pedagogical activity as the experimental group. The study concluded on the last day of class with a final assessment whereby all students completed the STARS-R, the revised CSSE, and the Study and Course Satisfaction Questionnaire.

Design

The procedure and measures outlined above resulted in a study design that included both pre- and post-tests and analyses of experimental versus control groups for some aspects of the study. Specifically, students’ anxiety toward statistics and levels of self-efficacy were assessed with a pre- and post-tests analysis. Furthermore, the effect of the two instructional techniques on

student performance and anxiety was analyzed by comparison of control and experimental groups.

Results

Data Cleaning

Data cleaning revealed no outliers. Skewness and kurtosis values were converted to z-scores and assessed with significance tests. Results indicated that all variables were found to be normally distributed ($ps > .05$). In terms of missing data, 7.2% ($n = 2$) of the participants failed to complete the pre-course questionnaires, 17.9% (experimental group = 1; control group = 4) were absent from the factor analysis session, 28.6% (experimental group = 3; control group = 5) were absent from the mediation/moderation session, and 25.0% ($n = 7$) failed to complete post-course questionnaires. When a student did participate in a particular phase of the study, however, his/her responses were 100% complete. This large percentage of missing data was to be expected, given that the study was dependent on class attendance. A missing value analysis determined that the pattern of missing data was most likely missing completely at random (MCAR) for three reasons: (1) Little's MCAR test was non-significant ($X^2 = 62.96$, $df = 68$, $p = .37$), (2) a series of independent sample t tests comparing cases with and without missing data for each dependent variable were all non-significant ($ps > .05$), and (3) there was no reason to suspect that the pattern of missingness would have been in anyway related to the missing values themselves if they had been available. In order to retain a sufficient sample size, mean substitution was used to replace the missing data and all significance tests were run before and after this substitution took place to identify any differences between the groups (no differences were found based on the type of dataset used). The results from the data set with mean substitution are presented below. Likert-scale data was analyzed with parametric tests as is common in many disciplines (Pell, 2005; Tabachnick & Fidell, 2007). Lastly, a Bonferroni correction was used to control for an experimentwise error rate of $\alpha = .05$.

Main Analyses

Students completed the STARS-R and the revised CSSE scales pre- and post-course. It was hypothesized that statistical anxiety would decrease (as measured by the STARS-R) and self-efficacy would increase (as measured by the revised CSSE scale). Paired samples *t*-tests revealed significant differences between the pre- and post-course assessments for all measures and large effect sizes were found (see Table 1).

Table 1
Mean Differences and Paired Samples t-test for Pre- and Post-Course Measures

Measures	$M_{Diff}(SE)$	t	p	r^2
Revised Statistical Anxiety Rating Scale	-7.33 (1.84)	-3.99	.001	.37
Revised Current Statistics Self-Efficacy	27.46 (1.83)	15.04	.001	.89

Further examination of the means demonstrated that, as hypothesized, statistical anxiety significantly decreased from pre-course ($M = 37.73$, $SD = 9.69$) to post-course ($M = 30.41$, $SD = 6.90$). Also, as hypothesized, CSSE scores significantly increased from pre-course ($M = 34.92$,

$SD = 9.78$) to post-course ($M = 62.38$, $SD = 7.04$), which demonstrated an improvement in participants' current self-efficacy. The effect sizes were also large.

In order to examine the effectiveness of the specific teaching techniques, both the experimental and control groups completed the STARS-R and a concept performance test for both factor analysis and mediation/moderation. Table 2 shows the results of these measures after the factor analysis lesson. Independent-samples t -tests revealed no significant differences between the experimental ($M = 38.01$, $SD = 10.94$) and control group ($M = 37.38$, $SD = 6.81$) for the STARS-R. Similarly, no significant differences were observed between the experimental and control group on the concept performance test ($M = 3.40$, $SD = .93$; $M = 3.62$, $SD = .80$). The corresponding effect sizes were also found to be small. All participants completed the teaching technique satisfaction questionnaire after completing the mixer. Items ranged on a 7-point scale from 1 (not at all) to 7 (very much), and these items were subjected to one sample t -tests to determine if mean ratings from participants differed significantly from the midpoint of the scale. Results indicated that students enjoyed the factor analysis activity ($M = 5.26$, $SD = .96$), did not find it stressful ($M = 1.70$, $SD = 1.15$) and agreed it should be used in future classes ($M = 4.91$, $SD = 1.16$) ($ps < .001$).

Table 2

Mean Differences between Scores for the Experimental and Control Group for Measures after Factor Analysis Teaching Technique

Measures	M_{Diff} (SE)	t	p	r^2
Revised Statistical Anxiety Rating Scale	.63 (3.44)	.18	.86	.01
Factor Analysis Performance Test	-.21 (.33)	-.65	.52	.02

Students also completed these measures in regard to the mediation/moderation activity (see Table 3). Independent-samples t -tests revealed no significant differences between the experimental ($M = 36.09$, $SD = 9.71$) and control group ($M = 35.77$, $SD = 4.22$) on the STARS-R. Similarly, no significant differences were observed between the experimental and control group on the concept performance test ($M = 3.89$, $SD = 1.00$; $M = 3.93$, $SD = .69$). Once again, small effect sizes were found. All participants completed the teaching technique satisfaction questionnaire again and these items were subjected to one sample t -tests to determine if mean ratings from participants differed significantly from the midpoint of the scale. Students enjoyed the mediation/moderation activity ($M = 5.15$, $SD = 1.46$), did not find it stressful ($M = 2.15$, $SD = 1.57$) and agreed it should be used in future classes ($M = 4.85$, $SD = 1.57$) ($ps \leq .001$).

Table 3

Mean Differences between Scores for the Experimental and Control Group after the Mediation/Moderation Teaching Technique

Measures	M_{Diff} (SE)	t	p	r^2
Revised Statistical Anxiety Rating Scale	.32 (2.83)	.11	.91	.00
Mediation/Moderation Performance Test	-.04 (.32)	-.13	.90	.01

Lastly, participants completed the study and course satisfaction questionnaire rating how satisfied they were with the course on three items, ranging from 1 (not at all) to 7 (very much). Overall, students enjoyed the specific techniques used ($M = 5.33$, $SD = 1.62$), felt it was worthwhile to participate in such a study ($M = 5.24$, $SD = 1.73$), and were very satisfied with the

statistics course ($M = 6.57$, $SD = .68$) with all means significantly above the midpoint of the scale ($ps < .001$). Correlations (see Table 4) were also examined between the averaged ratings of anxiety and self-efficacy and final course grade to determine if our results were in line with previous findings (Lane, Hall, & Lane, 2004; Onwuegbuzie, 2000; Onwuegbuzie & Wilson, 2004). A non-significant negative relationship between anxiety and performance was observed whereas a marginally significant positive relationship between self-efficacy and course performance existed. A significant and strong negative correlation was also observed between anxiety and self-efficacy. These patterns align with past research.

Table 4

Correlations between Statistics Anxiety, Self-Efficacy, and Course Grade

Measure	1	2	3
1. Revised Statistical Anxiety Rating Scale	-	-.61**	-.12
2. Revised Current Statistics Self-Efficacy		-	.38*
3. Course Grade			-

Note. ** $p = .001$, * $p = .06$

Post-hoc Focus Groups

The results of the above analysis provide evidence that statistics anxiety decreased while students' statistical self-efficacy increased during a course that relied on a multifaceted teaching framework. It could be argued that these changes were the result of progression through the course or traditional pedagogical aspects of the course (e.g., being clear and organized, integration of theory and research/practice), rather than the *new* aspects of the course introduced (i.e., orientation letter, humorous cartoons, real-world examples, assignments using relevant datasets). This is a legitimate concern given the single group pre-test post-test research design. To address this limitation, focus groups were carried out with psychology graduate students who had previously taken a graduate level statistics course or were currently enrolled in one to gain an understanding of what they believe works (or has worked) to reduce statistical anxiety and increase their self-efficacy while completing a graduate level statistics course.

Participants

As the decision to carry out focus groups was made after completion of the original study, an addendum was submitted and approved by our department's research ethics board. Subsequently, all graduate students in the psychology department were sent a recruitment notice via email. In total, 26 students (22 female, 4 male) participated in one of six focus groups (3 to 7 participants each). Participants ranged from 22 to 60 years of age ($M = 29.96$), and were completing either a Master's degree ($n = 14$) or Doctoral degree ($n = 12$). Of the participants, one had participated in the original study, 7 took the same course (with the same instructor) in the years following the study, and the remaining participants were currently enrolled in, or had completed, a graduate level statistics course with a different instructor.

Procedure

Semi-structured interview questions were designed to elicit participants' subjective experiences as to what works and what does not work when teaching graduate level statistics, and to indirectly assess whether the new aspects of the course (introduced over the course of this study, and carried through in subsequent years) were identified by students as being effective in reducing their statistical anxiety and increasing statistical self-efficacy. Interview questions were open-ended and were formulated to address aspects such as an instructor's personality characteristics, teaching and assessment methods, and more broadly, what approaches instructors have taken to reduce statistical anxiety and enhance self-efficacy. The length of each focus group interview ranged from 29 to 72 minutes ($M = 57$ minutes), and each focus group interview was audio-recorded for transcription purposes. We conducted a thematic analysis to derive common themes from the transcribed data and we used *NVivo v.10*.

Results

Overall, four key elements of a statistics course were identified by focus group participants as decreasing statistical anxiety and enhancing statistical self-efficacy: (a) the personality characteristics of the instructor; (b) the teaching methods employed; (c) the assessment methods; and (d) the clarity of the instructor's expectations and the material being taught.

Foremost, it was suggested that there are a number of personality characteristics that statistics instructors possess that can serve to reduce students' anxiety levels and increase their self-efficacy. These include being approachable and accessible (i.e., feeling comfortable seeking out help from the instructor, encouraging students to use office hours), demonstrating passion for teaching statistics, having competence (i.e., being certain of knowledge), being kind, warm and caring, and being empathetic (i.e., understanding that some students may be anxious). Several participants believed that one way to demonstrate empathy is for the instructor to share personal anecdotes as to how they got over their statistical jitters; another way is for the instructor to provide reassurance that not everything can be learned all at once—rather, statistics takes practice. Several students discussed receiving an orientation or introductory letter/email prior to the first class telling them “not to worry” and informing them as to what to expect in the course. In addition to reducing pre-course anxiety, this tactic also led the students to feel as though the instructor was more accessible to them. Additionally, a number of students believed that having a good sense of humour (and incorporating this into lectures) also served to reduce anxiety. These comments suggest students appreciated the approach taken in this course. The comments provide contextual information that may help us understand the observed decrease in anxiety over the course of the study, but they do not eliminate the possibility of other factors influencing the observed decrease.

Focus group participants identified a number of teaching methods as being effective at enhancing statistical self-efficacy and reducing anxiety. One of the most commonly acknowledged teaching methods across focus groups was the use of personally relevant and real-world examples. This was identified as a useful tactic both when going through examples in class, and also through the ability to use one's own data when completing assignments. Relatedly, the participants suggested that integrating hands-on application of the material being taught is beneficial to increasing students' understanding of the material and self-efficacy related

to statistics. Again, the results from the focus group provide insight that may help account for the observed differences noted by the survey data.

Anxiety around assessment was another common theme that arose over the course of the focus group interviews. Indeed, one of the most anxiety provoking aspects of a graduate level statistics course is the pressure to get a good grade (which subsequently affects opportunities for funding). Participants made a number of suggestions as to how to address the type of anxiety. Foremost, they believed that the instructor should refrain from attaching a letter grade to an assignment; rather, instructors should use qualitative assessments reflective of the real world (i.e., peer-review—"accept as is," "revise and re-submit" method). Using this format, which allows students to "re-do" an assignment, was thought to help lower statistical anxiety. Further, there was an overwhelming consensus that assignments, not tests, are the most practical way of assessing a student's knowledge of statistics. Participants believed that assignments are responsive to different learning styles and speeds, and that having a number of small assignments can help to reduce anxiety levels. Further, through formative feedback given on assignments (both positive and critical), students felt as though their statistical self-efficacy was enhanced.

Lastly, it was suggested that clarity of the instructor's expectations greatly influences statistical anxiety. One participant clearly articulated this:

Where I have experienced statistical anxiety, it's rarely been because I don't understand the statistics, it's because I don't understand what the professor is asking from me, and why I'm being evaluated that way and what I am supposed to do.

In the participants' experiences, a variety of methods were identified as being used to enhance clarity and subsequently reduce anxiety. One participant, for example, discussed how the welcome letter she received before the beginning of the course detailing what to expect in the course helped lower her pre-course anxiety. Additionally, several students suggested that the "how-to guides" provided by the instructor were useful as they provided some guidance as to what students were expected to know, and this subsequently reduced their anxiety levels. Lastly, in addition to clarity in expectations, a large number of participants suggested that the instructor can induce a lot of anxiety simply by being unclear when presenting new material. Therefore, clarity in the instructor's explanation of statistics is another key factor in keeping anxiety levels in check.

Discussion

The current study used a multifaceted teaching framework (i.e., an orientation letter, addressing the challenges of learning statistics, use of humour, personal anecdotes), originally described by Pan and Tang (2004), in an attempt to positively influence both students' statistical anxiety and their current statistical self-efficacy. Specifically, statistical anxiety levels were lower and current statistical self-efficacy was higher at the end of the course. Student satisfaction with the course was very high, and scores related to satisfaction with participating in the study and with the specific instructional techniques were significantly above the midpoint of the scales.

Results from the focus group interviews provided support for the contribution of these "new" aspects to the course (i.e., being accessible, use of humour, a welcome letter, using personally relevant data and real-world examples, using formative assessment methods) to reducing statistics anxiety and strengthening students' self-efficacy around statistics. Notably, two new components of the course were not alluded to in the focus groups (i.e., presenting

research on persistence in math, showing a statistical music video); however, this was not entirely unexpected as only a third of focus group participants had taken the course with this instructor. Nonetheless, while traditional pedagogical methods may result in lower statistical anxiety and increased self-efficacy, components introduced in the present study seem to have also played a role, at least according to the results from the focus group data.

Overall, the results of the current study are consistent with and extend Pan and Tang's (2004) finding that following a comprehensive teaching framework, including application-oriented methods and an attentive instructor, may help lower statistical anxiety among social science graduate students. Importantly, we also observed that students' feelings of current statistical self-efficacy increased. Lastly, the relationships documented among self-efficacy, anxiety, and performance are consistent with past findings. There is a consistent negative relationship reported between statistics anxiety and course performance (Onwuegbuzie & Wilson, 2003), and evidence of a positive relationship between self-efficacy and performance (Lane, Hall, & Lane, 2004). Our finding of a strong negative relationship between anxiety and self-efficacy supports past findings (Onwuegbuzie, 2000; Pajares & Miller, 1995), and it has been suggested that poor self-efficacy beliefs in the face of learning statistics may create a self-fulfilling prophecy for students (Perepiczka, Chandler, Becerra, 2011).

These findings contribute to the scholarship in the area of statistics education. Recent scholarship in this area has been classified into a number of different categories that represent trends in this line of research (van der Merwe & Wilkinson, 2011). The current work spans two categories according to this scheme: teaching and learning and non-cognitive factors. The examination of teaching and learning in statistics education has recently received the most attention from researchers, with investigations examining the use of particular activities or strategies on student learning. Studies about non-cognitive factors compose a much smaller percentage of published articles, but are important because they address issues of motivation, personality differences, and the topic of statistics anxiety. Learning is a complicated process and it is important to focus on both its cognitive and affective components. Onwuegbuzie and Wilson (2003) have provided a comprehensive review of statistics anxiety, and we wanted to include this important individual difference in the evaluation of the teaching framework used in this study. Statistics anxiety was shown to decrease over the course of this study, and we believe addressing this component of statistics education in the classroom can be beneficial to students. It is important to continue addressing the issue of statistics anxiety because researchers have recently argued that statistics anxiety and performance follow a curvilinear relationship, and that a moderate level of anxiety is optimal for performance in a statistics course (Keeley, Zayac, & Correia, 2008). Future work that evaluates particular pedagogical approaches in terms of statistics anxiety and performance will provide valuable information about student learning in this domain.

In this study we also wanted to determine the usefulness of two active-learning techniques in fostering specific content knowledge and reducing statistics anxiety. Previous research has shown that students value the factor analysis learning activity, known as the mixer, and that it improves understanding of this concept (Segrist & Pawlow, 2007). The mediation moderation think pair share activity was developed with the same goals in mind. However, both class activities did not significantly reduce anxiety or improve performance for the experimental group compared with the control group. While these outcome measures did not show a significant effect, this does not mean that these activities are not worthwhile. The ratings from the teaching technique satisfaction questionnaire were high and the stress associated with the

activities was low. It is perhaps more likely that we were unable to show an effect because only 15 minutes were dedicated to each activity, and this may have been insufficient time to significantly improve comprehension of these concepts. Importantly, the control and experimental groups were composed of small sample sizes that would have lowered the statistical power of the analyses. It is also possible that from a performance perspective, the short multiple-choice tests were insufficient to capture if the experimental group had learned and understood the concepts better than the control group. The selection of a multiple-choice format to test performance in the classroom was due to time constraints. In the future, it is recommended that instructors try to formulate an entire lecture around an active-learning technique and then examine its effectiveness using multiple forms of evaluation. For instance, it would be beneficial to evaluate the effectiveness of such techniques using student satisfaction ratings, recognition and recall assessment tools, and even longitudinal follow-ups to assess retention of the material. Additionally, adequate sample sizes should be used to ensure high statistical power.

Limitations and Future Research

This study was conducted in an advanced graduate statistics course for psychology students where the majority of participants were female. As such, readers should keep this context in mind when considering the applicability of the results to their own classrooms.

The main limitation of the current investigation is the lack of a control group in determining the effectiveness of the teaching framework. Therefore we cannot be certain that the multifaceted teaching framework caused decreases in anxiety and increases in efficacy. In educational research it is not always feasible or ethical to conduct a comparison between a control and experimental group. Within this study we were able to conduct such a comparison for the teaching activities, but we were unable to follow this design in the evaluation of the overall teaching framework. While a one-group pre-test post-test design is not ideal, within this area of research it is not uncommon for researchers to use a design that does not include a control group (e.g., Pan & Tang, 2004; Titman & Lancaster, 2011; Zanakis & Valenzi, 1997) and to acknowledge a trade-off between internal and external validity. Importantly, to compensate for this limitation we collected valuable information from student participants through focus groups to examine the instructional factors they thought were associated with decreases in anxiety and increases in self-efficacy.

Future studies may want to revise the current research design in order to determine which elements of a multifaceted teaching framework are most effective at reducing statistics anxiety and increasing self-efficacy. Ideally this would be done through the comparison of a control and experimental group. It may also be worthwhile to include questions about students' satisfaction with the affective responses and behaviours of the instructor as those were not directly examined here. It is important to combine such ratings with others that examine the degree of learning. Studies should examine whether or not learning objectives are met, whether performance and ability test scores change, and if students' ability to retain information over time increases, in order to fully determine the usefulness of certain classroom techniques.

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