PRIOR MATHEMATICS PERFORMANCE, STATISTICS ANXIETY, SELF-EFFICACY AND EXPECTATIONS FOR PERFORMANCE IN STATISTICS: A SURVEY OF SOCIAL SCIENCES STUDENTS IN A CARIBBEAN INSTITUTION OF HIGHER EDUCATION

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ABSTRACT

The objectives of this study were to examine (i) the expectation for performance (EFP) in statistics of first year university students, (ii) the relative effect of previous mathematics performance (PMP), perceived statistical self-efficacy (SSE), and statistics anxiety (SA) for understanding these expectations, and (iii) whether students' EFP scores differ based on sex and academic discipline. Findings point to average to high EFP in statistics, with no differences in these levels based on sex or academic discipline. PMP had little effect on students' EFP, but, moderate effects on their levels of SA. While SSE positively affected both students' SA, this measure produced a negative effect on their EFP in statistics. Both SSE and SA negatively affected students' EFP in statistics, but with minimally higher levels for the latter.

Keywords: *Statistics education research; Expectation for performance; Social sciences; Caribbean Institution of Higher Education*

1. INTRODUCTION

The issue of students' statistical performance remains an underlying thread within scholarly examinations of statistics education. Largely speaking, such a body of research juxtaposes a growing relevance of statistical reasoning within institutions of higher education with that of the persistent trepidation that university students face when attempting statistical courses (Garfield, 1995; Onwuegbuzie, 2004; Zeidner, 1991). Such divergent trends have sparked ongoing explorations of (i) learning and teaching approaches within statistics programs, (ii) challenges key stakeholders (students and faculty) confront within statistical courses, and (iii) possibilities for enhancing student experience and performance.

Such considerations have also prompted a range of empirical investigations that explore the cognitive and affective factors that shape students' performance in statistics. Of note are studies linking students' prior performance in mathematics (Cornell, 1999) and/or mathematics related anxieties to their performance in statistics (Onwuegbuzie, 1997; Onwuegbuzie & Wilson, 2003; Paechter et al., 2017). Another empirical thread centers on students' prior academic background (Keeley et al., 2008), and relatedly, reported levels of procrastination during the period of enrollment in statistical courses (Macher et al., 2011; Onwuegbuzie, 1997, 2004).

The exploration of statistics anxiety (SA) on students' performance in statistics related courses also emerges within the broader body of literature on statistics education (Cruise et al., 1985; Onwuegbuzie, 2000, 2004; Zeidner, 1991). While SA represents one of the most widely studied constructs (Tishkovskaya & Lancaster, 2010), many questions remain. These questions can be linked to:

Statistics Education Research Journal, 20(1), Article 4. https://doi.org/10.52041/serj.v20i1.98

- varied levels of SA (measured using the Statistics Anxiety Rating Scale-STARS) across academic disciplines (Onwuegbuzie, 2004; Onwuegbuzie & Wilson, 2003; Paechter et al., 2017);
- increasing concerns for the relative importance of one's self-efficacy in the understanding of students' performance in statistics (Finney & Schraw, 2003; Mihai-Bogdan et al., 2015; Perepiczka et al., 2011);
- growing contentions among researchers as to the nature, etiology, antecedents, and effects of the relationship between SA and statistical performance (Macher et al., 2013; Onwuegbuzie, 2000; Onwuegbuzie & Wilson, 2003); and
- lack of consensus on the methods for reducing statistics anxieties (Garfield & Ben-Zvi, 2007; Zieffler et al., 2008).

Given such contentions, the push for the enrichment of students' experiences within statistical programs continues unabated (Slootmaeckers et al., 2014). As a new and emerging area of investigation within statistics education (Zieffler et al., 2008), the call is also for empirical investigations that both deepen understandings of statistical performance and provide further evidence about the validity of existing measures, both within and/or beyond the contexts of origin. This paper therefore explores the applicability of two major constructs, Statistical Self-Efficacy (SSE) and Statistics Anxiety (SA), to the understanding of social sciences students' Expectations for Performance (EFP) in statistics within a major regional Caribbean university. Such research is particularly important given the growing transnationalization of higher education within the Caribbean.

2. CARIBBEAN CONTEXT

Unlike neighboring countries such as the United States (U.S.), where statistics education remains mostly embedded within the Common Core State Standards in upper elementary, middle, and high school levels (Franklin et al., 2011; Scheaffer & Jacobbe, 2014), Caribbean students at this comparative level of the education system are generally not exposed to any core or stand-alone statistics courses before they enter higher education. Common to both systems, however, is the attention to mathematics and English education as fundamental aspects of early-mid levels of the education system. For example, in the US the Common Core State Standards have been adopted by many states in mathematics and English (Akkus, 2016). Notably, the mathematics standards include appreciable statistics content separate from the popular Advanced Placement statistics exam (Akkus, 2016; Franklin et al., 2015). Likewise, in the Caribbean, the focus at the elementary (primary) and high school (secondary) levels is on building mathematics and English language skills, but with a substantively smaller exploration of statistics within the general curriculum (see Brown, 2005; Brown & Kanyongo, 2007, 2010). At the post-high school (tertiary) level, statistics and/or mathematics courses in the Caribbean region feature in some degree programs with varying frequency and difficulty across disciplines.

This design of the curriculum and the resultant challenges that ensue within the classroom have inadvertently influenced a growing body of research on mathematical performance within the Caribbean region. Key areas of investigation within this research have focused on low levels of academic achievements in mathematics (Ogunkula, 2012), students' lack of confidence in their ability to do mathematically related tasks (Garner-O'Neal & Cumberbatch, 2015), and low expectations surrounding student performance in mathematics (Ransome et al., 2016). Related studies have also tapped into the roles of instructors/teachers (Ransome et al., 2016). Other researchers have examined the relative confidence and performance levels of male students compared to female students (Brown, 2005; Brown & Kanyongo, 2007, 2010). Even within the work of Brown (2005) and Brown and Kanyongo (2007), discussions about hurdles facing mathematics education at primary (elementary) and secondary (high) school levels remain generally limited and inconclusive.

While the need for continued research on the mathematics performance of high school (secondary) students remains, explorations of students' performance within statistics education programs are equally important. Such research, however, is considerably lacking in the Caribbean region. Given the many questions that remain on the potential impact of prior performance in mathematics on the statistical performance of university students (Macher et al., 2011; Olani et al., 2011), the general anxieties related to statistics (Macher et al., 2013), the need for comparative data on other populations of students within the field of statistics education, and the empirical abyss that exists within the Caribbean, the study asked the following questions:

1. What are the Expectations for Performance (EFP) in statistics for social sciences university students?
2. What is the relationship between students' Previous Mathematics Performance (PMP) and their EFP in statistics?
3. What is the association between students' perceptions of their Statistical Self-Efficacy (SSE) and EFP in statistics?
4. What is the relationship between the Statistical Anxiety (SA) of students and their EFP in statistics?
5. To what extent do these EFP in statistics vary by sex and academic discipline?

3. REVIEW OF RELATED LITERATURE

Students' statistical performance remains a central point of examination within statistics education. In attempting to measure and report on performance trends in statistics courses, the tendency has been to use actual scores or grades as an objective indicator for performance (Shachar & Neumann, 2003). Despite this trend, there is a related conversation on the critical value of exploring students' expectations as a subjective evaluation of their performance within statistical courses or programs (Baloglu et al., 2017; Watson et al., 2007). The thinking here is that expectations emerge as formative cognitive tendencies, which are changeable over time and that can be employed within statistical interventions or reforms.

The impact of students' expectations on their academic performance is well documented (Khattab, 2015; Rodriguez, 2009). A key argument has been that high expectations for success has strong positive associations with both the pursuit of and actual achievement in one's chosen academic fields (Fitzgerald et al., 1996; Khattab, 2015; Onwuegbuzie, 2000), and that students with lower expectations are less likely to actively pursue academic success (Rodriguez, 2009). In the case of statistics education, for instance, one's definition of statistics as a course or preconceived notions of statistics as a subject can affect student attitude and eventual performance in statistics (McGrath, 2014; Mihai-Bogdan et al., 2015; Onwuegbuzie, 2000, 2004). We therefore explore in the following sub sections, some of the key factors, debates, or areas of contention within the broader body of literature on statistics education.

Previous Mathematics Performance (PMP) PMP emerges as a critical factor that influences university students' performance in statistics courses (Garfield & Ben-Zvi, 2007; Onwuegbuzie & Wilson, 2003; Paechter et al., 2017; Zeidner, 1991). Examinations of this measure, however, remain quite vast with varied applications. For example, some researchers call attention to the importance of mathematical competence (Johnson & Kuennen, 2006), particularly for students who have unfavorable beliefs with respect to their prior achievement in mathematics (Tomasetto et al., 2009). Other scholars call into question the curvilinear and motivating effects of low mathematics grades on students' performance in statistics (Garfield & Ben-Zvi, 2007). Yet another group of scholars has explored mathematical anxiety, defined in many cases as the extent to which students are worried about working with and manipulating numbers or their problem-solving skills (Ashcraft & Krause, 2007; Onwuegbuzie, 1997; Paechter et al., 2017; Zeidner, 1991). This line of investigation on previous mathematics performance, has spurred related studies on the relationship between PMP, SA, and EFP (Olani et al., 2011; Paechter et al., 2017). Given the many questions around the effects of previous mathematics performance on statistical performance Paechter et al. (2017) contended that PMP remains necessary, but not sufficient to explain reported variability in students' EFP in statistics courses. We hypothesized therefore that PMP has no effect on EFP in statistics and that PMP has no association with SA.

Statistical Self-Efficacy (SSE) Related studies within the field of statistical education have explored the role and/or impact of SSE, defined in most studies as an expression of one's confidence in their ability to perform statistical tests or to reason statistically (see Baloglu et al., 2017; Finney & Schraw, 2003; Mihai-Bogdan et al., 2015). Even within such examinations, various positions on the nature of that relationship emerge. Some researchers stressed the direct role of SSE on statistical performance, both in terms of students' attitude towards and belief in their ability to do statistically related tasks (Finney & Shaw, 2003; Mihai-Bogdan et al., 2015; Perepiczka et al., 2011). Others have shown that while SSE positively effects one's attitudes towards statistics, it may not necessarily produce the same effect on one's level of anxiety towards statistics (Bandalos et al., 1995; Perepiczka et al., 2011). A related issue within this debate is that of the validity of using general or task specific measures of self-efficacy (Finney & Schraw, 2003). We posited that SSE has no effect on EFP in statistics, and that SSE has no effect on SA.

Statistics Anxiety (SA) Empirically, SA, defined as the degree of worry or stress over the process, application, and interpretation of statistical data or statistical outcomes, stands as one of the strongest predictors of students' performance in statistics (Keeley et al., 2008; Macher et al., 2013; Onwuegbuzie, 1995, 1997, 2000; Onwuebuzie & Wilson, 2003; Tishkovskaya & Lancaster, 2010). In many cases, these studies advance early explorations of the statistics anxiety measure (see Cruise et al., 1985; Zeidner, 1991) with extensive variability in the findings based on reported differences:

- across academic disciplines (Paechter et al., 2017; Williams, 2013);
- between male and female students (Macher et al., 2011; Slootmaeckers et al., 2014);
- among different age groups (Slootmaeckers et al., 2014);
- in their prior mathematics scores (Paechter et al., 2017; Zeidner, 1991); and
- in their levels of efficacies related to understanding (Garfield & Ben-Zvi, 2007; Lunsford et al., 2006) and executing statistically related tasks (McGrath, 2014; Onwuegbuzie, 2004).

Yet, other researchers called for the advancement of existing studies on statistics anxiety, with increasing attention to sub-components of the measure. For example, a few researchers pushed for the separation of students' attitudes towards and/or thinking around statistics from the general anxiety measure (Finney & Schraw, 2003; Onwuegbuzie, 2000). Chew and Dillon (2014) also drew attention to the operationalization and computation of the statistics anxiety measure with an inherent focus on the use of anxiety related sub-scales, as opposed to attitudinal sub-scales within the STARS measure. In this scholarship on statistical anxiety, an underlying argument has been that of the relative importance of distinguishing (through specific measures), between the cognitive and affective factors that effect students' performance within related courses (Baloglu et al., 2017; Paechter et al., 2017; Slootmaeckers et al., 2014; Williams, 2010). In responding to such contentions, we postulated that SA has no effect on EFP in statistics.

4. METHODOLOGY

The main area of interest for this study is students' EFP. Given the importance placed by students on their expected performance and the tendency for expectations to serve as a strong predictor of performance in statistics classes (Fitzgerald et al., 1996; Onwuegbuzie, 2000), the researchers therefore explored an initial conceptual model (see Figure 1) that measures the relative effect of students' sex, academic discipline, PMP, SSE, and SA on EFP. Figure 1 represents the predicted direction of the association between each independent variable (sex, academic discipline, PMP, SSE, and SA) and dependent variable, EFP in statistics. The following sub-sections provide details on the methodology used to test the nature of these hypothesized relationships.

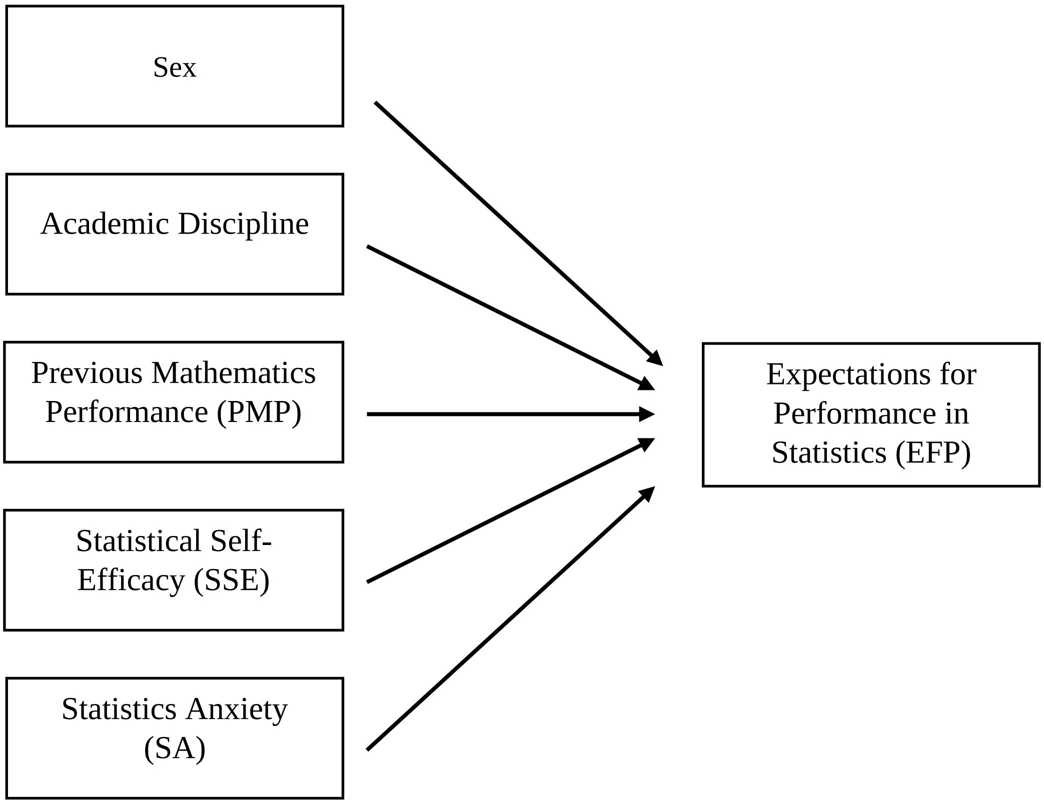

Figure 1. Conceptual model of students' EFP in statistics

4.1. RESEARCH DESIGN

For this study, researchers used a survey to gather information on the demographic background and the levels of SSE, SA, and EFP in statistics among first year university social sciences students. The use of the survey design allowed for a snapshot examination of students' EFP in an introductory statistics course. This research design presented a useful way of collecting initial data on the applicability and predictability of affective and cognitive factors on students' EFP in statistics. It also offered initial insights for understanding both the status of and potential for building statistics education within institutions of higher education in the Caribbean.

4.2. TARGET POPULATION AND COURSE DESIGN

The target population in this case consisted of three hundred and forty-four (344) registered students within a core introductory level behavioral statistics undergraduate course in the first semester of the 2017/2018 academic year. A central goal of this face-to-face course is to ground students in the conceptual and calculative aspects of quantitative research, those related to measuring and testing social relationships using both descriptive and inferential statistics. As a way of achieving this, assessments use a problem-based learning approach, in which scenarios are presented as a way of contextualizing research problems, hypotheses, designs, and analyses. The course is mandatory for all students registered within social sciences programs (i.e., sociology, social work, psychology, political science, international relations, strategic leadership and management, and criminology). Students registered in economics majors did not participate in this survey since they are part of a streamed program that carries its own statistical courses.

4.3. PROCEDURE

We recruited students based on their attendance in the final lecture for the course. In that session, we explained the nature, rationale, and potential contributions of this study. We also informed students of the ethical procedures, voluntary participation, and requirement for signed consent, without identifiers, and provided students with details of Institutional Review Board approval for this study [CEC333/10/17].

From the target population (N = 344), one hundred and ninety-nine (n = 199) participants (150 women, 44 men, 5 not stated) or 58% of the class were recruited based on their willingness to participate in the present study. The majority of participants (n = 177) were between the ages of 18 and 22 years old. Of the participants, eighty (n = 80) were psychology majors, thirty-three (n = 33) were criminology majors, thirty-one (n = 31) were international relations majors, twenty-seven (27) were social work majors, twelve (n = 12) were sociology majors, six (n = 6) were political sciences majors and four (n = 4) were from the leadership and management major. This sample was representative of distribution of students from previous undergraduate social science programs.

4.4. SURVEY INSTRUMENT

For this study, the researchers used a 79-item questionnaire, comprised of demographic items and measures of SA, SSE, and EFP in statistics. The instrument is included in the Appendix and the measures are discussed in the following sub-sections.

Demographic items Two demographic questions were included in this survey: sex (male/female) and academic disciplines of respondents, sociology, psychology, social work, criminology, international relations, leadership, and management and political science.

PMP In measuring PMP, we asked respondents to indicate their grade obtained in mathematics at the Caribbean Secondary (High School) Education Certificate (CSEC) Examination. This is because students take this final examination at the end of their five years in secondary or high school. Mathematics remains a core subject that all students must write as part of this final examination. Response options ranged from Grade 1 to Grade 5. In accordance with Caribbean Examinations Council (CXC) grading criteria, lower values indicate a better performance with Grade 1 being the highest possible grade and Grade 5 the lowest, with each grade corresponding to a range of marks between 0 and 100%.

SA We measured SA using the Statistics Anxiety Rating Scale (STARS; Cruise et al., 1985). The STARS is a 51-item scale comprising 6 sub-scales: worth of statistics or perceived usefulness of statistics in everyday life (16 items), interpretation anxiety related to deciding on the specific tests to be used and reading of the results (11 items), test and class anxiety (8 items), computational self-concept-when computing statistical problems (7 items), fear of asking for help (4 items), and fear of statistics teachers (5 items). Given that we executed the study in the semester following a change in teaching staff for the course under investigation and that students repeating the course would have encountered prior and current staff, the fear of statistics teachers sub-scale was not utilized.

In its original form, the scale presented some contextual challenges. To address the limitation surrounding some of these questions, we adjusted the wording of specific items to suit the population of interest. The amendments are noted in Table 1.

Table 1. Amendments to STARS scale items

Sub-scale	*Original Item*	*Adjusted Item*
Worth of Statistics	Affective skills are so important in my profession that I don't want to clutter my thinking with something as cognitive as statistics.	Affective (emotion/feelings) skills are so important in my profession that I don't want to clutter my thinking with something as cognitive (logic/ rational) as statistics.
	Statistics is worthless to me since it's empirical and my area of specialization is philosophical.	Statistics is worthless to me since it's empirical and my area of specialization is philosophical (theoretical).
Interpretation Anxiety	Reading an advertisement for an automobile, which includes figure on gas mileage compliance with population regulations, etc.	Reading an advertisement for a product which includes figures and numerical data.
	Interpreting the meaning of a probability value once I have found it.	Interpreting the meaning of a probability value (p-value) once I have found it.
	Interpreting the meaning of a table in a journal article.	Interpreting the meaning of a table in a book or journal article.
Computational self-concept	I can't even understand seventh- and eighth-grade mathematics; how can I possibly do statistics?	I can't even understand secondary school-level mathematics; how can I possibly do statistics?
Fear of Asking for Help	Asking someone in the computer center for help in understanding a printout.	Asking someone for help in understanding a graph.
	Asking a fellow student for help in understanding a printout.	Asking a fellow student for help in understanding a graph.
	Asking one of your professors for help in understanding a printout.	Asking one of your professors for help in understanding a graph.

Chew and colleagues (Chew & Dillon, 2014; Chew et al., 2018) have characterized the STARS scales as measuring two related and equally important constructs: SA (23 items, namely the interpretation anxiety, test and class anxiety and fear of asking for help sub-scales) and attitudes towards statistics (28 items, namely the worth of statistics, computational self-concept and fear of statistics teachers' sub-scales).

Sub-scales that measured anxiety asked participants to rate their level of anxiety experienced in specific situations. These were presented on a five-point scale ranging from no anxiety (1) to high anxiety (5) for items such as "Figuring out whether to reject or retain the null hypothesis" (interpretation anxiety), "Walking into the classroom to take a statistics test" (test and class anxiety), and "Going to ask my statistics teacher for individual help with material I am having difficulty understanding" (fear of asking for help). Higher scores for these sub-scales indicate higher anxiety.

For the purposes of this study, we summed the scores for the three anxiety-related sub-scales, interpretation anxiety, test and class anxiety, and fear of asking for help, to provide a total score for Statistics Anxiety (Chew & Dillon, 2014) with a maximum score of 115 for Statistics Anxiety. We used the worth of statistics and computational self-concept sub-scales within the development of the SSE measure. We removed the fear of statistics teachers from the scale. Questions within statistical anxiety scale produced an overall Cronbach's alpha of 0.921, above the 0.85 to 0.91 threshold reported by Cruise et al. (1985). We note that the differences in the Cronbach's alpha scores may have occurred due to the change in wording of a few items in these sub-scales. When we examined the sub-scales within the statistical anxiety measure however, all but one sub-measure, computational self-concept, met the threshold of 0.85. The specific sub-scales are shown in Table 2.

Table 2. Results of reliability analysis (Cronbach's alpha) for sub-scales of STARS

Sub-scale	Cronbach's alpha
Interpretation Anxiety (11 items)	0.886
Test and Class Anxiety (8 items)	0.890
Computational self-concept (7 items)	0.790
Fear of Asking for Help (4 items)	0.836
Worth of Statistics (16 items)	0.920

SSE For the purpose of this study, we defined SSE as students' perception of their ability to perform statistical calculations and analysis. As a way of capturing the cognitive and affective aspect of this measure, we embraced the attitudinal sub-scales of STARS and expanded this component with additional competency-based questions that specifically tested for students' ability to execute statistical calculations.

The self-report items of the STARS measuring attitude towards statistics required participants to indicate, on a five-point scale ranging from strongly disagree (1) to strongly agree (5), their level of agreement with statements such as "I feel statistics is a waste" (worth of statistics) and "I'm too slow in my thinking to get through statistics" (computational self-concept). Higher scores for worth of statistics and computational self-concept indicate a more negative perception of the worth of statistics and a more negative computational self-concept, respectively. These items provide a measure of the belief system surrounding statistics generally, and as such, were added as part of the SSE measure.

Additionally, in measuring students' belief in their ability to perform statistical calculations, we added a 10-item statistical competency sub-scale to the SSE measure. Participants were required to self-report their level of perceived statistical competence based on the response to a five-point scale ranging from not at all (1) to completely (5) in answering the following question: "On a scale of 1 to 5, how competent are you in the calculation of each of the following…?" In this case, we provided students a list of 10 calculation-based areas covered in the course and asked students to indicate their perceived level of efficacy in their ability to execute these specific statistical tasks. The areas, which were specific to the course content, included calculation of measures of central tendency, variability, and parametric and non-parametric statistical tests. We recoded items for this scale so higher scores indicated a more negative perceived statistical competence. Cronbach's alpha for this sub-measure was 0.782.

These two sub-measures constituted the composite measure for SSE. We used these to calculate a computed score for SSE, which allowed for a maximum score of 165. A higher score in this case was indicative of a lower level of SSE. Cronbach's alpha emerged as 0.931.

EFP in Statistics We defined EFP as students' prediction of their performance on a statistics course examination in the near future. We measured this variable using a 15-item scale developed for this study. Participants were required to answer the following question: "On a scale of 1 to 5, how well do you think you will perform on an examination if asked to answer a question on the following…?" We also provided students a list of 15 areas covered in the course and asked them to indicate their expected performance on a scale of very poorly (1) to very well (5). Areas of course content, both conceptual and calculation-based, included the research process and research design, normal distribution, measures of position, and named statistical tests. These areas represent key outcomes of the course and assess students' expectations to perform specific tasks related to the use of social statistics. We then calculated a total Expected Performance Score so that a participant could have a maximum score of 75 points. Cronbach's alpha was 0.799.

4.5. DATA ANALYSIS

We used SPSS Statistics 24.0 and SPSS Amos 25.0 to analyze the data from this cross sectional survey. The main points of analysis for the study included the testing of normality (using the Kolmogorov-Smirnov test), differences in the expectation for performance based on demographic factors (independent sample t-test and one-way ANOVA), associations between variables (Pearson Correlation), and structural equation modelling (SEM) to examine the effects of previous mathematics performance, statistics anxiety, and computational/mathematical self-efficacy on expectation for performance in statistics. In this case, the use of a SEM model allowed for the testing of conceptual or theoretical models (Quirk et al., 2001). Here, PMP appeared first in the model because it represented the result of a prior examination by students; SSE and SA appeared next as they were measured as variables that participants were experiencing at the time of the study. We used Maximum Likelihood to adjust for missing data. We also used Chi-square test, Normed Fit Index (NFI), Relative Fit Index (RFI), and Root Mean Square Error of Approximation (RMSEA) to determine the adequacy of the model. In assessing the fit of the model, a chi-square test with a *p*-value above 0.05 was required and was achieved in this study. Values above 0.95 for the NFI and RFI, and a value less than 0.05 for the RMSEA are measures of model fitness. As shown in Figure 2, the proposed model met the necessary requirements, according to students' EFP in statistics.

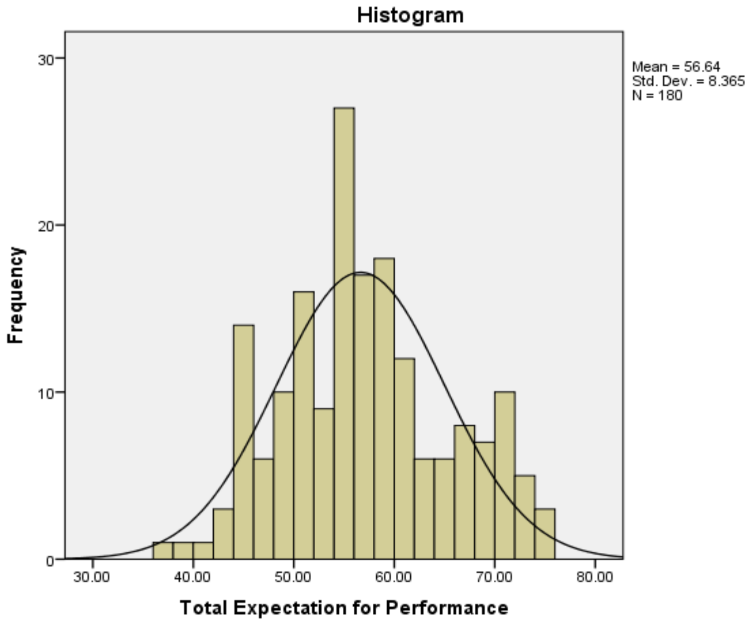

Figure 2. Histogram on students' Expectations for Performance in statistics

5. SUMMARY OF KEY RESEARCH FINDINGS

In addressing our research questions, we examined the reported levels of EFP, distribution and variability within this measure, and the relative effect of sex, academic discipline, PMP, SSE, and SA on EFP. We discuss the findings of these statistical analyses in the following sub-sections.

5.1. STUDENTS' EFP IN STATISTICS

With reference to our first research question, which sought to determine the EFP of our selected sample. Students' EFP scores ranged from 37-75 on an original scale of 15-75 (15 questions on a 1-5 Likert-Scale). When disaggregated to reflect low (15-37), average (38-56) and high (57-75) expectation scores, the data showed that 94 students or 52.2 percent of the sample reported average expectations for performance, while 85 or 47.2 percent of the sample reported high expectations (Table 3).

Table 3. Distribution of scores for students' Expectations for Performance in statistics

EFP	Frequency	Percentage
Low	1	0.6%
Average	94	52.2%
High	85	47.2%
Total	180	100.0%

Further examination of the distribution revealed a mean of 56.6 points, with a standard deviation of 8.37 points, median of 56, and mode of 54. There was little evidence the distribution deviated from normality (see Figure 2). In fact, the Kolmogorov-Smirnov test statistic was at 0.86, with *df* (180), and $p = 0.023$. Similarly, the Shapiro-Wilk test statistic was at 0.977, with degrees of freedom of 180, and a corresponding *p*-value of 0.005.

To answer Research Question 5, researchers also tested for possible variability in reported levels of EFP based on demographic factors such as sex and academic discipline. In the first instance, the findings did not indicate a difference in students' expectation for performance in statistics (EFP) based on their sex. In particular, examinations of the mean scores for expectations for performance for male students ($M = 55.23$, $SD = 8.70$) and female students ($M = 57.04$, $SD = 8.26$) did not indicate a difference in EFP in statistics, $t(178) = -1.214$, $p = 0.226$. In the second instance, the findings also suggested no differences in EFP based on academic discipline F(6, 172), -0.474, p = 0.827.

5.2. EXPLAINING STUDENTS' EFP IN STATISTICS

In our initial model, we tested for direct relationships between sex of student, academic discipline, PMP, SSE, SA, and EFP. Statistical analyses of the data using structural equation modelling, however, produced an alternative model that indicates direct and indirect relationships between these factors. On a collective level, the findings show that SSE and SA directly affect students' EFP. We note, however, that while SSE influenced both students' SA levels and EFP, the impact is greater on statistics anxiety (SA). SA, however, had the greatest effect on EFP, pointing to the need for further examinations of this variable. While PMP did not have a direct effect on EFP, it produced an indirect effect when SSE and SA are considered.

Since the results did not indicate differences in EFP based on sex or academic discipline, these variables were not included in the model. We examine direct and indirect relationships within the SEM diagram and more detailed discussions within the various sub-sections that follow.

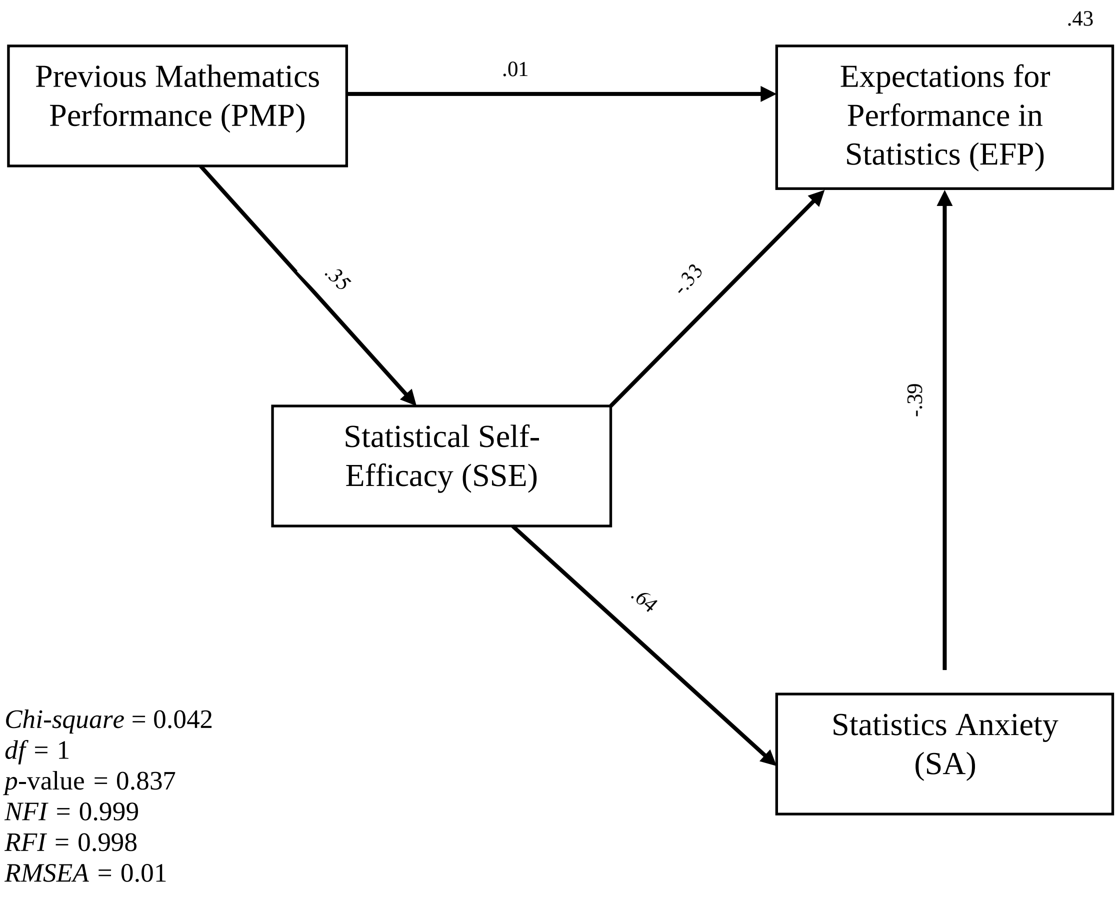

Figure 3. Effect of Prior Mathematics Performance, Statistical Anxiety and Statistical Self-Efficacy on Expectations for Performance in statistics

PMP and EFP in statistics While the findings point to a weak association between PMP and EFP in statistics (see Table 4), the results of the SEM (Figure 3) indicated little evidence that these variables had an effect on students' EFP in statistics (coefficient = 0.01, p = 0.914).

Table 4. Correlations of variables (Prior Mathematics Performance, Statistical Sefl-Effifiacy, Statistical Anxiety, and Expectations for Performance) in model

Variable	PMP	SSE	SA	EFP
PMP	1.00			
SSE	0.37	1.00		
SA	0.21	0.66	1.00	
EFP	-0.18	-0.60	-0.60	1.00

SA and EFP in statistics Statistical examinations pointed to an negative effect of SA on EFP (coefficient of -0.39, p = 0.001). Given the salience of SA in the literature on statistical performance, we also explored the relationships between these sub-scales and EFP. In examining the correlations between sub-scales of STARS and EFP, we found moderate negative correlations between interpretation anxiety and EFP (coefficient of -0.51, $p < 0.001$), and between test and class anxiety and EFP (coefficient of -0.53, $p < .001$). This suggests that the more anxiety participants experienced around the interpretation of results and that of their actual statistical tests, the lower their EFP. Fear of asking for help was also weakly negatively correlated with EFP (coefficient of -0.36, $p < .001$). At a collective level, the technical or calculative aspects of the statistical courses, (namely tests and class anxiety, and interpretation anxiety) emerged as the two critical but related aspect of SA measure that effect students' EFP (Table 5).

Table 5. Correlations between anxiety sub-scales of STARS and Expectations for Performance in statistics

	EFP in Statistics	*p*-value
Interpretation Anxiety	-0.51	<0.0001
Test and Class Anxiety	-0.53	<0.0001
Fear of Asking for Help	-0.36	<0.0001

SSE and EFP in statistics The findings also pointed to a negative association between SSE and EFP, coefficient = -0.60, $p < 0.001$. This finding does not support our third hypothesis. In that regard, it suggests that students with higher statistical self-efficacy (lower SSE scores) generally have higher expectations for performance in statistics (higher EFP scores). This result may also point to the role of self-efficacy as a predictor of both expectation and actual performance in statistics**.**

SSE and SA The study also examined whether SSE influenced reported levels of SA among students within the study. The findings suggest that SSE also negatively influences levels of SA with coefficient = 0.66, $p < 0.001$ (see Table 4). This result suggests that the less students perceive themselves to be statistically inclined or able to do statistics, the more they experience anxiety around the subject; similarly, the more anxiety they experience, the lower the perception of their abilities to execute statistically related tasks. Our fourth hypothesis was therefore, not supported.

PMP, SSE and SA In light of studies that have pointed to the effect of PMP on SA (Ashcraft & Krause, 2007; Onwuegbuzie, 1997; Paechter et al., 2017; Zeidner, 1991), we also examined the possible relationship between these variables. The findings point to an association between PMP and SA, with coefficient = 0.21, p = 0.006 (Table 4), suggesting no support for hypothesis 2. This result therefore implies that the higher a participant's grade in CSEC Mathematics, the higher their SA. The direction of the relationship in this case is effected by the CSEC grading scheme. Where the lower the grade the higher the performance, that is, 1, the highest grade, and 5, the lowest grade.

Moreover, while there was no direct relationship between PMP and EFP, it has an indirect effect on EFP, when its effect on SA and SSE is examined (Table 6). When we consider SSE, PMP has an indirect effect on EFP (0.35 x -0.33 = -0.1155). Similarly, when the relationship between SA and SSE with regard to PMP, an indirect effect on EFP was also found (0.35 x 0.64 x - 0.39 = -0.0874). The total indirect effect of PMP on EFP was therefore found to be -0.2039. This indicates that both SSE and SA have some influence in the relationship between a students' PMP at the secondary school level and their EFP in statistics at the tertiary level.

This result provides support for the mediating role of SSE and SA within the understanding of the relations between prior mathematics performance and expectations for performance in statistics. When SSE is examined, a direct effect of -0.33 was found, while an indirect effect of -0.2496 (0.64 x -0.39) was found when its interaction with SA was considered (Table 6). As noted by Zerbolio (1989), even when students are confident in their mathematical ability, this does not negate possible anxieties towards statistics.

Table 6: Direct, indirect and total effect of variables and Expectations for Performance

Variable	Direct effect	Indirect effect	Total effect
PMP	0.01	-0.2039	-0.193
SSE	-0.33	-0.2496	-0.0804
SA	-0.39	--------	-0.39

*Prior Mathematics Performance, Statistical Self-Efficacy, Statistical Anxiety

6. DISCUSSION AND CONCLUSIONS

The purpose of this study was to examine students' expectations for performance (EFP) in statistics and the factors that influence such expectation, namely previous mathematics performance (PMP), perceived statistical self-efficacy (SSE), and statistics anxiety (SA). The study also sought to determine whether students' EFP in statistics differ based on demographic factors, namely sex and academic discipline. We found that three measures, students' SA, SSE, and PMP accounted for 43% of the variability in students' EFP, with coefficient = 0.43. There was no evidence of a difference in students' EFP in statistics based on sex or academic discipline. Key findings were that PMP had little direct effect on students' EFP in statistics, but moderate indirect effect on their levels of SA and SSE. While SSE positively affected students' SA, this measure produced a negative effect on their EFP in statistics. Both SSE and SA negatively affected students' EFP in statistics, but with minimally higher levels for the latter.

In this study, PMP did not have a direct effect of EFP. One possible explanation for this indirect result may be that of the time lapse between a students' sitting of the CSEC mathematics examination, which takes place upon completion of five years of secondary or high schooling, and that of their entrance to the university, which for most students, takes place at least two years after the sitting of this examination. In the years between CSEC and enrollment in university, students who are interested in furthering their education have the option of pursuing advanced studies and examinations at secondary school or pursuing Certificate programs at other institutions. At this juncture, the tendency for students not to opt for mathematics or related areas of study in higher education institutions also raises deeper questions around the training and developmental thrusts within the region. It is also important to mention that the present study sampled students in the social sciences, many of whom opt not to do mathematics as a subject after CSEC. These findings strengthen the need for examinations, not only on previous mathematics performance, but also, on students' subjective evaluations of the mathematics-related thinking and competencies. Such analyses are particularly important for understanding the possible impact of such experiences on student perceptions, anxieties, and expectations for performance in statistics at the tertiary or higher education level.

Despite the lack of a direct relationship between PMP and EFP, our findings also show that examinations of the teaching and learning of statistics in the Caribbean should be grounded within understandings of the relative impacts of students' prior performance in mathematics on both their fears and levels of efficacies around related competencies. In this case, we noted that there were moderate but indirect relationships between PMP, SSE, and SA. This is consistent with many other studies in the field of statistics education (Garfield & Ben-Zvi 2007; Johnson & Kuennen, 2006; Onwuegbuzie & Wilson, 2003; Paechter et al., 2017; Zeidner, 1991), where despite some observed association, PMP, as measured by an examination result, did not have an direct impact on students' performance in statistics. At a broader level, however, the findings provide additional support for the associations between PMP and SA with students' performance in statistics (see Keeley et al., 2008; Macher et al., 2013; Onwuebuzie & Wilson, 2003; Tishkovskaya & Lancaster, 2010). While the present study examined students' EFP, these findings extend the explorative parameters of prior grade in mathematics as a predictive factor for SA and SSE.

While the study provides initial data that teases through these critical issues, three key limitations effect the generalizability and interpretations of findings. First, the study did not include students' actual performance in statistics, but only used their expectations for their performance. Second, the use of one-time self-reports does not allow for possible shifts in students' perception and/or expectations and does not eliminate the possibility for participants to respond based on perceived desirability. Given the formative tendencies of such expectations, it is important to recognize the value of such baseline cross-sectional research for future longitudinal studies. Third, the study did not control for potentially confounding variables. Thus, while associations were established, this may not be exclusive to the interactions between the two variables under investigation and may be subjected to other interactive or situational effects.

These inherent limitations therefore strengthen the need for further scrutiny of the teaching and learning processes to which students are exposed and/or for other factors that account for EFP in statistics. Key areas for future research are therefore:

- Further analyses and comparisons of both expectations for performance and actual performance in statistics courses at tertiary level institutions in the Caribbean.
- Examinations of students' expectation for performance across other Caribbean universities. This type of comparative analysis can strengthen curricula and pedagogical development, and/or reforms related to statistics education within the region.
- Extended analyses of the variance in students' expectation for performance across other disciplines and/or faculties. While this study offers a useful baseline study for the examination of students' expectations for performance within social science disciplines, this type of comparison remains valuable for assessments of the statistical proficiencies of university graduates.
- Further analysis of the impact of students' prior performance in and experience with mathematics, on the level of efficacies that they develop around mathematical competencies, the fears that they develop in the process, and the decisions to pursue (or not) statistics education within higher education.
- Further explorations of statistical content and exposure at early-to-mid levels of the education system. Such examinations can test for the relative impacts of existing curricula at these successive levels on students' attitude towards statistics. This type of investigation is important for any assessments of the adequacy of this existing content at these early-to-mid levels for the region.
- Refinement of the scales/measure for SA. While the findings speak to the transferability of the SA measure across contexts, it also confirms the need for further adjustments/adaptations of the questions and language within the scales. In particular, we note that the relevance of the testing and interpretative factors within the statistics anxiety scale may be on account of the emphasis on verbal reasoning and logical thinking skills within statistics courses; an area that continues to be a problematic area for students (delMas & Liu, 2005; Garfield, 1995; Garfield, 2003; Hirsch & O'Donnell, 2001). The findings therefore strengthen existing calls for continued interrogations of the variability, complexity, and perhaps contextuality that surrounds this SA measure. This type of conceptual and operational refinement is particularly important given the diverse application of these measures and the search for best practices associated with reducing students' anxieties towards statistics.
- Further investigations of the SSE measure. In this study, we recognized through the combined SSE (with attitudinal and competency based sub-measures), the value of the cognitive processes related to the EFP in statistics. This finding is consistent with the literature within the field of statistics education where SSE emerges as a direct predictor of performance (Mihai-Bogdan et

al., 2015; Perepiczka et al., 2011). The inclusion of attitudinal and competency based sub-measures, however, also requires further testing and validation.

- This raises more pointed questions as to the processes and dynamics through which SSE develop, the importance of prior experiences (not just performance) with mathematics, the circumstances through which these translate into reported levels of SA, and the processes through which teaching and learning praxes within the classroom can address these concerns. Answering these questions require deeper interrogations of classroom dynamics, relations and outcomes that extend beyond statistical examinations of the measures contained in this study. Such findings also add to ongoing debates in the literature on the nature of the relationship between SSE and anxiety towards statistics (see for instance Bandalos et al., 1995; Perepiczka et al., 2011).
- Exploration of alternative methodologies within the understanding of students' expectation for performance in statistics. In this case, we suggest the use of quasi-experiments, case studies, and/or mixed methodological designs that treat with the structural, social, and pedagogical factors that bear on how students' both think of and performance within statistics courses. Such expanded studies or unique methodological lenses can elucidate the connections between anxiety, statistical self-efficacy, and expectation for performance, with specific examinations of both teachers and students' perspectives. The findings of this research provide credible support for this.
- Further interrogations of the pedagogical and curriculum thrusts within statistics courses, with inherent foci on the evaluative, calculative, and affective aspects of these courses. The scholarly examination of these facets of statistics education are important given the developmental stages at which this type of learning is being introduced and against ongoing calls for non-hierarchical and creative means of presenting statistical information within the classroom (Cruise et al., 1985; Onwuegbuzie & Wilson, 2003; Slootmaeckers et al., 2014). While this type of innovative approach to the teaching of statistics is yet to be explored in the Caribbean, we see such investigations as a necessary part of enhancing students' expectations related to their performance in statistics and developing or promoting an appreciation for statistics education in the region.

With an increasing number of students taking statistical courses, such examinations remain central to the advancement of statistics education both at regional and international levels. If advanced as a body of research, then such explorations have substantial implications for how we approach the learning and teaching of statistics for students within higher education institutions. This is particularly important in the context of the Caribbean, where statistics education remains mostly situated within tertiary or higher education programs.

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APPENDIX

Dear Students,

The purpose of this research is to explore the possible associations, if any, between statistical anxiety, competencies and expectations for performance in statistics. This assessment is part of wider project geared towards improving the delivery and outcomes of [name of course].

This questionnaire has five (5) sections that cover questions on demographics, statistical anxiety, statistical competencies, and expectation for performance in statistics.

The questionnaire will take no longer than 20 minutes to complete.

Please note that:

- Your participation in this survey is voluntary
- Students will only be selected based on their willingness to be involved in this study
- Willing participant must sign the attached consent form
- There are no risks associated with this process
- There are no monetary benefits attached to participation in this survey

Should you have any questions on the above, please feel free to email either [emails provided].

Thanking you in advance for your consideration and participation.

Kind regards,
[Names of researchers]

Section 1: Demographic Questions

What is your sex?

1. Male
2. Female

Which program are you currently registered in?

1) Sociology
2) Psychology
3) Criminology
4) Social Work
5) International Relations
6) Political Sciences
7) Leadership and Management
8) Other

Section 2: Previous Performance in Mathematics

What was your grade for mathematics at the CSEC level?

1. Grade 1
2. Grade 2
3. Grade 3
4. Grade 4
5. Grade 5

Section 3: Statistical Anxiety

For the following statements, please rate your level of anxiety experienced:	Scale: No Anxiety				High Anxiety
Fear for Asking for Help					
Asking someone help in understanding a graph	1	2	3	4	5
Asking a fellow student for help in understanding a graph.	1	2	3	4	5
Asking one of your professors for help in understanding a graph.	1	2	3	4	5
Going to ask my statistics teacher for individual help with material, I am having difficulty understanding.	1	2	3	4	5
Interpretation Anxiety					
Figuring out whether to reject or retain the null hypothesis.	1	2	3	4	5
Making an objective decision based on empirical data.	1	2	3	4	5
Reading an advertisement for a product which includes figures and numerical data	1	2	3	4	5
Interpreting the meaning of a probability value (p-value) once I have found it.	1	2	3	4	5
Interpreting the meaning of a table in a book or journal article.	1	2	3	4	5
Trying to decide which statistical test is appropriate for your research project.	1	2	3	4	5
Reading a journal article that includes some statistical analyses.	1	2	3	4	5
Trying to understand the statistical analyses described in the abstract of a journal article.	1	2	3	4	5
Arranging to have a body of data put into the computer.	1	2	3	4	5
Seeing a student poring over the computer printouts related to his/her research.	1	2	3	4	5
Test and Class Anxiety					
Walking into the classroom to take a statistics test.	1	2	3	4	5
Doing the final examination in a statistics course.	1	2	3	4	5
Studying for an examination in a statistics course	1	2	3	4	5
Doing the homework for a statistics course	1	2	3	4	5
Finding that another student in class got a different answer than you did to a statistical problem.	1	2	3	4	5
Enrolling in a statistics course.	1	2	3	4	5
Going over a final examination in statistics after it has been graded.	1	2	3	4	5
Waking up in the morning on the day of a statistics test	1	2	3	4	5

Section 4: Statistical Self-Efficacy

Please indicate the extent do you agree or disagree with the following statements:

Worth of Statistics	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I don't see why I have to clutter up my head with statistics. It has no significance to my life work.					
I feel statistics is a waste.					
I wish the statistics requirement would be removed from my academic program.					
I'm never going to use statistics so why should I have to take it?					
I don't understand why someone in my field needs statistics.					
I wonder why I have to do all these things in statistics when in actual life I'll never use them.					
Affective (emotion/feelings) skills are so important in my profession that I don't want to clutter my thinking with something as cognitive (logic/ rational) as statistics.					
Statistics is worthless to me since it's empirical and my area of specialization is philosophical (theoretical)					
Statistics takes more time than it's worth.					
Statistics is a grind, a pain I could do without.					
I don't want to learn to like statistics.					
Since I am by nature a subjective person the objectivity of statistics is inappropriate for me.					
I can't tell you why but I just don't like statistics.					
I lived this long without knowing statistics, why should I learn it now?					
Statistical figures are not fit for human consumption.					
Statistics isn't really bad. It's just too mathematical.					
Computational self-concept	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I can't even understand secondary school-level mathematics; how can I possibly do statistics?					
I haven't had mathematics for a long time. I know I'll have problems getting through statistics.					

I’m too slow in my thinking to get through statistics.					
I could enjoy statistics if it weren’t so mathematical.					
Statistics is for people who have a natural learning toward mathematics.					
Since I’ve never enjoyed mathematics. I don’t see how I can enjoy statistics.					
I don’t want to learn to like statistics.					

Perceived Statistical Competence

On a scale of 1 to 5, how competent are you in the calculation of the following:

	1 Not at all	2	3	4	5 Completely
Measures of Central Tendency					
Measures of Variability					
Measures of Position (z-scores)					
Areas under the curve (using Table Z)					
Percentile					
The Chi square test					
The Pearson’s Product Moment Correlation					
Independent samples t-test					
Dependent samples t-test					
Analysis of Variance (ANOVA)					

Section 5: Expectations for Performance in Statistics

On a scale of 1 to 5, how well do you think you will perform on an examination if asked to answer a question on the following:

	1 Very poorly	2 Poorly	3 Not sure	4 Well	5 Very well
The research process					
Research Design					
Frequency Tables					
Graphical Illustrations					
Measures of Central Tendency					
Measures of Variability					
The Normal Distribution					
Measures of Position (z-scores)					
Areas under the curve (using Table Z)					
Percentile					
Applying the 7 Steps in hypothesis testing to the Chi-square test					
Applying the steps in hypothesis testing to the Pearson’s Product Moment Correlation					
Linear Regression					
Applying the 7 steps in hypothesis testing to the T-test					
Applying the 7 steps in hypothesis testing to Analysis of Variance (ANOVA)					