EXPLORING STATISTICS ANXIETY IN SEVERAL INTRODUCTORY STATISTICS COURSES TO UNDERSTAND DIFFERENCES BETWEEN TYPES OF STUDENTS AND TYPES OF COURSES

Craig Alexander [1], Eilidh Jack [1], Michael McEwan [2], and Mitchum Bock [1]
[1]School of Mathematics and Statistics
[2]Academic and Digital Development
University of Glasgow
Craig.Alexander.2@glasgow.ac.uk

Despite its importance in modern curricula, many students find statistics courses challenging, and the existence of barriers among students to learning statistical reasoning is an important area of study. This study explores the presence and level of statistics anxiety in several cohorts of students studying introductory statistics. The relationship with statistical anxiety dependent on specialisms is explored, along with their curricular choices. An online questionnaire was developed to explore the effects of statistical anxiety and attitudes towards learning statistics. Comparisons were made both within and between the cohorts of students and showed that demographic factors and gender play a minor but statistically significant role in explaining levels of statistical anxiety, but that no significant differences in statistics anxiety existed between cohorts.

INTRODUCTION

Statistics anxiety has been identified as a significant factor impacting student learning in statistics courses in a variety of contexts and subjects (Chew & Dillon, 2014). For example, students in educational, social, and behavioural subjects demonstrate significant statistics anxiety (Birenbaum & Eylath, 1994). Statistics anxiety is important in statistics education, but the factors that impact the level of anxiety and the impact of anxiety on performance are less well understood.

Several studies have been conducted to investigate a wide variety of factors on the level of statistics anxiety. Bourne (2018) demonstrated that attitude towards statistics, math ability, and mathematical confidence were all important factors in reducing statistics anxiety. Student demographics have also been shown to play a role, with mature students demonstrating increased statistics anxiety (Bill, 2003) and gender having a debated impact on the presence of statistics anxiety, with some studies demonstrating that females have higher levels of statistics anxiety (e.g., Baloglu et al., 2011). Whilst such studies clearly link personal and demographic factors with statistics anxiety, a separate phenomenon commonly linked with statistics anxiety is self-efficacy.

Self-efficacy is the belief in your own ability to resolve a problem or to meet the demands of a particular situation (Bandura, 1997). Self-efficacy is frequently linked with statistics anxiety and impact on learning. Onwuegbuzie (2003) suggested that statistics self-efficacy may be a contributing factor to performance in statistics courses. Demographics and self-efficacy clearly play an important role in statistics anxiety, but what has not been explored in depth are structural elements of degree programmes that influence *who* students are. Koemadij and Ailey (2018) found that specialist statistics students were more likely to harbour long-term ambitions related to statistics, perhaps impacting on self-efficacy, and willingness to study. In contrast, Gordon (2004) noted that students who are required to study a compulsory statistics course demonstrate less willingness to study. However, the combination of compulsion and specialism have not been explored yet are clearly important factors relevant in fully understanding statistics anxiety.

GOALS

Accordingly, we explore the presence and level of statistics anxiety in specialist and non-specialist student cohorts alongside voluntary and non-voluntary cohorts, further exploring self-efficacy and any resultant differences between these cohorts. We also consider the association of demographic and academic background factors on statistics anxiety.

In S. A. Peters, L. Zapata-Cardona, F. Bonafini, & A. Fan (Eds.), *Bridging the Gap: Empowering & Educating Today's Learners in Statistics. Proceedings of the 11th International Conference on Teaching Statistics (ICOTS11 2022), Rosario, Argentina.* International Association for Statistical Education. iase-web.org

METHODS

Measuring Statistics Anxiety

The statistics anxiety rating scale (STARS) developed by Cruise et al. (1985) is a widely used measure for assessing statistics anxiety. The scale consists of 51 items with a total of six sub-scales, namely: interpretation anxiety, test and class anxiety, fear of asking for help, worth of statistics, computation self-concept, and fear of statistics teachers. Following Chew and Dillon (2014), the first three sub-scales (corresponding to the first 23 items) were used in this study to measure the students' anxiety about statistics. Each item is measured on a 5-point Likert scale (1 represents no anxiety whereas 5 represents strong anxiety). The mean response across all 23 items were used as measures of statistical anxiety.

Measuring Self Efficacy

The general self-efficacy scale (GSE) by Schwarzer and Jerusalem (1995) is a 10-item psychometric scale designed to assess optimistic self-beliefs. Higher scores on the GSE indicate stronger self-efficacy, i.e., individuals' belief in their abilities to produce certain behavioural outcomes that may affect how they feel, think, and act. Five questions from the GSE scale were used in this study, each measured on a 4-point Likert scale (1. not at all true / 2. hardly true / 3. moderately true / 4. exactly true). The mean response was used as an overall measure of self-efficacy.

Demographics and Academic Background

At the host institution, undergraduates are typically recruited into four-year degree programs. Students are recruited into colleges that correspond to groups of cognate disciplines, with statistics being multidisciplinary and so recruiting students from multiple colleges. The academic entry requirements to each college and the main degree programs studied vary drastically across the student body; hence a variety of demographic and academic background was collected. The variables measured were gender, age, nationality, college of study, year of study, main subjects of study, and highest mathematical qualification.

Data Collection

Students were surveyed in three introductory statistics courses in the School of Mathematics and Statistics at the host institution in the 2019–2020 academic year. The three courses were selected to provide meaningful comparisons between "specialist" and "non-specialist" students and "voluntary" and "non-voluntary" courses. For the purposes of this study, "specialist" refers to students choosing mathematics and/or statistics amongst their main subjects of study at university.

RESULTS

Figure 1 shows boxplots of the overall anxiety score by types of learners. The median overall anxiety scores are similar for specialist and non-specialist learners and for the voluntary and non-voluntary courses. Confidence intervals were also computed and showed that there are no significant statistical differences between the mean overall anxiety scores when comparing various cohorts of students (i.e., all 95% confidence intervals for the differences in population means contain zero).

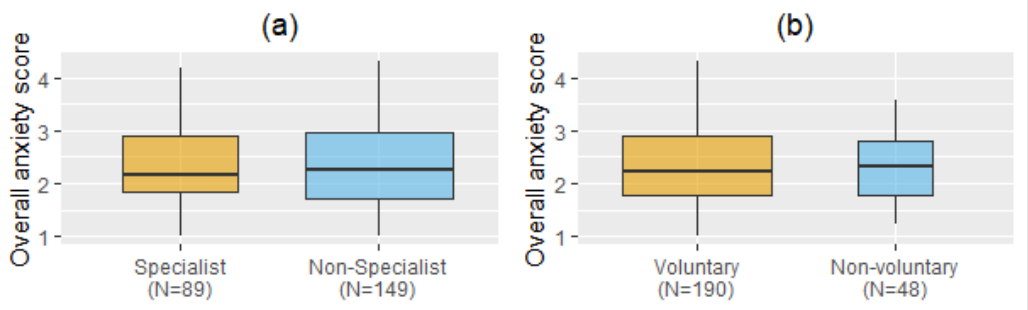

Figure 1. Boxplots of overall anxiety score for (a) specialist and non-specialist learners and (b) voluntary and non-voluntary courses

Statistics Anxiety by Demographic and Academic Factors

Because there are no statistically significant differences in mean overall anxiety scores between the specialist and non-specialist learners or between learners participating in voluntary and non-voluntary courses, the different cohorts of students were combined, and the overall anxiety scores were compared across various demographic and academic attributes collected in the survey. To illustrate, Figure 2(a) shows overall anxiety scores are generally higher in female learners than in male learners and a 95% confidence interval (CI) from these data estimates that female learners have, on average, overall anxiety scores between 0.226 units and 0.585 units higher than male learners. Figure 2(b) summarises the distributions of overall anxiety scores for different combinations of nationalities, and a one-way ANOVA applied to these data revealed borderline significant differences in mean overall anxiety scores (p-value = 0.049). Figure 2(c) shows overall anxiety score against self-efficacy score with a corresponding correlation coefficient of -0.541 with a 95% CI of [-0.625, -0.445], indicating that higher overall anxiety scores are associated with lower self-efficacy scores.

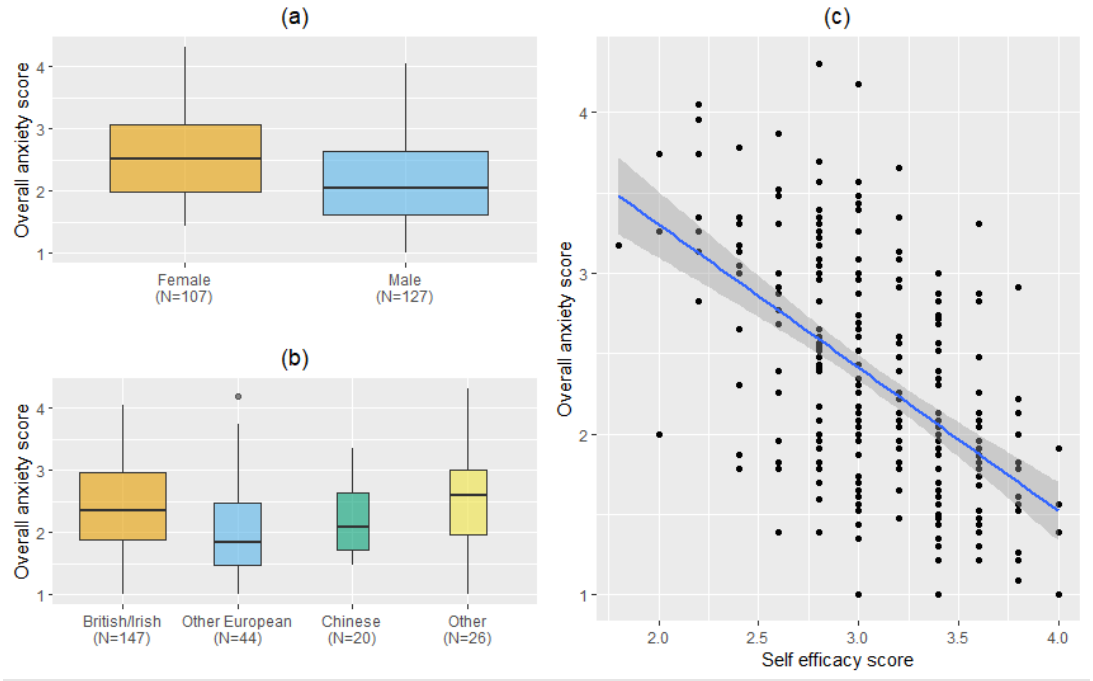

Figure 2. Boxplots of overall anxiety score for (a) gender and (b) nationality. Plot (c) shows a scatterplot of mean self-efficacy score against overall anxiety score with a fitted linear model with 95% confidence bands.

In order to consider the combined associations of these and other attributes with overall anxiety score, linear regression models were used with overall anxiety score as the outcome variable. A backwards elimination approach using the Akaike Information Criteria (AIC) as the metric was used to find the optimal model. Table 1 lists the parameter estimates from the optimal model and echoes the patterns seen in Figure 2 after accounting for all explanatory variables simultaneously.

Table 1. Coefficients from the final model with overall anxiety score as the outcome variable

Coefficient	Estimate	95% CI
Gender (Male)	-0.233	[-0.398, -0.068]
Nationality (Other European)	-0.185	[-0.394, 0.024]
Nationality (Chinese)	-0.373	[-0.660, -0.086]
Nationality (Other)	0.054	[-0.203, 0.310]
Self-efficacy	-0.862	[-1.049, -0.675]

In particular, the final model estimates that, when holding other variables constant, male learners have, on average, overall anxiety scores 0.233 units less than female learners. Considering nationality, only learners with Chinese nationality had a significantly different overall anxiety score compared to learners with UK/Irish nationality with, on average, an overall anxiety score 0.373 units lower than British and Irish learners. Finally, for each unit increase in self-efficacy, overall anxiety score decreased, on average, by 0.862 units.

CONCLUSION

A major focus of this study was to explore instances of statistics anxiety through the lens of student speciality (and, through association, by course). Within this study, no significant difference in levels of statistical anxiety was found between students enrolled in courses designed for specialists (maths and/or statistics students) compared to students in courses designed for non-specialist (students from all other disciplines). There have been few studies to explore the levels of statistics anxiety as influenced by speciality directly, but some studies have explored the indirect association between statistics anxiety and speciality. For example, Gordon (2004) noted that non-specialist students demonstrated less willingness to study, and a lower willingness to study was associated with higher anxiety.

The present study demonstrates that specialism alone is not a sufficient factor to better understand anxiety or predict its prevalence. As an aside, a major discovery in the present study was unintended: 43% of the students in a course designed and marketed for 'specialists' were not, in fact, specialists by our definition. Thus, using course enrolments as a proxy for specialism was not valid and was replaced with the bespoke definition of 'specialist' described above. This illustrates that a course's target student profile can be quite different from the actual student profile and any assumptions based on the target learner could be quite inappropriate.

REFERENCES

Baloğlu, M., Deniz, M.E., & Kesici, Ş. (2011). A descriptive study of individual and cross-cultural differences in statistics anxiety. *Learning and Individual Differences*, *21*(4), 387–391. https://doi.org/10.1016/j.lindif.2011.03.003

Bandura, A. (1997). *Self-efficacy: The exercise of control*. W. H. Freeman/Times Books/Henry Holt & Co.

Bill, J. A. (2003). Statistics anxiety: The nontraditional student. *Education*, *124*, 157–163.

Birenbaum, M., & Eylath, S. (1994). Who is afraid of statistics? Correlates of statistics anxiety among students of educational sciences. *Educational Research*, *36*, 93–98. https://doi.org/10.1080/0013188940360110

Bourne, V. J. (2018). Exploring statistics anxiety: Contrasting mathematical, academic performance and trait psychological predictors *Psychology Teaching Review*, *24*, 35–43.

Chew, P. K., & Dillon, D. B. (2014). Statistics anxiety update: Refining the construct and recommendations for a new research agenda. *Perspectives on Psychological Science*, *9*(2), 192–208. https://doi.org/196-208. 10.1177/1745691613518077

Cruise, R. J., Cash, R. W., & Bolton, D. L. (1985). Development and validation of an instrument to measure statistical anxiety. In *Proceedings of the Section on Statistical Education: Papers presented at the Annual Meeting of the American Statistical Association* (pp. 91–97). ASA.

Gordon, S. (2004). Understanding students' experience of statistics in a service course. *Statistics Education Research Journal*, *3*, 40–59. https://doi.org/10.52041/serj.v3i1.541

Koemadji, Z. A., & Ainley, J. M. (2018). Specialist and non-specialist students' attitude towards statistics. In M. A. Sorto, A. White, & L. Guyot (Eds.), *Looking back, looking forward. Proceedings of the Tenth International Conference on Teaching Statistics (ICOTS 10, July, 2018) Kyoto, Japan*. ISI/IASE. https://iase-web.org/icots/10/proceedings/pdfs/ICOTS10_C247.pdf?1531364324

Onwuegbuzie, A. J. (2003). Modeling statistics achievement among graduate students. *Educational and Psychological Measurement*, *63*(6), 1020–1038. https://doi.org/10.1177/0013164402250989

Schwarzer, R., & Jerusalem, M. (1995). Generalized self-efficacy scale. In J. Weinman, S. Wright, & M. Johnston (Eds.), *Measures in health psychology: A user's portfolio. Causal and control beliefs* (pp. 35–37). NFER-NELSON.