

STUDENT ANXIETY VARIES AMONG DEMOGRAPHIC GROUPS AND IMPACTS PERSISTENCE IN INTRODUCTORY BIOLOGY COURSES

Introduction to the Subject and Problem

Emotions are human reactions to future, current, and past events, and are a constant presence in academic classrooms (Pekrun, 1992; Mazer, 2017). In many cases these academic emotions are helpful by promoting action or reflection that increases student motivation, learning, and performance (Kim & Pekrun, 2014). However, not all emotions have positive impacts on student success. Anxiety has been of interest to undergraduate education researchers in recent years because of the increasing prevalence of this emotion in students (Bitsko et al., 2018; Castillo & Schwartz, 2013) and student reports of anxiety associated with active learning pedagogies in undergraduate science classrooms (Broeckelman-Post, Johnson, & Schwebach, 2016; England, Brigati, & Schussler, 2017).

Anxiety is a negative, prospective emotion that students experience when they are worried about failure and feel only partially certain about their ability to control the outcome (Pekrun, Frenzel, Goetz, & Perry, 2007). Anxiety has been shown to impact student persistence. England et al. (2017) identified a difference between the average general anxiety levels of undergraduate students who intended to stay in or leave the Biology major, with those intending to leave having higher anxiety. Witt, Schrodt, Wheelless, & Bryand (2014) found that receiver apprehension (a student's fear that they may not be able to understand the presented material) was negatively associated with the intent to persist in students' respective majors. In a study on course climate, Barthelemey, Hedberg, Greenberg, & McKay (2015) found that academic stress was negatively related to persistence.

Anxiety differs among demographic sub-sets of students in academic environments. The most widely studied differences have been between females and males, with females having consistently higher anxiety than males (Bayram & Bilgel, 2008; Bryant et al., 2013; Misra & McKean, 2000). Anxiety is also higher in freshman as compared to upper level students (Bayram & Bilgel, 2008). Anxiety in terms of underrepresented minorities has been studied in the context of stereotype threat (Steele & Aronson, 1995), in which invoking membership in a group with a negative stereotype causes the student to perform less well. This effect is hypothesized to be mediated by increased anxiety among these students (Steele, Spencer, & Aronson, 2002).

Given the increasing prevalence of anxiety among undergraduates (Castillo & Schwartz, 2013) and use of pedagogies that students say cause them anxiety (Broeckelman-Post *et al.*, 2016; England et al., 2017), it is important to investigate any potential links between anxiety and persistence in introductory science courses.

Methods and Procedure

Courses and Instructors

Measurements of student anxiety and persistence in the major were collected in fall 2016 from students enrolled in majors' introductory biology lecture classes at a large Southeastern public research university. The introductory biology sequence includes an Organismal and Ecological Biology (OEB) class and a Cellular and Molecular Biology (CMB) class, which can be taken in either order. Students in each course were mostly freshman and sophomore biology or pre-professional majors. The introductory courses at this university utilized the main tenets of *Vision and Change in Undergraduate Biology Education* (AAAS, 2011) to guide their delivery, including the use of active learning pedagogies.

All procedures for this study were approved by the institution's human subjects review board prior to the start of the research (IRB-16-03181-XP).

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Data collection

Data were collected through the use of two online surveys sent as links via an e-mail from each course instructor. Surveys were disseminated at two points during the semester: an initial survey within the first month of the semester and a final survey at week fourteen.

Students' perception of their general course anxiety was captured through a 7-item, 7-point Likert scale instrument adapted from Papanastasiou and Zembylas (2008) to measure anxiety levels toward research. The factor structure of this scale was delineated by Papanastasiou (2005). The scale was 7 points, where 1 was no anxiety, and 7 was high anxiety. For this study, the word research in each item was replaced with the words Biology lecture; this was the only change made to the instrument. The seven items were as follows: Biology lecture...makes me nervous, is stressful, makes me anxious, scares me, is complex, is complicated, is difficult. After performing confirmatory factor analysis (CFA), we used only the first four items of this scale to measure general course anxiety (CFA results not reported here).

Student responses to the first four items were averaged to arrive at a mean general course anxiety score for each student. Mean scores ranged from 1-7: the higher the mean, the higher the anxiety. The researchers use the word general to indicate that the anxiety measure was not specifically in response to any one aspect of the course, but instead a measure of overall perception of anxiety.

In addition to student anxiety, students self-reported demographic information regarding year in school (freshmen, sophomore, junior, senior, super senior), gender identity (male, female, other, or prefer not to respond), racial/ethnic identity (open response), and number of Advanced Placement (AP) courses completed in high school (0, 1, 2, 3, or 3+). On the final survey, students were asked whether they had changed their intended major since the beginning of the semester.

Data analysis

Gender was pared down to male and female. Ethnicity was coded into Caucasian vs. non-Caucasian based on student free responses to this question. There were 122 total matched responses from Biology majors.

Variables Related to Student Persistence

To assess the impacts of anxiety and demographics on student persistence (a student's intention to remain in or leave the major), binary logistic regression was performed. The dependent variable was that students indicated they were either leaving or remaining in the biology major. The independent variables included the following: general course anxiety (both time points), gender, year, ethnicity, and number of AP courses. Predictors were considered significant at $p < 0.05$.

Student Demographics and General Anxiety

We further investigated the relationship between student demographic variables (gender, year in school, ethnicity, and number of AP courses) and general course anxiety. Two multiple linear regression models were created (separate models for initial and final survey responses). All predictor variables for this model were categorical and were considered significant at $p < 0.05$. All predictors were dummy coded as 0 or 1: 0 for freshmen, 0 for females, 0 for non-Caucasians, and 0 for those with 0-1 AP courses. Hierarchical forward regression was used, meaning variables were entered into the model based on greatest increment to the R^2 value.

Levels of general anxiety were averaged and graphed based on students' intention to remain in the major. Anxiety levels were compared using an independent samples t-test and

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considered significant at $p < 0.05$. A Bonferroni correction was applied to account for multiple comparisons.

Results and Findings

Variables Related to Student Persistence

General course anxiety showed a mean of 2.70 on the initial survey and 2.74 on the final survey. At the beginning of the semester, a 1-point increase in general course anxiety meant one was 2.7 times more likely to leave the major (Table 1). Females were 7.871 times more likely to leave the major, and those with 0-1 AP courses were 3.088 times more likely.

Table 1. Odds ratio and significance values based on binary logistic regression for students indicating they were leaving the major, based on variables collected from both surveys (N = 122). An odds ratio less than 1 means that a 1-point increase in the anxiety scale or the presence of a demographic category makes it less likely that a student will leave the major. An odds ratio greater than 1 means that a 1-point increase in the anxiety scale or the presence of a demographic category makes it more likely for a student to leave the major. An odds ratio of 1 suggests that a student is equally likely to stay or leave. * $p < 0.05$, ** $p < 0.001$

	Student leaving
Independent Variable	Odds Ratio
Initial Gen Class Anxiety	2.700*
Final Gen Class Anxiety	1.852
Female	7.871**
Freshman	2.216
Non-Caucasian	0.369
0-1 AP Courses	3.088*

Student Demographics and General Anxiety

The best-fit model for the initial survey responses was significant ($F = 7.460$, $p < 0.001$), as was the best-fit model for the final survey ($F = 16.38$, $p < 0.001$). At the beginning of the semester, freshmen, females, and those with one or fewer AP courses were more likely to have higher perceptions of general course anxiety (Table 2). At the end of the semester, this trend continued for freshmen and females.

Table 2. Regression predictor values, standard error (SE), and p-values for general course anxiety for the initial and final surveys. * $p < 0.05$. N = 337.

Predictor (initial)	Value	SE	p-value	Predictor (final)	Value	SE	p-value
Intercept	3.447	0.179	< 0.01*	Intercept	3.407	0.143	< 0.01*
Year	-0.579	0.167	< 0.01*	Year	-0.913	0.177	< 0.01*
Gender	-0.402	0.183	0.029*	Gender	-0.410	0.194	0.035*
AP	-0.465	0.169	< 0.01*				

The measures of general course anxiety from the initial survey were significantly different between those students intending to leave the major versus those staying ($t = -3.824$, $p < 0.001$), with those staying in the major having lower initial anxiety (Figure 1). These results

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were similar for the general anxiety measures from the final survey ($t = -4.483$, $p < 0.001$); again, those remaining in the major had significantly lower anxiety.

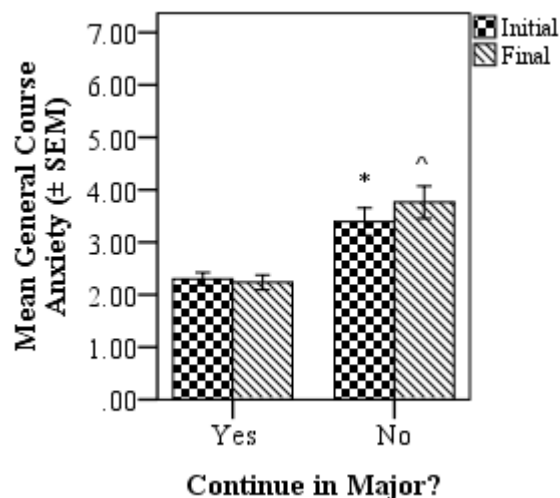


Figure 1. Biology majors ($N = 122$) who report leaving the major showed significantly higher initial general course anxiety ($*p < 0.001$). Biology majors who report leaving the major show significantly higher final general course anxiety ($^{\wedge}p < 0.001$). The Likert scale is 1-7, with 1 being no anxiety and 7 being high anxiety. Data are mean general course anxiety \pm standard error of the mean (SEM).

Discussion and Contribution

Higher levels of general course anxiety were positively associated with – and predictive of – a student’s intention to leave the major. This was found not just at the end of the semester, but also at

the beginning, suggesting prospective anxiety early in one course can impact students’ persistence in the major. This suggests that general course anxiety may be perceived as a future judgment on success in a degree program. The finding that anxiety impacts persistence is aligned with other recent studies (Barthelemey et al., 2015; England et al., 2017; Witt et al., 2014).

The findings that several demographic groups showed differential persistence support an extensive literature base on differential outcomes for sub-sets of students in science. Studies identifying gender differences in persistence are common in the biology education literature (Eddy, Brownell, & Wenderoth, 2014; Eddy and Brownell, 2016) and are thought to contribute to the lower than expected numbers of females in science (NSF, 2011).

Many of the impacted sub-groups in this study come from traditionally marginalized groups in science who sometimes feel they do not belong in the science classroom (Grunspan et al., 2016). This has negative impacts on self-efficacy (a person’s belief in his or her ability to succeed at a task), which is inversely related to anxiety (Bandura, 1989). Although there are many potential causes of these differentials, recent work has highlighted classroom climate issues that could impact emotional responses. For example, factors such as professor-student interactions, student-student interactions, and classroom pedagogical practices may influence how these groups perceive the course and experience anxiety (Barthelemey et al., 2015). Classroom differentials such as professors being more likely to call on males in class (Eddy et al., 2014) or females not being conferred the same respect for intellectual abilities that male students are in introductory biology (Grunspan et al., 2016), may lead to disenfranchisement and increases in anxiety.

For certain subsets of students in the classes, their emotional experiences and appraisals are different from the rest of the class, leaving them vulnerable in terms of STEM success. Further research on anxiety in the classroom is imperative in order to determine the actions instructors can take to mitigate anxiety in the classroom and potentially address the STEM attrition crisis.

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General Interest

These findings should be of interests to instructors in all STEM fields, as they measure the feelings of anxiety students may feel in the classroom as well as how these feelings vary among various subsets of students, many of whom may be vulnerable to leaving STEM. Given that some reported anxiety is a product of instructor effects, instructors may want to reflect on their pedagogical approaches to determine if any actions need to be taken to create a more welcoming classroom climate.

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