

# ***A COMPARISON OF CHEMISTRY ANXIETY BETWEEN ONLINE AND IN-PERSON STUDENTS***

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This study compared reported chemistry anxiety in an undergraduate chemistry course between online and classroom students. Results indicated slightly higher levels of anxiety for online students although findings were not statistically significant. However, activities resulting in high anxiety for both groups were identified. Gender was identified as a moderating variable with significantly more women than men indicating a high anxiety level when entering the lab and getting chemicals on their hands. Gender should be explored as a variable for anxiety and confidence when working with chemicals. Curriculum designers can also use the survey and methodology to evaluate their programs.

*Keywords:* chemistry anxiety, online courses, traditional students, nontraditional students

Anxiety is an emotional reaction to a perceived situation associated with helplessness and uncertainty. State anxiety is a short-lived emotional state characterized by tension, nervousness, and concern in response to a specific situation. Anxiety within higher education is an often-explored concept, with many factors identified as potential sources. External and environmental factors like employment status (Mounsey et al., 2013; Yan, 2007) and status as an international student (Khoshlessan et al., 2017) can influence undergraduate student anxiety. Learner characteristics and internal

factors such as self-esteem (Yan, 2007), social anxiety (Russell, 2012), beliefs about learning (Young, 1991), motivation (J. X. Yan et al., 2008; Young, 1991), prior experience in a subject area (Townsend et al., 1998), learning strategies (J. X. Yan et al., learning interest (J. X. Yan et al., 2008), degree progress (Stanley, 2016), academic major (Brown et al., 1981), and gender (J. X. Yan et al., 2008) have also been linked to anxiety in higher education. Institutional and classroom characteristics (transactional distance) influence anxiety, including instructor-learner interactions

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(Young, 1991), instructor's teaching methodology (S. L. Eddy et al., 2015; Young, 1991), instructor characteristics (J. X. Yan et al., 2008), test type (Khanna, 2015; J. X. Yan et al., 2008), assessed group work (Strauss, 2011), and classroom procedures like verbal communication (Broeckelman-Post et al., 2016; Young, 1991). Anxiety has been identified as a significant challenge in particular subject areas, particularly mathematics (Bradstreet, 1996; Jain et al., 2009; Kesici et al., 2009; Nunez-Pena et al., 2013).

Chemistry anxiety is a well-explored phenomenon in the literature. Studies targeting anxiety reduction in chemistry have demonstrated that students display high anxiety levels at the beginning of the course (Abendroth et al., 1983; Oludipe et al., 2010). Gender is a moderating variable for chemistry anxiety, with females reporting higher anxiety (Cooper, 1994; R. M. Eddy, 2000; Widanski et al., 2009). Low chemistry experience was also correlated to chemistry anxiety (R. M. Eddy, 2000; Widanski et al., 2009). The literature reports inconsistent results regarding an association between major and anxiety (R. M. Eddy, 2000; Widanski et al., 2009). One study did not report an association between anxiety and math experience (R. M. Eddy, 2000). In chemistry, strong task value has been shown to promote the use of diverse learning strategies, which encouraged the use of regulatory strategies, decreasing anxiety and indirectly increasing self-efficacy (Aydin et al., 2011).

Students have reported anxiety when starting a new online course, regardless of prior experience with online courses and course status as a required or elective (Conrad, 2002). However, students with prior experience in online courses tend to have more effective learning strategies and thus higher motivation; motivation, in turn, is associated with increased course satisfaction and final course grade (Wang et al., 2013). Computer anxiety has been shown to impact online learning, though self-efficacy can mediate the impact of anxiety on the perceived ease of use of the learning management system (Saade et al.,

2009). Transactional distance has been shown to reduce anxiety, though the elements of transactional distance had a varying influence by modality (Hauser et al., 2012). Structure characteristics (e.g., degree of autonomy) are key elements in an online course for reducing anxiety, while dialog (an interactive characteristic) is a priority for achieving anxiety reductions in a traditional face-to-face course. In a graduate-level statistics course, online students had higher anxiety and less favorable attitudes at the start of the course, but affect improved, and anxiety dropped throughout the term, eventually arriving at similar levels to on-campus students by the end of the term (DeVaney, 2010). While distance learning may be a source of anxiety for some students, there is some evidence that a distance modality can reduce anxiety for some students due to elements like the ability of students to set their own pace, absence of public criticism and peer pressure, and the opportunity to practice in private (Hurd, 2007).

While a small amount of student anxiety may have measurable benefits (Keeley et al., 2008), too much can have negative impacts on short and long-term academic performance (Ashcraft, 2002; J. X. Yan et al., 2008; Zoller et al., 1989), including loss of motivation and attention (Zeidner et al., 2005). In chemistry-specific studies, anxiety was negatively associated with self-efficacy (Jain et al., 2009; Kesici et al., 2009) and positively associated with self-handicapping behavior, significantly predicting performance (Rotairo et al., 2015). Because it is unclear how chemistry anxiety may vary by modality, more work is needed to compare student anxiety between online and traditional courses (Conrad, 2002). This work will test the hypothesis that higher student anxiety will occur in the online and in-person modalities at the start of the term. Understanding the degree of anxiety and the causes of anxiety can help support targeted interventions to reduce anxiety. Managing anxiety helps level the playing field in science, technology, engineering, and mathematics, increasing the pass rate of low-income students, who are

already more susceptible to anxiety (Rozek et al., 2019).

## **METHODS**

### ***Participants***

Undergraduate students enrolled in on-campus and online sections of an introductory general chemistry course from a medium-sized private institution rated as “selective” by the *U.S. News and World Report* (“Admissions: Embry Riddle,” 2022). The university was considered midsized, with approximately 6,000 campus students and 21,600 online students worldwide.

On-campus students are typically 18 to 22; 76% are male. The three most prevalent student ethnicities were 53% White, 18% international, and 12% Latino. On-campus students engaged in a traditional 16-week semester. The on-campus learning environment was traditional (synchronous, in-person), with most students living there.

Online campus students tended to be male (88%) and White 55% (followed by Hispanic/Latino 13%). The online campus studied had a strong military presence (47%), with ex-military or military family members making up another 30% of the student body. The age of the average online student was 34, and most worked full-time while attending class. Online students engaged in a 9-week format, and the Canvas learning management system asynchronously supported the online learning environment.

### ***Study Participants***

Students directly involved in the study were typically in their first or second year. As mentioned, campus students took the class via traditional face-to-face lectures, and online students attended the class 100% online (asynchronously). In most cases, the chemistry was one of several course options students could select to satisfy the science requirement for graduation.

The survey was launched through SurveyMonkey, soliciting participation via emails and learning management system course announcements from the course instructors. Both campus and online students were surveyed simultaneously to minimize possible environmental factors that could have impacted the results. The response rate was 16% ( $n = 27$ ) for on-campus students and 20% ( $n = 17$ ) for online students. Survey recruitment occurred during the first 10% of the course, thus minimizing the influence of instructor, course design elements, or pedagogical choices on the results.

## **MEASURES AND DATA ANALYSIS**

### ***Chemistry Anxiety Instrument***

Many previous studies on chemistry anxiety used the Derived Chemistry Anxiety Rating Scale (DCARS; R. M. Eddy, 2000; Huey, 2013; Rotairo et al., 2015; Widanski et al., 2009). Modifications to this scale were necessary to address on-campus-specific language used in the DCARS survey (Appendix 1). A Likert scale ranged from “not at all” to “extremely anxious.” Research participants were provided a survey that included specific demographic questions and the modified DCARS.

### ***Demographic Data***

Because the modality could influence demographics, which could serve as moderating variables, we collected demographic data (Table 1). Demographic data within the on-campus and online campus students in this survey differed slightly from gender and ethnicity breakdown in the students directly involved in this study. However, ethnicity was very similar between the studied groups (on-campus and online). From the on-campus group, 67% of respondents reported White ethnicity, with all other ethnicities reporting less than 8%. From the online group, 76% of respondents reported White ethnicity, with another 12% as Hawai-

**TABLE 1**  
*Demographic Data for Study Participants*

<i>Demographic</i>	<i>On-Campus</i>	<i>Online</i>
White	67%	76%
Black	7%	—
Hispanic	7%	—
Indian	7%	—
Asian	4%	—
Other	7%	—
Hawaiian/Pacific Islander	—	12%
Prefer not to say	—	12%
Male	78%	53%
Female	22%	47%
18–24 years old	96%	41%
25–34 years old	4%	12%
35–44 years old	0%	47%
Early degree progress	26%	18%
Less than half complete	52%	24%
More than half complete	15%	35%
Near graduation	7%	24%
GPA: 3.5–4.0	52%	59%
GPA: 3.0–3.49	26%	35%
GPA: 2.5–2.99	15%	6%
GPA: 2.0–2.49	7%	0%

ian or Pacific Islander and another 12% declining to answer. There was a difference in gender and age between the two groups, which has been noted in other studies as well (Cummings et al., 2015; Lyke et al., 2012). Degree progress and cumulative grade point average (GPA) were similar across the groups.

### ***Procedure***

Survey participants were recruited using non-probability sampling. Survey responses were anonymous, and data were collected between October 2019 and October 2020. The study was reviewed and deemed exempt through the host institutional review board.

### ***Data Analysis***

This study used a descriptive research method. Data were tested using the appro-

priate chi-square or Fisher's exact test ( $\alpha = .05$ ) to evaluate responses to individual survey questions. Data from the five Likert categories were collapsed into two major categories to increase cell counts (DiStefano et al., 2020). Responses of "not at all," "a little bit," and "moderately" were counted in the "low anxiety" category. Moderate or neutral responses indicated an acceptable stress level—within reasonable limits ... tending toward the mean or average. Responses of "quite a bit" and "extremely anxious" were counted in the "high anxiety" category. Student responses were first compared by modality, assuming equal expected frequencies between the two categories. The second test conducted was a two-by-two chi-square test of independence to determine if there was an association between course modality and their responses.

## RESULTS

### Hypothesis Testing

#### Factor 1—Chemistry Learning Anxiety

We hypothesized that higher student anxiety would occur at the start of the term in the online modality versus the in-person modality. In Factor 1 of the DCARs, chemistry learning anxiety reported anxiety levels were statistically independent of course modality on all 17 questions in this factor. However, some questions documented higher anxiety than others. Questions where at least 25% of learners from one modality reported high anxiety are presented in Figure 1. The learning topics that trigger the most anxiety are reading and interpreting formulas and equations and purchasing and reading a chemistry textbook. While the variables did not yield statistically significant associations, it is interesting that anxiety is higher for online students in each area. In-person students did not have at least 25% reporting high anxiety for any chemistry learning questions.

#### Factor 2—Chemistry Evaluation Anxiety

As with Factor 1, the reported anxiety level and course modality were statistically independent. This category of questions, focusing on evaluating mastery of chemistry concepts, demonstrated much higher anxiety than learning chemistry. Only one question in this section did not report at least a quarter of students with high anxiety (Figure 2). It is important to note that more than half of the students in both groups reported high anxiety at being given a pop quiz in chemistry. Other evaluation topics that students reported high anxiety for include working on an abstract chemistry problem, waiting to learn evaluation results (even when performance was anticipated to be strong), taking a quiz, being given a difficult homework set due the next session, solving complex problems on a test, taking a chemistry test, and thinking about an upcoming chemistry test. The high level of anxiety in this category offers insight into how we could design our courses and specific interventions to mitigate evaluation anxiety in chemistry.

FIGURE 1

High Anxiety Questions from Factor 1 of the DCARs Instrument

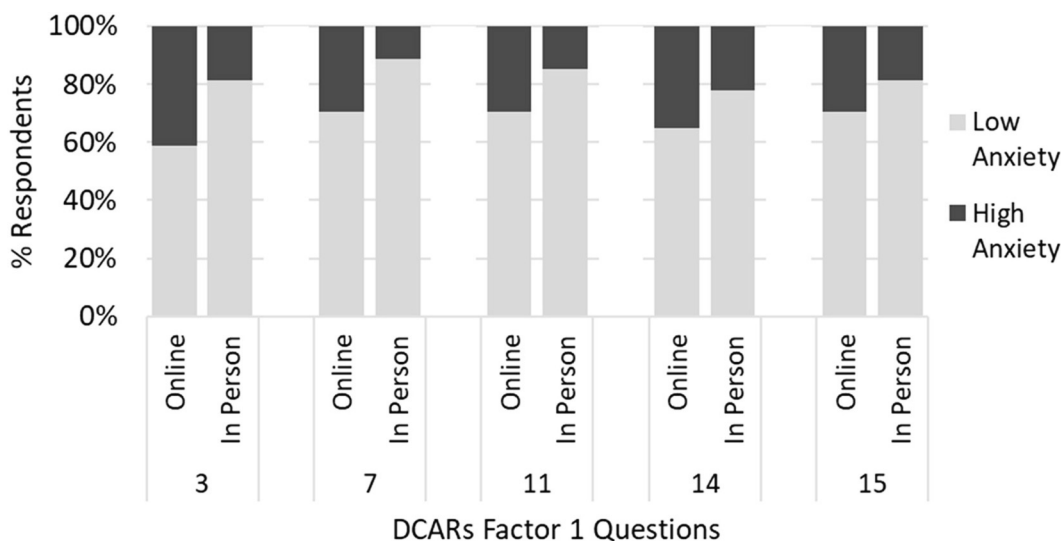
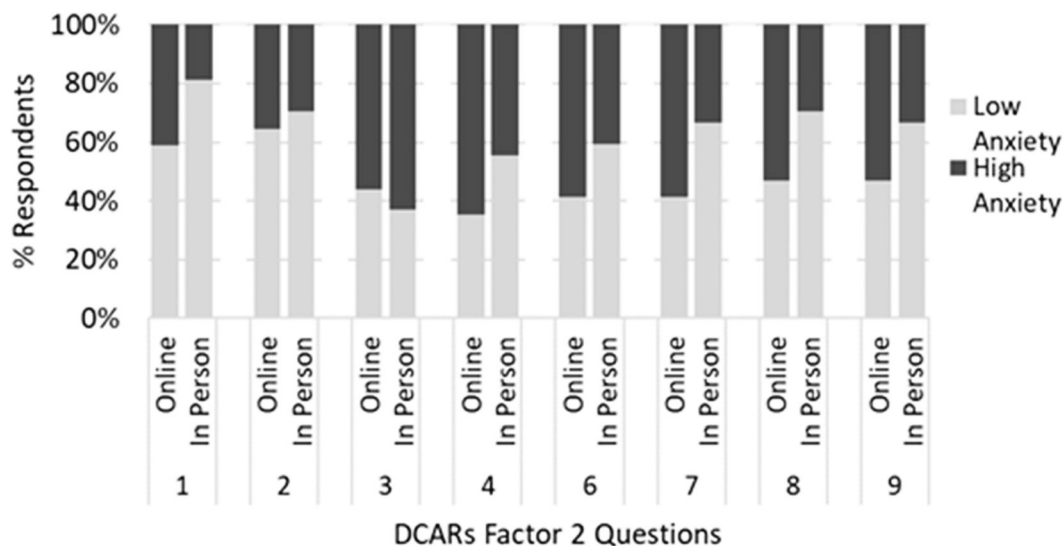


FIGURE 2

High Anxiety Questions from Factor 2 of the DCARs Instrument



### Factor 3 – Chemical Handling Anxiety

The responses regarding handling chemicals were statistically independent of course modality between online and campus-based students. Overall, this category reported very low levels of anxiety. Nearly half (41%) of online students reported high anxiety regarding handling a chemical with an unknown identity. On this same question, 22% of in-person students reported high anxiety; however, the association between variables was not statistically significant. This may be important in designing chemical activities to avoid working with unknowns in introductory chemistry or communicate that the nature of the experiment will include an unknown.

## DISCUSSION

Previous literature on chemistry anxiety focused on the traditional in-person modality. Our results for in-person and online students align with previous studies (Huey, 2013; Rotauro et al., 2015; Widanski et al., 2009),

who reported higher chemistry evaluation anxiety than anxiety related to learning chemistry or handling chemicals.

Gender as a moderating demographic variable for chemistry evaluation anxiety had mixed reports, with some studies reporting significant associations between levels of anxiety and gender (male and female students) (Widanski et al., 2009). In contrast, others reported levels and anxiety, and gender was not an associated variable, in which case both genders reported similar anxiety levels (Huey, 2013). While our study supported the idea of gender as a moderating variable for specific dimensions of chemistry anxiety, this relationship was not found in chemistry evaluation anxiety but in chemical handling anxiety. In this study, each question on the survey was examined in relation to possible moderating demographic variables of race, gender, age, and GPA. Of the demographic variables examined, reported anxiety levels were significantly dependent on the gender of the respondent on two survey questions.

For both questions, 50% of women answered that “Getting chemicals on your

hands during the experiment” and “[They] experienced high anxiety when entering the workspace for performing chemical experiments” compared to 0% of men. Both questions yielded a similar Fishers Exact test  $p$ -value of .029 and Cramer’s  $V$  of .588 ( $n = 17$ ,  $p = .015$ ). Future work should explore gender as a moderating variable for anxiety and confidence levels when working with chemicals in laboratory activities.

While other studies did not explore GPA as a moderating variable for chemistry anxiety, our study shows GPA may be a factor in some aspects of chemistry anxiety, yielding a significant Fisher’s exact test  $p$ -value of .008 ( $n = 16$ ) between those with a GPA of 3.0 to 3.49 (more anxious responses) and 3.5 to 4.0 (fewer anxious responses) for the question: “Waiting to get a chemistry assessment (quiz or test) returned in which you expected to do well.” This may have been due to the 3.0 to 3.49 group wanting to improve their grades.

With the continued trend of increasing online chemistry course offerings, more data should be available to validate these results in the future.

### **Limitations**

This study has provided insight into the chemistry anxiety experienced by students in different course modalities. A sample-related issue is a nonresponse error. The survey was voluntary. Voluntary surveys can introduce bias, with an over-representation of strong opinions, both positive and negative. As this study explored anxiety, it is reasonable to think that some students may have opted out of participation based on the topic. The survey was not incentivized, resulting in a response rate that fell below ideal sample size parameters, given the population size, actual response rate, and a 95 percent confidence level. This resulted in a margin of error of 15% for the online students and 18% for the in-person students. Due to the sample response rate and the influence of demographic variables, the results may not be generalizable to other populations.

The online campus used standardized syllabi, textbooks, course design, homework, quizzes, tests, and labs, ensuring that all course sections were taught uniformly. This standardization in course delivery may not be the case in all university settings. Care should be taken to consider this variable when replicating this research and/or interpreting the results of this study.

The instrument used in this study was developed and validated with on-campus classes, and modifying the language to address online students may have influenced reliability. Similar to previous work (Huey, 2013), Cronbach’s alpha was used to measure the reliability of the survey. In the study, Cronbach’s alpha yielded a result consistent with a high internal consistency (39 items:  $\alpha = .97$ ).

### **CONCLUSIONS**

This study aimed to compare the levels of chemistry anxiety across three factors for students enrolled in an on-campus and an online general chemistry course. The data from this exploratory study does not show a statistically significant association between reported student anxiety levels and course modality (traditional classroom environment or asynchronous online chemistry environment). However, the discovery that activities such as handling unknown chemicals generated high anxiety levels in both groups will be considered during curriculum reviews.

### **RECOMMENDATIONS**

The DCARs survey and methodology used in this study can serve as a template for future research regarding student groups and anxiety levels.

Future researchers should evaluate change in anxiety throughout the term in both modalities. While it is expected that anxiety may decrease over the term as students become more familiar with chemical concepts and skills, it is unknown if modality influences

chemistry anxiety over time. Drops and withdrawals will likely influence results as more anxious students may not persist in the course.

It is also essential to explore other sources of anxiety in chemistry learning, including the co-occurrence of mathematics and trait anxiety. A better understanding of sources of anxiety can identify opportunities in course design to reduce anxiety, thus promoting student success.

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