Fear of Negative Evaluation and Student Anxiety in Community College Active-Learning Science Courses

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ABSTRACT

Student anxiety is a growing concern for colleges and universities. As science classrooms transition from traditional lecture to active learning, researchers have sought to understand how active learning affects undergraduate anxiety. However, although community colleges educate nearly half of all undergraduates, no studies have explored the relationship between anxiety and active learning in the context of community college science courses. In this study, we interviewed 29 students enrolled across nine community colleges in the southwestern United States to probe factors that increase and decrease their anxiety in active-learning science courses. Using inductive coding, we identified a set of common factors that affect community college student anxiety in active learning. We found that community college student anxiety decreased when students perceived that active-learning activities enhanced their learning by providing them with multiple ways of learning or the opportunity to learn from others. We also identified fear of negative evaluation as the primary construct underlying student anxiety in active learning and described factors that mediated students' fear of negative evaluation in the community college science classroom. This work highlights how instructors can create more inclusive active-learning science classrooms by reducing student anxiety during active-learning instruction.

INTRODUCTION

Undergraduate mental health issues are on the rise, and colleges and universities are seeking to improve mental health for their student populations (National Council on Disability, 2017). Mental health is defined as a "state of well-being in which every individual realizes their own potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a connection to their community" (World Health Organization, 2014, http://origin.who.int/features/factfiles/ mental health/en/). Anxiety has been identified as a primary cause of college student mental health concerns (Center for Collegiate Mental Health, 2017) and is defined as an unpleasant emotional state or condition characterized by subjective feelings of tension, apprehension, and worry and by activation or arousal of the autonomic nervous system (Spielberger, 2013). Symptoms of anxiety include nervousness, unease, a sense of impending doom or danger, sweating, trembling, an inability to maintain focus, uncontrollable worry, restlessness, fatigue, and insomnia (National Institute of Mental Health, 2016; Mayo Clinic, 2019). A recent survey found that 62.9% of undergraduates reported feeling overwhelming anxiety within the last year, and 27.4% of undergraduates perceived that anxiety negatively affected their academic performance (American College Health Association, 2018).

Anxiety can be conceptualized as an achievement emotion, or an emotion that is tied to achievement activities or achievement outcomes (Pekrun, 2006), and is a

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"ASCB®" and "The American Society for Cell Biology®" are registered trademarks of The American Society for Cell Biology. multifaceted reaction to the threat of failure (Covington, 1992). Thus, it is unsurprising that anxiety is a prominent emotion expressed by students enrolled in college science courses (Zoller and Ben-Chaim, 1989; Mallow, 2006; England et al., 2017, 2019; Cooper et al., 2018c; Cooper and Brownell, 2020). College science courses include many evaluative situations, or opportunities for students' academic abilities to be evaluated (e.g., when answering a question during class, explaining a concept to another student, or taking a quiz), which can lead to heightened anxiety for students who fear they may not achieve their goal (e.g., incorrectly explaining a concept or incorrectly answering a question; Stipek, 1993; Cooper et al., 2018c). Further, students often perceive college science courses to be particularly difficult compared with college courses in other disciplines, so the risk of not achieving academic goals is likely higher (Udo et al., 2004; Mallow, 2006).

Studies have demonstrated that elements of the college classroom can affect student anxiety. For example, a study of 216 college students enrolled in a statistics course found that instructor argumentativeness and verbal aggressiveness directly affected student perceptions of classroom climate, which is defined as the communicative interactions between instructors and students and the ongoing relationships between them. Further, students' perceptions of classroom climate affected their motivation, which in turn influenced their anxiety (Lin et al., 2017). In sum, aggressive and argumentative instructor behavior can lead to student perceptions of an unsupportive classroom climate, decreasing students' motivation and subsequently increasing their anxiety. Additionally, students' perceived understanding of a topic (e.g., statistics) and their perceived difficulty of the course in which they are enrolled have been shown to be positively correlated with students' anxiety about that particular topic (Rancer et al., 2013). Further, high academic stress has been shown to be positively associated with college student anxiety (Misra and McKean, 2000).

Anxiety levels vary within and across students and are typically determined by measuring the intensity and frequency of students' anxious feelings (Swain and Jones, 1993; Spitzer et al., 2006). The Yerkes-Dodson law suggests that low levels of anxiety in college science courses may be beneficial to students, while high levels of anxiety are detrimental; student performance increases with anxiety, but higher levels of anxiety above a certain threshold have a negative impact on performance (Yerkes and Dodson, 1908; Teigen, 1994). Specifically, studies have demonstrated that anxiety can increase student motivation (Deshpande and Kawane, 1982; Jun Zhang, 2001; Sarid et al., 2004). However, anxiety is also associated with decreased student motivation and engagement, poor academic performance, and students' intentions to leave their science majors (McKeachie, 1951; Culler and Holahan, 1980; Fletcher and Cassday, 2010; Vitasari et al., 2010; England et al., 2017, 2019). Despite the potential benefit of low levels of anxiety, national and collegiate organizations have called for efforts to reduce college student anxiety in order to improve students' overall mental health and well-being (Gallagher, 2014; Center for Collegiate Mental Health, 2017; National Council on Disability, 2017; American College Health Association, 2018; American Psychological Association, 2019).

The Relationship between Student Anxiety and Active Learning at 4-Year Research Institutions

Increasingly, college science courses are being transitioned away from traditional lecture into active-learning courses (American Association for the Advancement of Science, 2015). In active learning, students often engage in activities and/or discussions with other students. Active learning, on average, has been shown to increase learning and decrease failure in college science courses (Freeman *et al.*, 2014). Recently, researchers have begun to investigate the effect of active learning on undergraduate anxiety in college science courses at large public research-intensive (R1) institutions to better understand how to implement active learning in ways that do not exacerbate student anxiety (England *et al.*, 2017, 2019; Cooper *et al.*, 2018c; Cooper and Brownell, 2020).

In our previous interview study of 52 college students enrolled in active-learning science courses at an R1 university, we identified that active learning has the potential to both increase and decrease student anxiety (Cooper et al., 2018c). These findings support the control-value theory of achievement emotions, which posits that both the value students place on achieving and the level of uncertainty students have over their ability to achieve will affect their anxiety (Pekrun, 2006; England et al., 2019). If a student perceives no value in an evaluative active-learning activity (e.g., working in a group to complete a worksheet), then they will likely not experience anxiety in anticipation of failure. However, if a student does value a particular achievement in active learning (e.g., making a valued contribution to an in-class discussion) and is uncertain about whether or not they will succeed, then the student will likely experience anxiety. Conversely, if active learning causes the student to be more confident in their ability to achieve a particular outcome (e.g., perform well on an exam), then active learning will likely decrease the student's anxiety.

We have previously found that active learning decreased student anxiety when students perceived that they had more control over their performance in the course because they believed that active learning enhanced their knowledge (Cooper *et al.*, 2018c). Students described that participating in active-learning activities such as clicker questions and group work provided them with opportunities to practice applying their knowledge and clarified their understanding of science content, which they perceived as enhancing their learning and consequently increasing their chance of success in the course. Additionally, students' anxiety decreased when they were able to work with group mates whom they had previously established relationships with, because they were more certain of how the group mate would respond if they were to make a mistake or put forth an incorrect idea.

We also identified that active learning increased student anxiety when students felt they had less control over their academic performance in the course and when they were unsure how successful they would be at interacting with others during class (Cooper *et al.*, 2018c). We identified fear of negative evaluation, or a student's sense of dread associated with being unfavorably evaluated while participating in a social situation (Watson and Friend, 1969; Weeks *et al.*, 2005), as the primary factor underlying the students' anxiety in active-learning college science courses at an R1 institution. In contrast to traditional lecture, there are a greater number of social situations in active-learning classrooms in which students are asked to interact with one another or with the instructor. Students described experiencing fear of negative evaluation in active-learning social situations, such as when talking to their group mates or when anticipating that the instructor would call on them to speak in front of the class when they did not volunteer. In alignment with control-value theory (Pekrun, 2006), students expressed anxiety because they were uncertain about how their performance would be evaluated by others and feared that they would be judged or outwardly ridiculed by other students or the instructor of the course if they provided an incorrect answer. Students also perceived that high levels of fear of negative evaluation heightened their anxiety and hindered their performance in class, which supports the assertions of the Yerkes-Dodson law. Specifically, we found that student fear of negative evaluation negatively impacted students' abilities to think through science problems and prevented students from clearly articulating their thoughts about science.

In sum, we found that students frequently reported that most active-learning practices have the potential to decrease their anxiety when they perceive that engaging in the practice will improve their learning. However, the social aspects of active-learning courses, which require students to communicate with others, have the potential to increase students' reported anxiety if they fear that others will negatively evaluate them.

Exploring How Active Learning Affects Student Anxiety in Community College Science Courses

The few studies exploring the relationship between active learning and student anxiety in college science have been conducted exclusively at large R1 4-year institutions (England et al., 2017, 2019; Cooper et al., 2018c). However, community colleges have been recognized as key contributors to undergraduate science education (Fletcher and Carter, 2010; Schinske et al., 2017); approximately 41% of undergraduates are enrolled at a community college, and 48% of students with science and engineering undergraduate degrees have attended a community college (National Science Foundation, National Center for Science and Engineering Statistics, 2010; American Association of Community Colleges, 2019). Further, because community colleges tend to have more racially diverse, nontraditional student populations, community colleges are poised to play a major role in the persistence of underrepresented students in undergraduate science (Hagedorn and Purnamasari, 2012). Despite the importance of community colleges in educating undergraduates, there is a paucity of studies probing educational practices in the sciences at these institutions (Fletcher and Carter, 2010; Schinske et al., 2017; Lo et al., 2019). Understanding the educational practices as well as the challenges students face in community college science courses is critical, because the attrition rates of students pursuing science careers are higher at community colleges compared with 4-year institutions (Bettinger, 2010). Therefore, studying factors such as student anxiety that may negatively affect student persistence in science (England et al., 2017) is an important step in further understanding ways in which community colleges can maximize student success (Heller and Cassady, 2017).

Community colleges are distinct from 4-year research institutions in both student population and structural features of the institution. Community colleges are often open access and sig-

nificantly more affordable than attending a 4-year institution, so there tends to be a higher proportion of students who are from lower socioeconomic backgrounds (Anders et al., 2012; Labov, 2012). Students who attend community college are also more likely to have additional responsibilities outside class, such as working a full-time job, than students who are enrolled at 4-year institutions in the same geographic location (Anders et al., 2012; Labov, 2012). Additionally, community colleges often serve students seeking associate's degrees as well as students participating in vocational and technical programs, so the career goals of students in a science course are more diverse (Labov, 2012). Importantly, the previous studies of the effects of active learning on anxiety have been conducted exclusively at R1 4-year institutions, and their conclusions may not be applicable to active-learning community college science courses that include more diverse students with different career interests and more demands on their time outside academics. Further, community college science classes are typically smaller than science classes at 4-year R1 institutions (National Center for Education Statistics, 2019), so some of the findings, namely the high levels of student anxiety resulting from being called on in front of the whole class (England et al., 2017; Cooper et al., 2018c), may not be applicable in smaller settings. Additionally, although student anxiety has become a more prominent concern among colleges and universities in recent years, community colleges may have more limited resources to assist students with anxiety compared with 4-year colleges and universities (National Council on Disability, 2017) and are less likely to promote social connections among their students, which has been shown to reduce student academic anxiety (Heller and Cassady, 2017). This is of particular concern, given that community colleges are more likely to serve the most susceptible student populations for experiencing mental health issues, such as nontraditional students, students of low socioeconomic status, and students of color, who may encounter challenges and stressors beyond the scope of academics that further exacerbate mental health issues (National Council on Disability, 2017). Therefore, community colleges are likely to benefit from further understanding the relationship between active learning and anxiety in their science courses.

Study Purpose

Given the distinct context of community colleges and the unique population of students who are being trained at community colleges, there may be differing factors affecting student anxiety in community college active-learning science courses than active-learning courses at large R1 institutions. The purpose of this study is to identify what factors increase and decrease student anxiety in the context of active-learning science courses at community colleges.

METHODS

This study was approved by the Maricopa Community Colleges Institutional Review Board (#2018-10-661) and the Arizona State University Institutional Review Board (#8980).

To identify what factors increase and decrease student anxiety in the context of active-learning science courses at community colleges, we chose to conduct semistructured interviews with community college students who were currently enrolled in at least one active-learning science course. We previously used this methodology when identifying factors that affected student anxiety at 4-year institutions (Cooper *et al.*, 2018c) and found that the semistructured interviews allowed students to highlight any factors, not just those that we had hypothesized, that affected their anxiety, which was our intention for this study as well.

Positionality of Researchers

Four members of our research team are from an R1 institution and have worked closely with community college transfer students in a program designed to transition community college transfer students into basic science research at a 4-year institution (K.M.C., L.E.G., V.R.D., and S.E.B.). One member of our research team is a full-time community college science instructor (J.M.C.). Additionally, all members of the research team are proponents of active learning and teach both small- and large-enrollment biology, education, or professional development courses using active learning.

Interview Recruitment

We recruited students to be interviewed who were enrolled in active-learning biology courses at community colleges, where the class sizes range from 24 to 48 students. We contacted community college instructors within a district-wide community college network in the Southwest region of the United States in the Spring 2019 semester. Specifically, we emailed the chairs of biology departments at nine community colleges and asked them to send an email to all instructors in their departments on our behalf. The email asked all instructors who self-identified with teaching their biology courses in an active-learning way to help us recruit students in their courses for an interview study about the experiences of community college students in active-learning science classrooms. We defined active learning for the instructors as incorporating student-centered practices into their courses to maximize student learning, such as using classroom response technology, creating worksheets for students to use, integrating group work into class, or incorporating whole-class discussions. Since department chairs were responsible for sending out the email to instructors in their departments, we do not know exactly how many instructors were contacted. Six instructors replied to the solicitation and agreed to participate; they sent out a recruitment email to all students in their active-learning biology courses. The recruitment email invited students to participate in an interview study about their experiences in active-learning community college science courses in exchange for a small amount of extra-credit points in the biology course from which they were recruited.

All students who wished to participate in the study signed up for an interview time, and we conducted interviews with 29 students who had attended community college classes at nine different institutions. While we recruited students from biology courses, we interviewed students about their experiences in any active-learning science courses at community college in order to maximize the number of experiences that they could draw upon. Before the interview, the participants were asked to complete a demographic survey (see the Supplemental Material for a copy of the survey questions that were analyzed).

Student Levels of Anxiety

When recruiting students for the study, we were intentionally vague about the study's focus on anxiety, because we sought to

interview students with varying levels of day-to-day anxiety and did not want to dissuade high-anxiety students from participating or limit our sample to only students for whom anxiety is a salient part of their identities. To estimate trait anxiety, or the amount of anxiety that one experiences day-to-day, we asked each participant to complete the Generalized Anxiety Disorder seven-item scale (GAD-7; Spitzer et al., 2006). We chose this scale because it measures generalized anxiety as opposed to more specific forms of anxiety and because it measures anxiety as an enduring personality trait (Turner and Gellman, 2013). Because the Yerkes-Dodson law suggests that some anxiety can be beneficial, but higher levels of anxiety are typically detrimental, the GAD-7 helps contextualize each individual student's baseline anxiety. The GAD-7 consists of seven Likert-scale questions about how frequently one experiences symptoms of anxiety with four answer choices ranging from "not at all" to "nearly every day." A copy of the GAD-7 can be found in the Supplemental Material.

Student Interviews

All interviews were conducted by one researcher (V.R.D.) via the videoconferencing platform Skype to accommodate students' schedules, as students were recruited from different community college campuses in the region. She began the interview by asking students to describe what aspects of their active-learning community college science courses, if any, increased or decreased their feelings of anxiety and why. To contrast students' experiences in active learning and traditional lecture, she also asked students what aspects of their traditional lecture science courses, if any, increased or decreased their feelings of anxiety. Additionally, we developed questions based on the findings of our previous study that identified three active-learning practices that students reported significantly affected their anxiety: classroom response technology (e.g., clicker questions), group work, and calling on students who did not volunteer (e.g., cold call or random call). At least half of the interview participants in our previous study had reported that each of these practices either increased or decreased their anxiety (Cooper et al., 2018c). In the current study, the interviewer asked specifically about each of these practices. We conducted think-aloud interviews with five undergraduate students who had recently transferred from community college to a 4-year R1 institution to establish the cognitive validity of the questions. The questions were revised after each think-aloud interview, often by clarifying what a word meant, until no question was unclear or misinterpreted by the students (Trenor et al., 2011). The final interview script can be found in the Supplemental Material.

The semistructured nature of the interviews allowed the interviewer to explore interesting topics that emerged in an interview with one student that may not have been discussed in every interview (Creswell and Creswell, 2017). Interviews were audio-recorded and transcribed upon completion. The average interview time was 35 minutes, and interviews ranged from 20 to 45 minutes. Data were anonymized, and pseudonyms have been given to students to protect their identities.

Interview Analysis

Four authors (K.M.C., V.R.D., S.E.B., and J.M.C.) began by individually reviewing all student interviews and taking detailed analytic notes during the initial round of analysis (Birks and Mills, 2015). In this initial coding, the aim was to explore each idea a participant expressed and note any common themes that emerged (Saldaña, 2015). After initial exploration, the four authors discussed their codes and identified overarching categories that emerged from the interviews (Birks and Mills, 2015). The coders' agreement was high before discussion; most of the discussion revolved around grain size of the themes. Within each overarching category, the researchers articulated relevant subcategories.

Once an initial set of themes was established, two researchers (K.M.C. and V.R.D.) individually reviewed all of the interviews to confirm the validity of the themes and to identify any new themes that the group may have missed during the initial analysis. The researchers took detailed memos throughout their review of the transcripts (Birks and Mills, 2015). They then reconvened to discuss their initial coding and compared similarities in coding themes and discussed quotes to confirm findings using constant comparative methods (Glesne and Peshkin, 1992). The researchers also built connections within coding groups to overarching themes established previously and determined new coding groups that emerged upon the review of all transcripts. They used their notes to revisit previously established themes and to discuss what quotes from the interviews they reviewed fell under which themes. This constant comparison of quotes was meant to ensure that the description of the theme adequately represented all quotes within the same group and that the quotes were not different enough from one another to warrant a separate theme. This approach allowed for multiple revisions of coding themes and allowed the authors to define a final set of codes.

Once each code was discussed in detail, the two researchers created a final codebook with refined definitions of emergent themes (the final coding rubric can be found in the Supplemental Material). Two researchers (K.M.C. and V.R.D.) individually coded all 29 interviews using the coding rubric. Afterward, they compared their codes for each interview and discussed any portion of an interview that they had coded differently until they reached agreement on final codes (Braun and Clarke, 2009; Nowell *et al.*, 2017). The researchers determined that data saturation had been reached within the current sample; by the 17th interview, no additional themes emerged. Therefore, no further recruitment was needed (Guest *et al.*, 2006).

RESULTS AND DISCUSSION

We discuss our results as we present them in order to elaborate on our findings and contextualize them within the previous literature. Specifically, community college students report that active learning decreases their anxiety in active-learning courses because they perceive that active learning enhances their performance. We highlight two reasons why students report active learning enhances their performance and subsequently decreases their anxiety: 1) active learning provides students with additional access to help from the instructor and opportunities to learn from other students in class, and 2) active learning provides different approaches to learning. We also highlight that students report that active learning can increase their anxiety and identify student fear of negative evaluation as the primary factor underlying student anxiety in active learning. We discuss that the social situations in active learning lead to student fear of negative evaluation as well as the positive and

the negative effects of fear of negative evaluation on students. We conclude this section by identifying aspects of college science courses that may decrease student fear of negative evaluation.

Participants and Study Context

In this study, we interviewed 29 community college students who were enrolled in at least one community college active-learning science course at the time of the interview. These 29 students had all attended classes at one or more of the nine community colleges in the district. Of the students interviewed, 76% identified as female and 24% identified as male. Forty-five percent of the students identified as white/Caucasian, 31% identified as Hispanic/Latino/a, 7% identified as Black/ African American, 7% identified as Asian/Pacific Islander, 3% identified as American Indian/Alaskan Native, 3% identified as multiple races, and 3% declined to state. Forty-one percent of participants identified as a first-generation college student, 21% identified as a primary caregiver in their familial units, and 48% reported working more than 20 hours per week during the semester. The majority of the students (79%) intended to transfer to a 4-year institution. Over half of the students (55%) were interested in pursuing a major in nursing or allied health (e.g., x-ray technician, dental hygienist), 7% of students were interested in pursuing science-focused majors (i.e., biological sciences, exercise science), 7% of students were undecided, and the remaining 31% of students were interested in other nonscience careers (e.g., education, business, psychology). Categorizing students' day-to-day anxiety levels using the GAD-7 scale (Spitzer et al., 2006), we found that 38% of students identified with experiencing minimal anxiety (GAD-7 score <5), 34% identified with experiencing mild anxiety (GAD-7 score 5-9), and 28% reported experiencing moderate anxiety (GAD-7 score 10-14). A summary of student demographics can be found in Table 1. A table listing individual students with their respective demographics and GAD-7 scores can be found in the Supplemental Material along with a table of the percentage of students who attended each community college.

Throughout the interviews, community college students described a variety of ways in which they felt different from what they sometimes referred to as the "typical" student who attends a 4-year institution. Specifically, students described having multiple responsibilities in addition to school, such as raising a family or working a full-time job; these differences have been well established in the literature comparing students enrolled in community colleges with students enrolled at 4-year institutions (Anders *et al.*, 2012). Additionally, at the time participants were sampled, it was not required for students at the community colleges to declare a particular major. However, we did collect information about students' intended majors. Notably, only two of the interview participants intended to pursue a career in basic science.

Students Report That Active Learning Decreases Anxiety in Community College Science Courses because Students Perceive That Active Learning Enhances Their Learning and Performance

We found that, overwhelmingly, community college students enrolled in active-learning science courses felt that active-learning practices decreased their anxiety, because the students

TABLE 1.	Summary of community college student participant
demogra	phics

Demographics	All students $n = 29, \%(n)$
Gender	
Female	76 (22)
Male	24 (7)
Decline to state	0 (0)
Race/ethnicity	
American Indian or Alaska Native	3 (1)
Asian/Pacific Islander	7 (2)
Black/African American	7 (2)
Hispanic/Latinx	31 (9)
White/Caucasian	45 (13)
Multiple races	3 (1)
Decline to state	3 (1)
College generation status	
First generation	41 (12)
Non–first generation	55 (16)
Decline to state	3 (1)
Hours worked per week	
Do not work	31 (9)
1–20 hours	21 (6)
21–40 hours	31 (9)
40+ hours	17 (5)
Decline to state	0 (0)
Serve as primary caregiver (e.g., to a child)	
Yes	21 (6)
No	79 (23)
Decline to state	0 (0)
Intention to transfer	
Yes	79 (23)
No	21 (6)
Decline to state	
Career goal	
Nursing or allied health	55 (16)
Non-science careers	31 (9)
Science career	7 (2)
Undecided	7 (2)
GAD-7 score	
Minimal (GAD-7 score of <5)	38 (11)
Mild (GAD-7 score of 6–9)	34 (10)
Moderate (GAD-7 score of 10-14)	28 (8)

perceived that they learned more during active learning compared with traditional lecture.

Active Learning Provides Students with Access to Help from the Instructor and Opportunities to Learn from Other Students during Class, which They Report Decreases Their Anxiety

When talking about their anxiety levels, students often contrasted their experiences in active-learning science courses to traditional lecture courses or portions of courses where instructors lectured at students and students listened passively. Students described that, compared with active learning, there were fewer opportunities during traditional lecture to access help from the instructor or other students, which increased their anxiety. Specifically, students often had questions about the science content during traditional lecture but felt uncomfortable asking questions during class, because there did not seem to be enough time or because it would disrupt the flow of the class.

Grace: "When an instructor is just throwing material at you it almost makes you feel intimidated, like you don't want to ask a question because they're on a roll and you don't want to be that one person to raise your hand."

Teresa: "[Traditional lecture increases my anxiety the most] probably because I like to ask questions and I feel like I probably can't do that in [lecture] just because we're all on a time crunch and all questions can't be answered unless you stay after, but not everyone has the time [to stay after]."

Teresa went on to explain that having the chance to ask questions during class can be especially important for students who do not have the time to stay after class; she described why balancing college and other demands can be particularly challenging for the students she has met at community college.

Teresa: "Everyone that I have talked to [at community college] has a job or other things outside of school. School is also a job, but we all have jobs outside of work, so it's just trying to juggle schoolwork and homework and studying. That's probably what increases [my anxiety], just trying to balance it all."

Teresa echoes research findings highlighting that community college students often have competing demands on their time (Anders et al., 2012; Velez et al., 2018; Cooper et al., 2019). Specifically, one study found that 34% of community college students cited balancing work and school as a challenge to their success, and 61% said that their work hours do not leave additional time for studying (Porter and Umbach, 2019). Additionally, 30% of community college students have reported that family and friends can be a challenge to their success, particularly because it can be difficult to balance family demands, such as finding childcare, with the demands of college. Given these challenges, participants frequently reported that a lack of opportunity to ask questions, clarify information, or correct misunderstandings during class time may be particularly anxiety-inducing for community college students if they are acutely aware that the time they are able to devote to learning science is limited.

In contrast to traditional lecture, community college students frequently reported that active-learning courses decreased their anxiety because of the increased opportunities to clarify their understanding of science content during class. Specifically, students highlighted how the opportunity to talk with instructors during class helped alleviate their anxiety.

Ellie: "[Active learning decreases my anxiety] because if you're not getting a specific area of [the content], physically you see the teacher and say 'Look, I really need help with this.' Then, they can visually show you or they can walk you through it. (...) Having the opportunity to get help increases your knowledge, which if you're understanding [the science content] better, then you're getting better test scores, you're doing better on your assignments, you don't feel as anxious. You want to go to class because you're not like 'Oh my God, I just can't do this. I feel like I'm going to fail."

Students also described that active learning decreased their anxiety because they were often asked to work in groups, which they perceived as helping to improve their understanding of science content. Specifically, students highlighted that hearing different ideas from other students was particularly helpful in reducing their anxiety.

Hector: "Group work definitely decreases my anxiety. In our class, we sit in groups and we help each other out, so that decreases anxiety because we're just working together and we all have different ideas, and we can just help each other out when we're stuck on a problem."

Additionally, students like Heather perceived that group work improved their understanding of science content and decreased their anxiety when they had the opportunity to teach science content to someone else.

Heather: "I think just being able to talk through the concepts with other people, instead of just sitting quietly [decreases my anxiety]. By trying to explain it to other people and having other people explain it to you, it can help you understand the concepts better."

Student perceptions that discussing science content with others during group work enhances their learning have been widely supported by the literature. Studies have demonstrated that peer instruction, or students explaining science concepts to one another, improves student performance on formative assessment (Crouch and Mazur, 2001; Smith et al., 2009), and that when biology students work in groups during the semester, as opposed to working independently, they score higher when taking exams (Gaudet et al., 2010). Additionally, as many students described, hearing content explained by someone other than the instructor can also enhance student understanding (Harper and Daane, 1998; Chi et al., 2004; Cooper et al., 2018b). Overwhelmingly, the students in this study perceived that they learned more in active learning compared with traditional lecture, which is in contrast to a recent study in which students in large introductory physics courses perceived that they learn less in active learning compared with traditional lecture, even though the study demonstrated that students indeed learned more in active learning (Deslauriers et al., 2019). Thus, the students in our study are likely correct in their assumptions that they learn more in active learning, which decreases their likelihood of failing, subsequently decreasing their anxiety. This finding aligns with previous findings demonstrating that the more a student perceives they know about a particular topic, the less anxiety they feel in the context of a particular course (Rancer *et al.*, 2013).

Students Perceive That Active Learning Provides Them with Different Approaches to Learning

Students explained that active learning also decreased their anxiety because it involves multiple approaches to learning;

that is, students in active-learning courses were exposed to different types of activities that were meant to help students learn science content.

Brittany: "Yeah, active learning decreases my anxiety. I think just hands-on and doing multiple facets of learning because everyone learns differently. My current [active-learning science instructor], she does videos if you need to visually see what's going on. And she recorded audio for the PowerPoint (...) so if you need more of that audio aspect, then you have the audio. And then she goes over things in class and is drawing them and you're copying notes. So there's kinesthetic, there's visual, there's auditory; there are multiple facets of learning, which I feel like just increases your comprehension and decreases your anxiety because you feel like you have a better grasp on the information."

Bianca: "Yeah, [active learning decreases my anxiety] because I'm more of a visual and kinesthetic learner, so I'm always trying to move or manipulate things with my hands. It's not just a traditional lecture. We're constantly using manipulatives, we're constantly getting up and walking around the classroom."

Like Brittany and Bianca, students often mentioned that their active-learning instruction targeted different types of learners, such as auditory learners, visual learners, or kinesthetic learners. These students were likely referring to learning styles or the idea that individuals differ with regard to what mode of instruction (e.g., auditory, visual, kinesthetic) helps them learn best. Researchers have concluded that teaching students in ways that match their dominant way of learning (or learning style) does not predict how well students will learn (Pashler et al., 2008; Rohrer and Pashler, 2012). In fact, the concept of learning styles has even been dubbed "one of the most pervasive myths about cognition" (Nancekivell et al., 2019, p. 1). Importantly, this pervasive myth has been reported to be accepted by much of the U.S. population, including both educators and non-educators (Nancekivell et al., 2019). While we were not able to observe the extent to which instructors at these institutions emphasized learning styles, learning styles were emphasized on the district-wide community college website as an important aspect of student learning (Maricopa Community Colleges, 2019). Therefore, it is unsurprising that some of the students in our study perceived that they learn best when taught using a specific mode of instruction, which ultimately decreased their anxiety.

Students' reported anxiety likely did not decrease because the way they were taught matched their learning style and increased their performance, but instead because they were introduced to multiple ways of learning. Universal design for learning (UDL) is a teaching approach that aims to provide all students with the opportunity to succeed (Meyer *et al.*, 2014; CAST, 2018). UDL suggests that multiple means of representation, or presenting content in different ways, can give learners various ways of acquiring information and knowledge. This can be especially important for students with disabilities, for whom some modes of learning may be inaccessible. Further, UDL encourages multiple means of engagement to help motivate different students. Additionally, Paivio's dual coding theory (DCT) highlights the benefits of both verbal and nonverbal approaches to learning, emphasizing that individuals have nonverbal mental systems specialized for processing imagery and verbal mental systems specialized for processing linguistic information (Paivio, 1991). DCT argues that, by engaging in both verbal ways of learning, such as listening, and nonverbal ways of learning, such as studying an image, one can reach a conceptual understanding and retain knowledge in a particular area (Clark and Paivio, 1991). Therefore, it is possible that students like Brittany are not actually responding to their instructors teaching to a specific learning style, but instead recognizing that they benefit from a combination of both verbal and nonverbal approaches to learning.

In sum, we identified that students perceived that active learning enhanced their learning and performance, which consequently decreased their anxiety. This aligns with a previous study of a community college chemistry course for nonmajors that compared the experiences of students in a traditional version of the course with students in an active-learning version of the course that incorporated group work, activity sheets, and student presentations (Hemraj-Benny and Beckford, 2014). These researchers concluded that, compared with students in the traditional lecture course, students in the active-learning course learned more, measured by exam scores, and felt less anxious about taking another science course in the future. Although the authors were not fully able to determine whether students' learning was responsible for their decreased anxiety, our findings would suggest that this may be the case.

More broadly, it has been well documented that, on average, active learning leads to student learning gains in college science courses (Freeman *et al.*, 2014), and this has been demonstrated specifically in the context of community college science courses (Lloyd and Eckhardt, 2010; LoPresto and Slater, 2016; Pape-Lindstrom *et al.*, 2018). Therefore, it is likely that the students' perceptions that active learning enhanced their learning were accurate. Additionally, students' assertions that their enhanced learning decreased their anxiety are supported by the control-value theory of achievement emotions; assuming that succeeding in biology is important to students, active learning can bolster their confidence about their ability to learn in class and reduce uncertainty they may feel about failing subsequent evaluative tasks, ultimately decreasing their anxiety (Pekrun, 2006).

Active Learning Can Increase Student Fear of Negative Evaluation, which Consequently Increases Student-Reported Anxiety in Community College Science Courses

We found that fear of negative evaluation was the primary factor underlying students' reported anxiety in active-learning courses; students described experiencing fear of negative evaluation when engaging in social situations during active learning, such as asking and answering questions during class and working in groups. Further, we identified specific aspects of active learning that students reported alleviated and exacerbated fear of negative evaluation and novel ways in which fear of negative evaluation affects students.

Social Situations in Active-Learning Science Courses Can Increase Student Fear of Negative Evaluation, Leading to Higher Levels of Reported Anxiety

By definition, people only experience fear of negative evaluation when they are involved in or anticipate being involved in a social situation. Thus, we hypothesized that, in active-learning community college courses, which increase social interactions among students and between students and instructors, students would experience some fear of negative evaluation. At some point during the interview, over half of the interview participants described experiencing fear of negative evaluation in their active-learning science courses.

Some students described experiencing fear of negative evaluation during group work or when thinking about asking a question during class. These students' fear of negative evaluation seemed to arise because they did not view themselves as "good at science" and feared that other students or the instructor would perceive something they said as "stupid."

Claire: "There are a lot of people in my group. Six or seven people that I've never talked to before. Since I'm not good at biology, it's like, 'Oh no. I don't want to say something stupid.' Then they'll be like, 'Oh, this girl is not smart."

Bianca: "I feel like if I were to ask a question [in class] it would be one of those questions that either the instructor or the rest of the class would see as stupid. (...) Teachers have always been able to easily grasp everything and when it comes to math or science, I've always struggled."

Unfavorably evaluating oneself has been shown to cause individuals to expect to be negatively evaluated by others (Kocovski and Endler, 2000). Therefore, students who assume they are not good at science may be more likely to think that others will negatively evaluate their ability in science courses. Additionally, a student's academic self-concept, or perception of their own intelligence as it compares with other students' intelligence in a particular domain, has been shown to correlate with students' self-reported participation in small-group discussions (Cooper *et al.*, 2018e). Thus, it is possible that students who perceive themselves as having low ability in science experience particularly high fear of negative evaluation and are less likely to engage in active-learning activities, such as group work.

While fear of negative evaluation may cause some students to not contribute to small-group discussions, a student's lack of contribution to discussions also seemed to elicit fear of negative evaluation. For example, Ellie and Olivia describe not contributing when they do not understand the content and subsequently worry that their group mates will negatively evaluate them.

Ellie: "The only time that group work increases my anxiety is if I don't really understand the subject and I'm trying to contribute or participate with the group. (...) If we're matched up in pairs or three people and we're going over a certain subject and I don't understand it and can't answer any of the questions, I feel anxious that my classmates will think that I'm not contributing or more of a burden. (...) [How other students think of me] has mattered to me since I was little. With my learning disability and all the other stuff I have, it bothers me. I'm self-conscious. Always."

Olivia: "I know if I'm confused on a topic, and if I don't quite understand and I have to engage with my group, I get a little bit anxious just because I can't contribute as much to the conversation as I would like to." Other students frequently complained about students like Ellie and Olivia who did not contribute to group discussions or group work. Students often mentioned other students' lack of contribution during group work as a factor that tended to increase their own anxiety, because they felt as though their learning was compromised when others did not contribute, or they felt as though work was unevenly distributed.

Penny: "[What increases my anxiety] is people not participating in the answering of the questions [in group work] and then just writing things down that you wrote down, because then you're only getting one side of the answer. That's the worst thing that you can do when working in a group."

Antonio: "Working with [someone who doesn't participate] increases my anxiety. It could ruin my grade because I see this person not doing anything. They're just there wasting their time in the classroom."

These students seemed to take a student-deficit approach, assuming that students in their group chose not to contribute because they did not feel like it, not because they felt as though they did not know enough to participate. This can be a common assumption among students, but instructors who are explicit about the various reasons why students might not be participating can help other students be more understanding of why a student may not be participating (Cooper *et al.*, 2017a). Additionally, students with learning disabilities, like Ellie, are prone to having high anxiety, and creating spaces where these students do not feel judged for their contributions, or lack thereof, may be an important step in creating a more inclusive scientific community (Nelson and Harwood, 2011).

While group work seemed to primarily elicit fear of negative evaluation from the students who were not confident about their academic abilities in science, fear of negative evaluation was prevalent among most students who were asked to speak in front of the whole class when they did not volunteer. Generally, students described that their instructors used cold call during class, which they described as being called on when they did not volunteer without using any system to ensure randomness and without providing students with any opportunity to discuss an answer with others before speaking. Importantly, students with the most extreme fear of negative evaluation never referenced having time to think through a question before being asked to share out or having time to discuss the question with a neighbor, both of which have been suggested to be important for student learning when asked to answer a question in front of the class without volunteering (Nicol and Boyle, 2003; Nielsen et al., 2012). Specifically, students described that they were anxious when the instructor called on students who did not volunteer, because they were afraid that if they were called on by an instructor and they did not know the answer, they might look "foolish" or feel "humiliated."

Denise: "I'm scared that [the instructor is] going to call on me and I'm not going to know [the answer.] (...) I don't want to say the wrong answer and then look foolish in front of everyone."

Hector: "If [your answer to a question] is wrong, then you just feel ashamed. It just makes you feel like you're not smart enough. That public humiliation in front of other classmates, [having the wrong answer] just makes you feel less confident in class. And you know if the instructor calls on you and your answer is wrong, and then your classmates are just 'Oh, this kid is not smart."

Yvonne: "The reason why I'm afraid to give the wrong answer is because maybe that will change people's opinions of me. Maybe they will be more disappointed in me. Maybe they would not want to be my partner for certain projects or maybe it's just a kind of a damaging of my own pride."

Historically, fear of negative evaluation in the context of college has been documented almost exclusively in language-learning courses, which regularly integrate social situations in which students are asked to practice speaking a language in front of others in class (MacIntyre and Gardner, 1991; Oxford, 1999). Even with the increased adoption of active learning among college science instructors and the subsequent increased interactions among students in science, there are very few studies that have documented fear of negative evaluation in the context of active-learning college science courses (Cooper et al., 2018c; Cooper and Brownell, 2020). Notably, it is often assumed that students' fear of negative evaluation when speaking in front of others is limited to large classrooms; yet this current study illustrates that, even in smaller community college classes, students can experience fear of negative evaluation when asked to speak in front of the whole class.

Fear of Negative Evaluation Impacts Students in Community College Science Classrooms by Negatively Affecting Their Abilities to Think about Science, Their Abilities to Articulate Their Thoughts about Science, and Their Perceptions of Their Own Intelligence

The psychology literature suggests that people who experience fear of negative evaluation monitor their environment for the threat of potential negative evaluation (Heimberg et al., 2010). For many of the students in this study, the threat of potential negative evaluation surfaced when their science instructors would call on students who did not volunteer to answer questions. When someone monitors the environment for the threat of potential negative evaluation, it increases their cognitive load, or the amount of information held in working memory, and consequently hinders their ability to think and perform specific tasks (Sweller, 1994). In this study, when students experienced an instructor who cold called students, they perceived it as a threat of negative evaluation and focused their attention on the threat of being called on, which likely increased their cognitive load and limited their ability to think about the science, as described by Daniel, Brittany, and Ellie.

Interviewer: "To what extent does being anxious influence your performance when speaking in front of the whole class in your college science courses?"

Daniel: "[My performance is] worse. I just feel like there's a lot of pressure and I try to think too fast and too much at once. There's a lot that starts racing through my head. I just can't think straight." Brittany: "Definitely a lot. (...) You're so worried about knowing all of this information and being prepared that your brain is focusing so much on that aspect instead of learning the information and carrying over information."

Ellie: "[I perform] worse because I'm more worried about [being judged] than about what I'm actually doing."

Additionally, we also identified that fear of negative evaluation hindered some students' abilities to articulate their thoughts about science, as described by Claire and Carmen.

Interviewer: "How did you feel in those moments when you knew the instructor was going to call on students who do not volunteer?"

Claire: "My stomach is so tight, I get hot, and then I feel like I don't know how to talk."

Carmen: "I don't want to feel like I look stupid, because I'm trying to find my words, and trying to figure out what we were talking about. (...) I think about how I look, as in how people see me, whether it's my speech or the answer that I give. I feel like I focus more on my appearance and how other people perceive me. It just kind of detracts [from me talking about the answer]."

People like Carmen who experience fear of negative evaluation are usually hyperaware of their performance (in this case, speaking in front of the class) and monitor their performance for potential flaws (Heimberg *et al.*, 2010). People often monitor whether they are blushing or sweating (e.g., Carmen mentions monitoring her appearance), and whether their voice is cracking or shaking (e.g., Carmen mentions monitoring her speech; Rapee and Barlow, 1991; Eysenck and Calvo, 1992; Owens *et al.*, 2008). This excessive monitoring can increase cognitive load, limiting a student's ability to think or to articulate their thoughts about science, which explains why Carmen may have trouble finding her words and remembering what she was talking about when she was called on to answer a question during class.

We also identified a novel way that fear of negative evaluation can negatively impact students' perceptions of their own intelligence. Students described that their fear of negative evaluation can cause them to doubt their own abilities in science or to second-guess themselves.

Interviewer: "How does worrying what your classmates think of your response influence your anxiety?"

Hector: "Maybe if someone is self-conscious about themselves, they think about what other people think of them. If your classmates don't think you're smart, then you perceive yourself as not smart."

Brittany: "I think you just start getting a little bit more doubtful about yourself and really reanalyzing yourself and doubting yourself about whether you know information or not."

Penny: "Even if I do know the right answer, I won't be the first one to say it, because I second-guess myself and I think, 'Oh I could be wrong.' No one likes being wrong in front of everyone and getting told they're wrong. Sometimes teachers want you to be wrong so that they can correct you in front of everyone and make a point about how it's easily misinterpreted. But that's still embarrassing if you're that person that they're talking about. If I feel that way, then I won't be as eager to participate."

Self-efficacy, or students' belief in their ability to complete a task, develops when students compare their ability against the goal they are trying to achieve (Bandura, 1982). If students' fear of negative evaluation causes them to doubt their ability to succeed or to feel "less smart," this may ultimately lower their self-efficacy in science, which has been shown to be an important predictor of student performance (McConnell et al., 2010). Further, students whose fear of negative evaluation diminishes their confidence in their ability to contribute to group discussions may also be experiencing imposter phenomenon or may believe that their competence, as perceived by others, is not real (Clance and Imes, 1978). Imposter phenomenon has been shown to be positively related to anxiety (Chae et al., 1995; Fraenza, 2016), and social anxiety in particular is a key feature of imposter phenomenon because of the imposing threat of evaluation (Kolligian and Sternberg, 1991). Specifically, students may fear that, if they contribute an incorrect answer to a discussion, their instructor and their peers may find out that they are less smart than they were previously perceived to be (Fraenza, 2016).

Fear of Negative Evaluation Can Motivate Students to Learn Course Content

Fear of negative evaluation also seemed to inspire some students to pay attention in class or study the science content, because they were afraid of how others would view them if they were to get the answer wrong. For example, Brittany first describes how being called on in front of the whole class makes her feel anxious. However, when probed about whether it ever decreased her anxiety, she explained that it helps motivate her to prepare for class by learning the information, though ultimately she said it increased her anxiety.

Brittany: "[When you get called on, you feel anxious,] because you're put in the spotlight in front of various people and you don't know how they're going to respond if you have the wrong answer. Are people going to laugh, are people going to make jokes, are people going to think you're stupid if you get the wrong answer?"

Interviewer: "Are there any aspects of instructors calling on students that decrease your feelings of anxiety?"

Brittany: "Yes and no. I feel like overall it might benefit me, because you have to really make sure that you're knowing the information prior to going to class. But I think that in general that's more of an increase in stress level rather than decreasing anxiety just because it is a spotlight situation."

Bianca and Noah echo that the fear of being evaluated can push them to work harder.

Bianca: "[Being judged] kind of pushes me to apply myself further and actually work harder."

Noah: "A little bit of pressure will make a blade sharper. But too much pressure and you will destroy the blade. (...) If you're someone that gets a wrong answer and then you're still willing to find out what the right answer is, that would be a positive outlook on judgment and anxiety."

Noah's blade analogy conforms to the principles of the Yerkes-Dodson law; if a student experiences some fear of negative evaluation and anxiety, it might motivate the student to study and consequently improve performance, but if a student's anxiety is too high it may inhibit their thinking or speaking skills, ultimately limiting performance (Yerkes and Dodson, 1908). For some students, the fear of being negatively evaluated can motivate them to work harder to learn content before coming to class, which may ultimately decrease students' anxiety and improve their performance. However, for Brittany, the decrease in anxiety stemming from increased preparation did not outweigh the increase in anxiety brought on by her fear of negative evaluation. This finding aligns with a previous study, which found that cold calling in a large biology course caused students to pay attention, but also caused some students to experience severe anxiety (Broeckelman-Post et al., 2016). It is important to note that all students enter biology courses with different levels of trait anxiety, or different amounts of anxiety that are enduring parts of their personalities (Turner and Gellman, 2013), as we demonstrate in this study with the wide range of student scores on the GAD-7 scale. Particularly, females and lower-performing students are known to have higher trait anxiety than their male and higher-performing peers (McKeachie, 1951; Kessler et al., 2005; National Institute of Mental Health, 2016). Thus, for some students, the fear of negative evaluation that they experience may motivate them to improve their performance, while for others, the same amount of fear of negative evaluation may hinder their performance.

Aspects of College Science Courses That May Decrease Student Fear of Negative Evaluation

We identified a range of factors that instructors can alter when implementing active-learning practices to reduce student fear of negative evaluation and subsequent student anxiety. For example, students highlighted that knowing other students in their small groups helped to reduce their fear of negative evaluation during group work.

Yvonne: "[One aspect of group work that decreases my feelings of anxiety] is, for my bio class, I know all the people in my group. So, I have a personal relationship with them. (...) If I'm with people I don't know, I feel I'll be nervous because mostly I'll be thinking about how they think about me. I'll be concentrating on that more than concentrating on the work that we are supposed to be doing."

Daniel: "I think [my anxiety] is definitely better when I'm in a group with people that I'm comfortable with. Because I know everybody is in the same boat as me and we usually read at the same pace and everything."

This finding aligns with control-value theory; if students feel as though they have control over the situation because they have developed relationships with others in their group and think they know how other students will perceive them, then their anxiety will decrease.

We also identified ways in which instructors can call on students when they do not volunteer that can minimize students' existing fear of negative evaluation. The science education literature suggests that using a system to randomize who is called on can reduce bias with regard to who is called on in college science courses; in biology courses in which random call is not practiced and students volunteer to answer questions, only 40% of female voices are heard, even when females make up 60% of the class (Eddy et al., 2014, 2015; Tanner, 2013). However, to our knowledge, there have been no systematic studies in the context of college science that have identified best practices for minimizing student anxiety and subsequently maximizing student learning when calling on students who do not volunteer. Students in this study suggested that, when instructors use cold call, it would alleviate their anxiety if the instructor provided them time to talk with other students before they answered the questions. This practice has been described as warm calling.

Interviewer: "Is there anything that your science instructors do that can decrease your feelings of anxiety in the classroom?"

Penny: "I like to work with groups. So something [the instructor] does if he's asking a question to the whole class, instead of calling on one person, he'll say, 'Talk to your group and then one person will answer,' and it's like more of an agreed thing. It's not like you're [the only one] being called on."

Penny highlights that conferring with a group can take the pressure off an individual student, presumably because the answer is not solely assigned to that student, and they will not singularly bear the burden of classmates' negative evaluation if the response is incorrect. Claire provided another reason why conferring with group mates can decrease anxiety:

Claire: "You don't really have a lot of time to think about [the question during cold call]. I'd rather [the instructor] be like, 'OK, talk for a second to your neighbor,' and then you have your idea in place and then your neighbor's, so then you can come up with a better answer. You have time to think instead of just blurting out what first comes to mind."

Claire expressed that having time to talk with group mates would provide additional time to think through a problem. Additionally, it would allow her to hear another student's ideas. Building on other students' ideas has been shown to improve a student's chances of getting an in-class question correct (Smith et al., 2009, 2011; Chi and Wylie, 2014) and can enhance student self-efficacy with regard to getting the question correct (Kocovski and Endler, 2000), both of which may consequently decrease student fear of negative evaluation. Control-value theory would also support students' assertions that having sufficient time in class to talk with others before answering a question would decrease anxiety. Giving students more time to prepare may help them feel as though they have more control over the outcome if they were to be called upon. Similarly, practicing saying one's answer in front of others or talking with others in class to refine thoughts or to generate new ideas may

help students be more confident in the outcome of being called on by the instructor, ultimately reducing their anxiety.

Students also explained that instructors' responses to student answers have the potential to significantly decrease students' fear of negative evaluation during whole-class discussions. Specifically, instructors who successfully error frame, or suggest that students' incorrect answers are useful and natural (Bell and Kozlowski, 2008), seem to reduce students' fear of negative evaluation by normalizing incorrect answers, minimizing embarrassment, and encouraging creative thinking.

Linn: "Even if you say something that's kind of stupid, [the instructor] validates ... not validates what you have to say, but she can kind of figure out where you're coming from and then she brings it around to the right answer. So it doesn't make you feel as stupid as it does when an instructor goes to you and just says, 'Nope, that's wrong' and goes to the next person."

Teresa: "I've been called on and I was wrong, but my teacher was like, 'Hey, it's OK.' They'll go over the right answer and go back to why I was wrong, and then they will say, 'Thanks for trying.' They don't make you feel dumb or less educated. They'll correct you and not make you feel like you were completely wrong, but at least you were in the right ballpark. They don't make you feel bad about it. I know my teacher won't judge me and will always be on my side, even if I am wrong. They don't judge you that you're not paying attention. It's just you don't understand it."

While error framing has been historically defined as framing students' errors as natural and useful (Bell and Kozlowski, 2008), we argue that it also includes validating students' thinking or suggesting that the instructor could see why a student might think in a particular way. Error framing has been shown to increase student motivation (Steele-Johnson and Kalinoski, 2014) and to help build relationships between faculty and students (Cooper *et al.*, 2018a). One hypothesis for how error framing can lead to positive outcomes is that error framing may reduce students' fear of being negatively evaluated by the instructor in the future and consequently motivate them to participate while strengthening their relationship with the instructor.

Finally, it may serve instructors to be transparent about why they are calling on students who do not volunteer in their classroom. Many students assumed that instructors had very specific agendas when calling on students who did not volunteer; they either wanted to prove to themselves that students were learning the content or they wanted to make sure students were paying attention.

Olivia: "[When the instructor calls on me], probably they want me to say the right answer. Especially if they just covered that topic in lecture or something, and then they turn to me. They want me to know the right answer, and they want me to prove that I was paying attention. But if I'm not, or if I wasn't paying attention, then I feel like I would just make a fool out of myself."

Students assumed that instructors called on students to punish those who do not pay attention or who did not learn the content. Studies have suggested that uncivil behavior by students, such as not paying attention, and by instructors, such as calling on students with the intent to embarrass them, is on the rise, and that both students and instructors have noticed (Clark and Springer, 2007; Knepp, 2012; McNaughton-Cassill, 2013). If instructors are, in fact, calling on students who do not volunteer as a way to enhance student learning as opposed to calling on them to punish them, then our findings suggest it is imperative to share this motivation with students, because students may be unaware of instructor intentions; persuading students that a particular practice is useful for their learning is key when getting them to buy in or meaningfully engage with the practice (Cavanagh et al., 2016). However, if instructors are calling on students as a way to embarrass them in an attempt to deal with uncivil behavior, then it may be having a more detrimental effect than instructors intend. This also means that some students' fear of negative evaluation may not be in response to an intentional active-learning practice, but instead to uncivil instructor behavior toward students. Building relationships with students, engaging students in activities, and having one-on-one conversations outside class could all discourage uncivil student behavior without inciting student anxiety.

In sum, we identified that active learning affects student anxiety in community college science classrooms in many of the same ways that it affects student anxiety in 4-year college science classrooms. Specifically, both the community college students in this study and the 4-year students in our previous study (Cooper et al., 2018c) identified that active learning could decrease their anxiety in active-learning classes when they perceive that active learning enhanced their learning. Similarly, students in both studies also described experiencing fear of negative evaluation, which we determined to be the primary factor underlying student anxiety in active-learning classrooms at both types of institutions. However, community college students highlighted a set of unique factors that they perceived affected their anxiety. They perceived that multiple ways of learning decrease their anxiety because those practices helped them learn; that their perceived limited science knowledge enhanced their fear of negative evaluation; and that their fear of negative evaluation had a negative impact on their perceptions of their own intelligence but could increase their motivation to learn course content. We have no reason to believe that these factors highlighted by the students in this study are unique to community college students, but additional research would need to be done to assess how generalizable such findings are.

Caveats and Future Directions

Community colleges often respond to local needs, which can differ greatly among community college systems (Fletcher and Carter, 2010), and in this study we recruited students who had attended nine community colleges within a single county in the southwestern United States. Therefore, the results of this study may not be generalizable beyond this specific community college system and region, and we invite future studies to build upon our findings by studying students at institutions in different parts of the country. Additionally, the same active-learning practice (e.g., calling on students when they do not volunteer, group work) can be implemented in a variety of different ways that can affect student anxiety. The findings of this study are dependent on how these students experienced active-learning practices, which may differ from how active-learning practices are enacted by different instructors at different institutions. Future studies could explore what motivates instructors to use active-learning practices that may induce student anxiety and whether instructors take particular steps to reduce student anxiety when implementing a particular active-learning practice. Finally, some students' anxiety is classified as a disability, because it substantially limits major life activities, such as engaging in course work (Americans with Disabilities Act of 1990, 1990). As such, under the Americans with Disabilities Act and Section 504 of the Rehabilitation Act, if particular aspects of courses are interfering with these students' abilities to learn, instructors must make reasonable modifications to their courses to accommodate students (Americans with Disabilities Act of 1990, 1990; Rehabilitation Act of 1973, Pub. L. No. 93-112, § 87, 1973). More research needs to be done to identify effective and reasonable accommodations for students with anxiety.

CONCLUSIONS

This study aimed to fill a gap in the literature by identifying aspects of community college active-learning science courses that increase and decrease student anxiety. While we hypothesized that student anxiety in community college active-learning courses would be impacted differently than student anxiety in 4-year research institution active-learning courses, our findings did not generally support this hypothesis. We identified that, when students perceive that active learning enhances their knowledge, it decreases their anxiety in the context of active-learning science courses. We also identified fear of negative evaluation as the primary factor underlying student anxiety in active-learning courses that integrate social situations, such as group work or calling on students when they do not volunteer. Students reported that fear of negative evaluation can be exacerbated when they perceive their science knowledge is limited, but mitigated when they have ample opportunities to prepare their thoughts and talk with their peers before sharing their thoughts with the whole class. Establishing relationships among group mates and instructor error framing was also found to mitigate fear of negative evaluation. Finally, we identified that fear of negative evaluation can positively affect students by increasing their motivation to learn course content but can negatively affect students by lowering their perception of their own intelligence and hindering their ability to think through science problems and articulate their thoughts about science. These findings echo our previous work done in the context of a 4-year research institution and indicate that the effects of student anxiety in college science courses may be more pervasive than previously thought and less dependent on course size or institutional context.

We recommend that instructors generally avoid inducing anxiety as a way to motivate students and recommend alternative ways of motivating students that do not threaten the performance of a certain subset of students; for example, instructors can motivate students by strengthening the perceived relationship between the instructor and the students (Allen *et al.*, 2006; Baker, 2010; Cooper *et al.*, 2017b, 2018a,d), helping students see the personal relevance of what they are working to learn (Theobald *et al.*, 2015), or providing autonomy over in-class tasks (Garcia and Pintrich, 1996). Additionally, instructors can still provide extrinsic incentives such as graded preclass assignments to encourage preparation (Moravec *et al.*, 2010; Jensen *et al.*, 2018) or increase accountability by implementing a group activity that requires prior preparation, such as a jigsaw activity in which students will be responsible for sharing their knowledge about a particular topic with a small group. However, how these specific activities influence student anxiety has not yet been explored, and future research should take a more fine-grained approach to identifying how specific instructional practices may influence student anxiety. Overall, we encourage instructors to be thoughtful about unintended consequences of their instructional practices that may have a negative impact on students.

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