How Does Utilizing Clicker Questions for Exam Preparation Affect Test-Taking Anxiety in Human Anatomy Students in a Flipped Classroom?

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Abstract

While active learning strategies have been promoted by researchers as practices to increase performance and retention, some practices have been shown to have unintended negative effects on students such as increasing anxiety. Students often report the debilitating effect of test-taking anxiety on their performance. This study investigated the use of an exam preparation process utilizing clicker questions to help human anatomy students at a community college cope with test-taking anxiety by practicing answering timed questions and regularly confronting the specific impact of anxiety on their performance. Students completed early and late semester surveys which measured self-reported test-taking anxiety levels and social anxiety in response to various teaching practices. There was no difference in test-taking anxiety between students who received clicker questions and students who did not. However, when comparing test taking anxiety across a subset of students who took both the early and late surveys, independent of treatment, a significant decrease in test taking anxiety was observed from the start to the end of the semester. Students also reported a change in effectiveness of teaching practices, rating lectures as effective early in the semester, while emphasizing active learning more at the end of the semester. https://doi.org/10.21692/haps.2024.005

Key words: active learning, flipped classroom, test-taking anxiety, coping skills, clickers

Introduction

Active Learning

The traditional lecture-based approach in college classrooms is slowly being recognized as an inefficient and ineffective way to create meaningful learning experiences. This is not to say that lecturing is not a reliable way to transfer information; but with the technology available, it can be done through video streaming and recordings outside of the classroom. Active learning is a more effective strategy to increase student success in college classrooms across institutions and disciplines (Entezari & Javdan, 2016; Freeman et al., 2014; Jensen et al., 2015). In anatomy and physiology courses, students struggle with the sheer volume and difficulty of concepts presented. Students struggle to succeed and some of them must repeat the courses to achieve grades that allow them to move forward in their prospective health programs. This is especially true of marginalized and first-generation students who have the added barrier of access and knowing how to navigate the invisible curriculum. Active learning and increased course structure are major components of an inclusive teaching environment as defined by Kelly Hogan and Viji Sathy (2022). Increasing course structure creates more opportunities for students to assess their knowledge with frequent, low-stakes assessments rather than a few high stakes assessments as in a traditional STEM college course.

The Flipped Classroom

In a flipped classroom, students spend very little time in the classroom listening to an instructor deliver a lecture. Rather, the lecture is delivered outside the classroom using video recordings. Activities conventionally done at home, such as quizzes, worksheets, and open-ended questions are done in the classroom under the guidance of the instructor. The flipped classroom has been shown to be effective in increasing student performance in anatomy and physiology courses (Entezari & Javdan, 2016; Tune et al., 2013), as well as across various disciplines in higher education (Deslauriers & Wieman, 2011). It also lends itself well to a regular practice of active learning.

It has been shown that the successes in the flipped classroom are attributed specifically to active learning strategies that allow students to be engaged with their peers and instructors, reflect on their own thinking processes, and

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deconstruct difficult concepts in the classroom (Jensen et al., 2015). Students are exposed to and acquire a habit of regularly learning through evidence-based instructional practices such as think-pair-share, muddiest points, collaborative quizzes, drawing to learn, and clicker questions. Students from historically excluded and marginalized groups can greatly benefit from a teaching approach that scaffolds a path to mastery of core concepts using classroom time to reinforce concepts and study skills (Nardo et al., 2022; White et al., 2021).

Clicker Questions

One such active learning strategy that this research will focus on is the use of an online quizzing system with live clicker questions which allows students to use their smartphones, laptops, or tablets as the response device to timed questions displayed on the projector. A histogram with correct versus incorrect responses is displayed on the screen after the timer ends and the instructor can directly address misconceptions. The students can use anonymous nicknames and, for the purposes of this study, the questions did not count towards the students' final grades.

The use of clickers allows students to respond to various types of questions including multiple choice questions (MCQs), true/false (T/F), open-ended, and labeling images or figures in real time while displaying the percentage of correct versus incorrect responses. It allows the instructor to observe the extent to which a particular concept requires attention based on the results of the clicker question displayed after each question. This technology promotes student-centered learning in the classroom and serves as an opportunity for the instructor to address approaches to exam-style questions, test-taking anxiety, and reading comprehension.

Classroom practices that increase student engagement such as clickers, worksheets, cooperative learning, think-pair-share, and others have been shown to increase student success across undergraduate STEM courses when compared to a purely lecture-based course (Freeman et al., 2014). Many studies have demonstrated the successes of these practices in STEM classrooms but few have considered that some practices might have negative effects such as increasing anxiety (England et al., 2017). Some instructional practices, especially those with a social component, have been shown to provoke anxiety in college students, and more so in first-generation college students (Hood et al., 2020, 2021). The use of clickers in the classroom are rated by students to provoke lower levels of anxiety, levels that are comparable to passively listening to an instructor give a lecture. In contrast, practices like cold-calling provoke higher levels of anxiety and first-generation students consistently rate all these practices as more anxiety promoting compared to their continuing-generation peers.

Academic Anxiety

When discussing anxiety provoking instructional practices, we're referring to state anxiety as opposed to trait anxiety. State anxiety is a feeling or emotional state, typically situational, while trait anxiety is a characteristic of the person (Endler & Kocovski, 2001). Anxiety is reported in college students and more so in science classes. It can have negative effects on exam performance if not resolved (Okebukola, 1986).

Even though some practices provoke anxiety in students and more so for particular groups of students, it is important to address the reasons why students may be undergoing this psychological stress and teach them how to cope with it rather than avoiding using these techniques. Clicker systems were rated as causing lower levels of anxiety by students surveyed when compared to other practices such as cold-calling, volunteering to answer a question, or completing worksheets (England et al., 2017; Hood et al., 2020). Students at SLCC frequently report exams as inducing high levels of anxiety, test-taking anxiety, and negatively affect their performance despite feeling prepared and comfortable with the material. This study aimed to use timed, exam-style clicker questions to help students cope with test-taking anxiety. The hypothesis was that by practicing timed questions with the instructor and continuously confronting the specific impact of anxiety on their performance, students would report lower levels of anxiety and higher levels of academic self-efficacy or their perceptions about their own academic abilities.

The research project investigated the following questions:

1. *How does using clicker questions affect test-taking anxiety in human anatomy students in a flipped classroom?*
2. *How do various evidence-based instructional practices (EBIPs) affect students' self-reported anxiety levels?*
3. *How do students perceive effectiveness of various EBIPs?*

Methods

Study Design

This study was conducted in the Fall 2022 semester following Institutional Review Board approval and student consent. The participants were enrolled in a one semester Human Anatomy course that is a prerequisite for all students going into health science programs (nursing, radiology technician, dental hygiene, etc.) and typically taken during the second year of an associate degree.

The study was conducted using two course sections taught in a *hybrid modality,* meaning students registered for a 3-credit hour course which met synchronously once per week for 80-minute sessions. Students were expected to engage with course material asynchronously online through

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the Learning Management System (LMS) to account for the remaining credit hours. Both sections were taught as *flipped classrooms* where students were required to watch all lecture content at home through prerecorded videos and perform various learning activities, quizzes, group work, and assignments in the classroom during synchronous class meetings under the supervision of the instructor. One section was designated as the control group and the other section was designated as the intervention group (clicker group).

Student Survey

Students responded to a set of survey questions at the beginning (early) and end (late) of term. This meso-level survey contained three instruments that measured students' self-reported academic self-efficacy, social anxiety (mini-SPIN; Connor et al, 2001), and test anxiety (Spielberger Test Anxiety Inventory, Spielberger et al., 2014). Students responded to various statements in each instrument by rating their level of agreement or disagreement on a Likert scale. The social anxiety section had 5 questions to measure students' self-perception of their anxiety related to EBIPs, and 5 questions about how those EBIPs contributed to their learning. The test-anxiety section asked them to report how often they felt various emotions related to nervousness and discomfort around taking exams. The academic self-efficacy section asked 10 questions about students' beliefs in their abilities.

The social anxiety and academic self-efficacy measurements were part of a larger study for the CAPER project and therefore are not discussed in detail here. This study focuses on the effects of clicker questions on test-taking anxiety. Students were additionally given the Test Anxiety Inventory (TAI) before each exam (before exam 2, 3, and 4). Students were given a review session before each lecture exam and then completed the TAI. Students responded to the TAI a total of 5 times throughout the semester: timepoint 1 was during the first two weeks of the term, timepoint 2 was during week 5 before unit exam one, timepoint 3 was during week 9 before unit exam two, timepoint 4 was during week 13 before unit exam 3, and timepoint 5 was during week 17 before unit exam four and the final examination. Students did not receive an exam preparation session before the 3rd unit exam because the instructor had COVID and was not able to administer that session.

The group who received the intervention (clicker group) participated in an exam preparation session with a timed online quiz using clickers while the control group was given a similar exam preparation session but without the use of clickers and timed questions. Instead, the instructor projected learning objectives and various questions to help students discuss which concepts they wanted the instructor to clarify. The clicker group's exam preparation session aimed to simulate the testing environment by timed, exam style clicker questions. The questions were either multiple choice or true/false and tested on concepts that would be covered in the unit exam that followed.

Question Prompt to Students	Answer Choices
Which structure is derived from the peritoneum of the abdominal cavity?	A. mediastinum testis B. tunica vaginalis C. raphe D. spermatic cord
Which is not a function of the urinary system?	A. regulation of lymphocyte production B. storage of urine C. regulation of blood volume D. excretion of wastes
The capillaries of the glomerulus differ from other capillary networks in the body because they:	A. drain into an arteriole instead of a venule B. filter nutrients from the glomerular capsule C. absorb nutrients from the glomerular capsule D. secrete mucus
Which gland secretes a fluid containing fructose?	A. seminal vesicle B. erectile bodies C. vestibular gland D. prostate gland

Table 1. *Examples of questions and learning outcomes projected for clicker group preparation session (taken from power point slides in the review sessions).*

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Task/Question	How students demonstrated their understanding of the learning target
4.9 Identify where each type of connective tissue is found in the body.	Students discuss in groups
4.11 Explain the structure and function of skeletal, cardiac, and smooth muscle.	4.11 Which of the following muscle types is **voluntary**? A. skeletal B. cardiac C. smooth
1.2 Describe the hierarchical levels of organization in the human body.	1.2 Which of these places the organization of structures from most complex to least complex? A. organism, tissue, cell, organ, organelle B. organelle, cell, tissue, organ, organ system C. organ system, organ, tissue, cell, organelle
4.4 Explain where each epithelial tissue is found in the body.	Students discuss in groups

Table 2. *Examples of questions and learning outcomes projected for control group exam preparation session.*

Preparation sessions for both the clicker and control groups took 20-30 minutes during the class meeting and included 15-25 questions. Questions were displayed on the projector with a timer of about one minute per question for the clicker group whereas the control group did not have a timer and students were not required to respond in a definitive way other than discussing possible answers with their peers.

Student Population

Students enrolled in the human anatomy course, BIOL2320, at Salt Lake Community College (SLCC) are predominantly 2nd year pre-health majors going on to professional programs or transferring to four-year institutions for various health science career-related programs. SLCC serves a large population of Hispanic and Latino/a/x students, first generation, and non-traditional students.

Identified Gender, % (n)	
Male	5.6 (4)
Female	58.3 (42)
Ethnicity, % (n)	
White	47.2 (34)
Black	5.6 (4)
Native or Alaskan Native	1.4 (1)
Asian	5.6 (4)
Other	4.2 (3)
Missing	33.3 (24)
Latino/a/x Origin, % (n)	
No	48.6 (35)
Yes	16.7 (12)
Missing	34.7 (25)
First Generation Status, % (n)	
No	45.8 (33)
Yes	20.8 (15)
Missing	33.3 (24)

Table 3. *Demographic data of student participants. Students self-identified their gender, ethnicity, Latine origin, and first-generation status (n = 72). One student responded non-binary and one responded gender queer and non-binary. One student responded prefer not to say for ethnicity.*

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Test-Taking Coping Skills for All Student Participants

All student participants in this study were introduced to the relationship between stress and performance (Chaby et al., 2015) as well as the effect of deep diaphragmatic breathing on heart rate (Magnon et al., 2021). Throughout the semester, student participants were reminded regularly by the instructor of the value of mindfulness as a coping mechanism for testing anxiety. Prior to the first exam, the instructor led the class in a mindful meditation to guide students in visualizing themselves in a testing environment, focusing on breathing, and persisting through feelings of discomfort. During review sessions before each exam, students were again reminded to lean on these skills to aid in alleviating the debilitating effects of test anxiety.

Data Analysis

Survey. All quantitative results from responses on the Likert scale were downloaded to Microsoft Excel for manipulation. Results were from 5 different time points (1st through 5th). The measures of social anxiety, test-taking anxiety, and open-ended questions about effectiveness of various EBIPs were administered during the first timepoint (week 1-2) and 5th timepoint (week 15-16).

Test Anxiety Inventory. TAI reported values were collected using Qualtrics survey instruments on a Likert scale. Mean TAI ratings were compared across time points between the control group and the clicker group to test the hypothesis that timed clicker questions would help alleviate test-taking anxiety.

To measure what happened with test anxiety for all students who completed the 1st and 5th semester surveys, we compiled the reported values and did a paired sample students t-test with a Wilcoxon post hoc test.

Social Anxiety in Response to EBIPS: Results from the social anxiety instrument were compiled and downloaded. We looked at social anxiety self-reported values in response to various EBIPs from the 1st and 5th timepoints.

Qualitative Results. At the end of the social anxiety inventory, students were asked "For the activities that you found helpful, please explain why they were helpful. Did they help you develop more effective study strategies? If so, what were those strategies?"

The first step in the analysis was to read through all the open responses and identify recurring themes in each of the 1st and the 5th timepoints. These themes were coded by listing them in a table. Next, we tallied how many times each of the themes appeared and compiled them into tables. Once finalized, representative quotes were selected from each theme.

Results

Quantitative Results

No difference in the mean Test Anxiety Inventory (TAI) between the control and clicker groups was observed across time points (Figure 1, Table 4, and Table 5). However, when data was compiled to compare TAI ratings for only participants who completed the 1st and 5th semester survey, a paired sample t-test showed a significant decrease from the beginning of the semester to the end of the semester independent of whether or not students were exposed to clicker questions in their pre-exam preparation (Figure 2). The mean TAI rating at the 1st timepoint was 56.0 and it decreased to 41.7 in the 5th timepoint ratings.

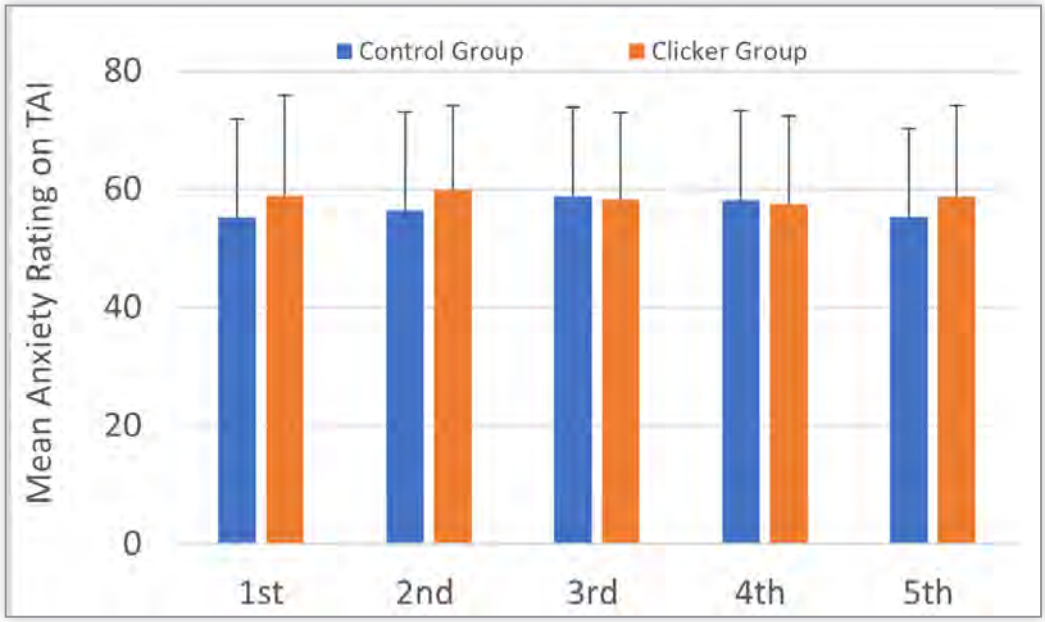

Figure 1. *Mean test anxiety inventory ratings between control and clicker groups. Students took the Spielberger's TAI 5 times throughout the semester. 1st timepoint (control group, n=24; clicker group, n= 21), 2nd timepoint (control group, n=20; clicker group n=23), 3rd timepoint (control group, n=25; clicker group, n=24), 4th timepoint (control group, n=15; clicker group, n=23), 5th timepoint (control group, n=18; clicker group, n=28).*

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	TAI Rating 1st Timepoint	TAI Rating 2nd Timepoint	TAI Rating 3rd Timepoint	TAI Rating 4th Timepoint	TAI Rating 5th Timepoint
N	24	20	25	15	18
Mean	55.3	56.4	58.8	58.1	55.4
Std. Deviation	16.7	16.7	15.1	15.2	14.9

Table 4. *Control group mean TAI scores over time.*

	TAI Rating 1st Timepoint	TAI Rating 2nd Timepoint	TAI Rating 3rd Timepoint	TAI Rating 4th Timepoint	TAI Rating 5th Timepoint
N	21	23	24	23	28
Mean	58.9	60.0	58.2	57.5	58.8
Std. Deviation	17.0	14.2	14.7	14.8	**15.3**

Table 5. *Clicker group mean TAI scores over time.*

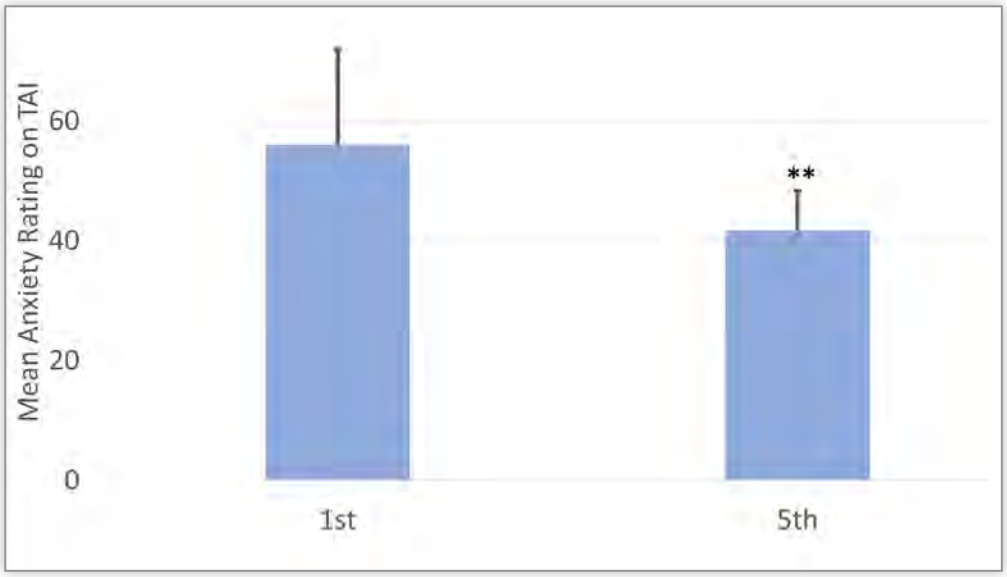

Figure 2. *Compiled anxiety ratings on TAI for students who completed 1st and 5th timepoint surveys (n=35).*

We next analyzed student ratings of anxiety caused by various teaching practices. Examination of the data revealed that the distributions of these ratings did not meet the assumption of normality, so non-parametric inferential tests were used to test for differences. Figure 3 shows the mean anxiety ratings of five different teaching practices that student reported at the start of term (1st timepoint) and end of term (5th timepoint). No significant differences were found in these ratings between the control and clicker groups, so data from the two groups were pooled. Comparison of ratings using a Friedman test indicated significant differences across the five teaching practices (χ^2 (4) = 97.2, $p < 0.001$). Follow-up pairwise comparisons using the Durbin-Conover test indicated significant differences between all practices except for between the use of clickers alone and with others, which did not differ significantly in rated anxiety (see supplementary materials for these test statistics). As shown in Figure 3, cold calling received the highest anxiety rating whereas lecturing with PowerPoint received the lowest.

We next analyzed ratings made at the end of the term, which are shown in Figure 3. At this time point, students were also asked to rate the use of the clicker app for induced anxiety. The results of a Friedman test indicated significant differences in ratings across these six teaching practices (χ^2 (5) = 131, $p < 0.001$), and post-hoc comparisons revealed

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differences between all practices. Similar to ratings made at the start of term, anxiety ratings at the end of term were highest for cold calling and lowest for lecturing.

Additional pairwise comparisons of ratings made at the 1st and the 5th timepoints were conducted for each practice. These comparisons indicated no statistically significant differences in ratings over time for each of the five teaching practices.

Qualitative Results

Early Semester Survey

Recurring themes identified in student responses to the question, "For the activities that you found helpful, please explain why they were helpful. Did they help you develop more effective study strategies? If so, what were those strategies?"

Most students mentioned at least one of the five themes (Table 3) that corresponded to the five EBIPs mentioned in the previous questions. In the beginning of the semester, students focused on listening to lecture videos or going through PowerPoint presentations while listening to the instructor. This was the most common response; it appeared 18 times in the early semester survey as an activity that helped students learn. The second most common response that was mentioned was working through a problem with another student or in a group; it appeared 16 times. Answering questions individually, cold-calling, and volunteering to answer a question posed by the instructor were not common but still mentioned as effective teaching practices.

Late Semester Survey

At the end of the semester, only three students mentioned listening to a lecture as an effective practice while working with other students still seemed important to participants. Answering questions individually was mentioned 10 times at the end of the semester as opposed to only 5 times in the beginning of the semester. Volunteering and cold calling were still rated by very few students as being effective teaching practices.

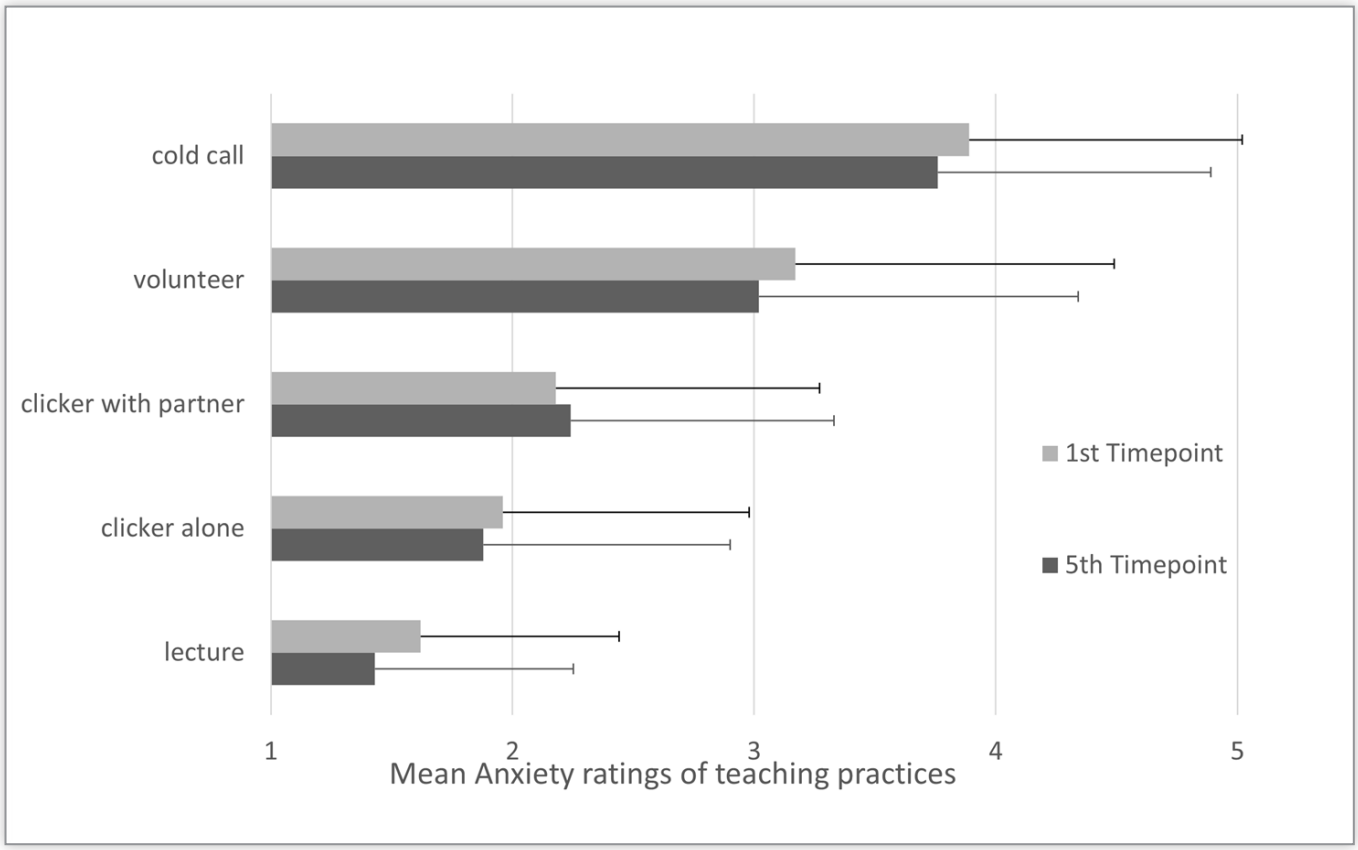

Figure 3. Mean anxiety ratings of teaching practices.

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EBIP in Response	Number of times mentioned		Representative Quote
	1st Timepoint	5th Timepoint	
Listening to instructor give lecture through PPT	18	3	I am a visual learner so watching power points and seeing examples/ photos helps me learn better. I also like to take notes and listen rather than do activities. The most helpful thing for me is the lectures and PowerPoints. They help me understand all the knowledge I need to know for each subject/chapter.
Working through problems with another student(s)	16	11	Working with another student in groups of 2 seems to be the most beneficial way of answering for me. That way we can help cover the gaps of understanding. I found working with other students to be helpful because I was able to work through my thought processes with their help and also have them further explain to me the subject.
Volunteering	3	3	Answering questions from an instructor allows me to self-assess my knowledge of the content in that moment. Volunteering to answer a question makes it more likely for me to remember the information as I am actively seeking it out without much anxiety.
Answering questions on my own	5	10	When I work alone to answer a question or do my work It helps me know where I am and what I need to work on. In class assignments, it helped to reflect on what we had learned outside of the classroom before going into the lecture.
Cold calling	5	2	Cold calling does create a necessity for students to both study and learn as well as actively listen / participate. All of this helps the student learn. I remember concepts most when I answer a question posed by the instructor or through cold-calling, whether I know the answer or not. After this experience, I'm sure to retain the information. I suppose it's helping me develop more effective strategies now that I think of it.

Table 6. *Qualitative Results from Student Responses on Effectiveness of EBIPS*

Discussion

Our results showed that students reported significantly lower levels of test anxiety whether they received clicker questions or not. In both groups, an emphasis was placed on mindful breathing, reading exam questions, decoding multiple choice questions, and study techniques. While we did not measure test-taking coping skills in any way, it is worth mentioning that teaching students how to self-regulate and continue to perform in the face of discomfort caused by test anxiety may have had an impact on their self-reported TAI ratings. Teaching students how to use deep diaphragmatic breathing (Magnon et al., 2021) may have had some impact on testing anxiety when we consider that each review session for both groups focused on these skillsets.

Open ended questions asking students about which EBIP they found most helpful and why revealed that each of the EBIPs mentioned in the survey (lecture, working on questions individually, working on questions in groups, volunteering, and cold calling) appeared as a recurring theme in student responses. While it was not surprising that students rated volunteering and cold calling as unhelpful and working through problems as helpful, it was interesting to observe a change in student attitudes about listening to lecture and PowerPoint presentations. In the early survey, this EBIP was mentioned 18 times while in the late survey, only 3

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participants stated that listening to a lecture was a helpful EBIP. Students focused more on working through problems and working with another student.

We suspect that many students entering this course had either not been exposed to or had negative experiences with active learning and rated lecture as a highly valuable practice. After a semester of weekly opportunities to practice applying concepts in class and working actively with their peers, it seemed that students gained an appreciation and realization that active learning is effective. Lecture delivery did not change from the beginning to the end of the semester; students continued to watch lecture videos outside the classroom and perform active learning inside the classroom. These results also suggest that if students see their performance improve, they may be more willing to engage with active learning and cooperative learning even if they associate a level of anxiety with those practices.

Another theme that arose in the late semester student responses was that students rejected the notion that one activity was more helpful than others to the prompt, "For the activities that you found helpful, please explain why they were helpful. Did they help you develop more effective study strategies? If so, what were those strategies?" We observed that in many responses, students mentioned at least two EBIPs they found helpful, whereas in the early survey, they more often chose only one EBIP. While this study did not specifically survey students about their attitudes towards belonging or self-efficacy, students tended to become more comfortable in the classroom as the semester progressed. While teaching style and practices did not change throughout the term, the hope for all instructors is that *students* change. The fact that students choose multiple modalities of learning as beneficial demonstrates a higher level of understanding of themselves as learners.

This study highlights the importance of finding ways to improve student ability to become active participants in their learning process. Instructors can use structured pedagogical tools like clicker questions, exam wrappers, and study skills labs or guide students to achieving more self-awareness through mindfulness practice and exam preparedness skills. Many studies focus on student attitudes toward various teaching practices (England et al., 2017; Hood et al., 2020, 2021; Nguyen et al., 2016) and their performance as a result of a variety of active learning strategies (Rao & DiCarlo, 2001). We also understand the impact of faculty belief systems on student performance. It has been demonstrated that faculty, specifically STEM faculty, who believe that ability is fixed rather than dynamic, have larger racial achievement gaps in their classrooms compared to those with the opposite mindset (Canning et al., 2019). In the face of this information, it is surprising to us that little has been done to help instructors address these issues in the classroom. Our results indicate that instructors may be able to shift student beliefs about themselves and help them develop better attitudes about test taking.

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