Research Paper

Peer Teaching in General Chemistry: Benefits to Information Retention and Lowered Student Anxiety

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Abstract

Students in the first semester of the general chemistry sequence participated in a peer teaching exercise and were subsequently evaluated for information retention and test anxiety. Test anxiety was measured through a pretest survey, and information retention was measured through scores on embedded exam questions and at the start of the next semester on a lab review assignment for students continuing to the second semester chemistry course. Participation in peer teaching showed an average 20% reduction in students' self-evaluation of test anxiety and an increase in information retention in both short and longer term evaluations. Students participating in peer teaching scored on average 20% higher on a final exam question than those who participated in a non peer-teaching review. This increased retention was shown to carry over into the subsequent semester in students participating in General Chemistry II.

Keywords: peer teaching, information retention, test anxiety, molecular structure

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Peer teaching broadens the more common technique of reciprocal peer tutoring (in which a pair of students alternates being the tutor or the tutee) and places each student at the front of the class to teach their classmates for part of an assignment. The nature of an assignment for peer teaching is open-ended, which allows the design to fit within the content of any course. Since explaining a concept to someone else helps extend one's own learning and critical thinking abilities, this practice gives students the opportunity to better understand the material being studied, to become better problem solvers, and to develop enhanced critical thinking skills. Increased interaction between classmates helps students be more actively engaged in their education. This technique has been applied in General Chemistry I courses with follow-up evaluation in subsequent General Chemistry II. Obstacles to incorporating peer teaching, including getting students to "buy in" to the program, are discussed, as are the program's benefits, specifically with regard to retention of course information, increased problem-solving abilities and reduction of student test anxiety.

Background and Literature Review

Several studies have shown that using cooperative and active learning strategies (like peer teaching or peer tutoring) can positively affect student performance and mitigate students' anxiety related to the subject or topic (Holmes & Hwang, 2016; Guita & Tan, 2018; Choi-Koh & Ryoo, 2019).

The benefits of cooperative learning strategies, particularly as related to mathematics, have been well documented (Alegre et. al., 2020). Science courses often invoke the same anxiety for students that has been studied for mathematics (general chemistry courses have significant mathematical content, often requiring a college algebra course as a prerequisite).

This study extends the traditional model of reciprocal peer tutoring, wherein a pair of students alternates being the tutor or the tutee (Youde, 2020) to a classroom setting where each student in the class takes on the role of teaching for a portion of the exercise. Traditional peer tutoring has been studied across various disciplines, often with a focus on students with learning disabilities, and it has been found to have benefits for both proficient and struggling students across subjects (Huber & Carter, 2019; Mahoney, 2019; Sarid et. al., 2020; Griffin & Griffin, 1997; Griffin & Griffin, 1998; Rittschof & Griffin, 2001).

Methods

The primary aim of this study was to determine the effects of a peer teaching exercise on college chemistry students' content retention and test anxiety. The hypothesis was that participating in peer teaching would (a) help students gain a better understanding of the course content while retaining that information to a higher degree and (b) minimize the effects of testing anxiety related to the course content.

Some sections of the relevant courses served as control groups where students completed the same set of problems on an individual basis instead of in the peer teaching format.

A total of 317 students in a first semester general chemistry course (CHM 151, General Chemistry I in the North Carolina Community College System catalog) participated in the initial study. A separate analysis of 121 students who had moved on to take the second semester course in the general chemistry sequence (CHM 152, General Chemistry II) was also conducted.

Students in General Chemistry I learn how to identify the shapes and bond angles of molecules after drawing a molecular structure that represents the characteristics of the bonding present in the molecule (a Lewis structure). One laboratory session of the course is devoted to students working through a series of molecular formulas to draw structures, identify the molecular shape and bond angles, and determine if the molecule is polar or nonpolar.

The peer teaching exercise involved students selecting two molecular formulas from a list of compounds used for a thorough review of the topic. Students were given a period of 15-30 minutes to prepare a lecture on how to arrive at the structure, bond angles, shape, and polarity of their two molecules. Instructions specified that students should be describing their thought process in detail during their presentation; every aspect of how they reached an answer should be described during their teaching presentation. Students proceeded to take turns teaching the class on one of the selected molecular formulas. For the first presentation, the instructor picked the molecular formula that allowed for the more detailed teaching presentation. Often this was the more complicated of the two structures, but sometimes it was a structure that addressed topics not yet covered in class.

Students were not allowed to take any notes to the board as they offered their presentation. This requirement encouraged them to carefully explain each step in their process and to make sure they engaged with the other class members playing the role of their students. The members of the class who were not presenting were encouraged to ask questions of the teaching student. However, particularly early in the exercise, the instructor was prepared to serve in this role, as students who had not yet presented would generally not want to barrage the teaching student with questions. If time permitted, students could present their remaining structure/s as well. The interactions between students and teachers were often much more animated on the second pass as comfort with the exercise increased.

Information on student performance on a question related to the topic of the peer teaching exercise was collected for classes that participated in the exercise and for classes that reviewed the topic with a traditional worksheet of all the molecular formulas and an answer key. More long-term retention of the content was evaluated by comparing scores on a review of the material administered during the first lab exercise of the General Chemistry II course. Students who had participated in the peer teaching exercise were compared to those who had experienced the traditional review on a worksheet assignment.

Results

A survey of student attitudes toward the topic of determining molecular shapes and bond angles was administered between the review period (where the students participated in peer teaching or a non peer-teaching review) and the final exam for the General Chemistry I course. The data from this survey was

compiled and sorted according to the method of review on the topic in which students participated. Students who had been part of the peer teaching group were significantly more confident in their knowledge of the topic (an average score of 7.4 out of 10, with 0 being completely lacking confidence and 10 being completely confident) than students who did the review as a worksheet (an average score of 5.3 out of 10). Standard deviation within the data set was 0.47 points for the peer teaching group and 0.49 points for the non peer-teaching group. See Figure 1. A few students who were part of the review and took the final exam in the course did not participate in or return the survey of confidence, resulting in a small difference in the total number of participating students.

After the final exam for the courses was completed and graded, the specific results for a question on molecular shapes and bonding (the question used involved drawing and analyzing five different molecular structures) was compiled and the data was sorted by the version of the review students experienced (peer teaching or non peer-teaching). Students who participated in the peer teaching exercise scored, on average, a full five points higher on the 25-point question on the final exam—a 22.8 average score for students in the peer teaching group versus a 17.8 average for students in the worksheet review group. Standard deviations in the data were 2.1 points for the peer teaching and non peer-teaching groups and 2.2 points for the no review group. See Figure 2. Both groups that participated in a review performed better than students who either missed the review or took the exam early (before the review exercise).

When students transitioned from General Chemistry I to General Chemistry II, their retention of knowledge on the topic was evaluated with an assignment during the first laboratory meeting of the subsequent semester. The improved performance of students who had participated in the peer teaching exercise was still evident, with peer teaching participants scoring 4.7 points higher on the 20-point exercise than students who did not participate in the peer teaching exercise during their General Chemistry I course. The standard deviation in both sets was 1.6 points. See Figure 3. Any student with a larger than usual gap between the two semesters when taking General Chemistry I and General Chemistry II (for instance, students in pre-engineering sometimes take General Chemistry I in the fall semester of their freshman year and General Chemistry II in the spring semester of sophomore year with a yearlong gap in between) was excluded from the control group so as not to bias the comparison in favor of peer tutoring.

Discussion

The original hypothesis was that participating in peer teaching would (a) help students gain a better understanding of the course content and retain that information to a higher degree and (b) minimize the effects of testing anxiety related to that course content. This hypothesis was shown to be correct for both premises. Data from final exams showed that students who took part in peer teaching performed better on questions related to the topic of the exercise. Evaluation of students' knowledge after they moved on to the next course in the general chemistry sequence also showed the increase in understanding was retained over the period between the courses. The second premise, that students would be more confident and exhibit lower anxiety about being tested on the material, was confirmed in survey data of student attitudes after the peer teaching exercise but before the course's final exam.

While the peer teaching exercise was shown to benefit students relative to the learning objectives of the course, there are some additional considerations of the activity that should be noted by an instructor wishing to apply this technique.

The Role of the Instructor

The interaction between the instructor and the participating students is crucial for the success of the exercise (as is the case for most teaching interactions). Participating students need to be amenable to presenting in front of the class and responding to questions from classmates and the instructor. The instructor also needs to enforce that students are presenting with sufficient detail to qualify as "teaching" their classmates the concept. A student who turns their back to write on the board for a significant period of time and then begins to explain only after everything is written (i.e., points to their picture and says, "Here's what I have") is not engaging the task at a level that will help them gain a deeper understanding of the material or help their classmates see the problem solved through someone else's approach. An instructor needs to have a relationship with the students that allows interruptions

of someone who is not meeting the assignment expectations without resulting in that student feeling singled out. This potential problem can be assuaged if students understand the goals of peer teaching before participation in the exercise.

The Role of the Student

Students with a very limited ability to present in front of the class may resist this activity. A large enough fraction of the class not being engaged could limit effectiveness. Additionally, students who are making no attempt to learn the course material will also inhibit the effectiveness of this activity as they will not be able to reasonably teach their assigned molecules without ample intervention from the instructor.

The Role of Time

Since this activity requires the presence of the class, the time available is limited in a way that a worksheet approach for review is not. (If students do not finish the worksheet during class, they can continue the work outside of class.) While the peer teaching exercise can always be supplemented with additional problems done outside of class, the instructor should make sure that a sufficient number and variety of problems are addressed during the exercise that students get a thorough review of all aspects of the material. This is partially addressed by students preparing to present two molecular structures with the instructor choosing which one is presented initially.

Conclusion

The main conclusion that can be drawn from this study is that peer teaching may be beneficial for student understanding of difficult concepts and for retention of that understanding. This increase in understanding leads to higher student confidence and lower anxiety.

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Author's Note

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Appendix A

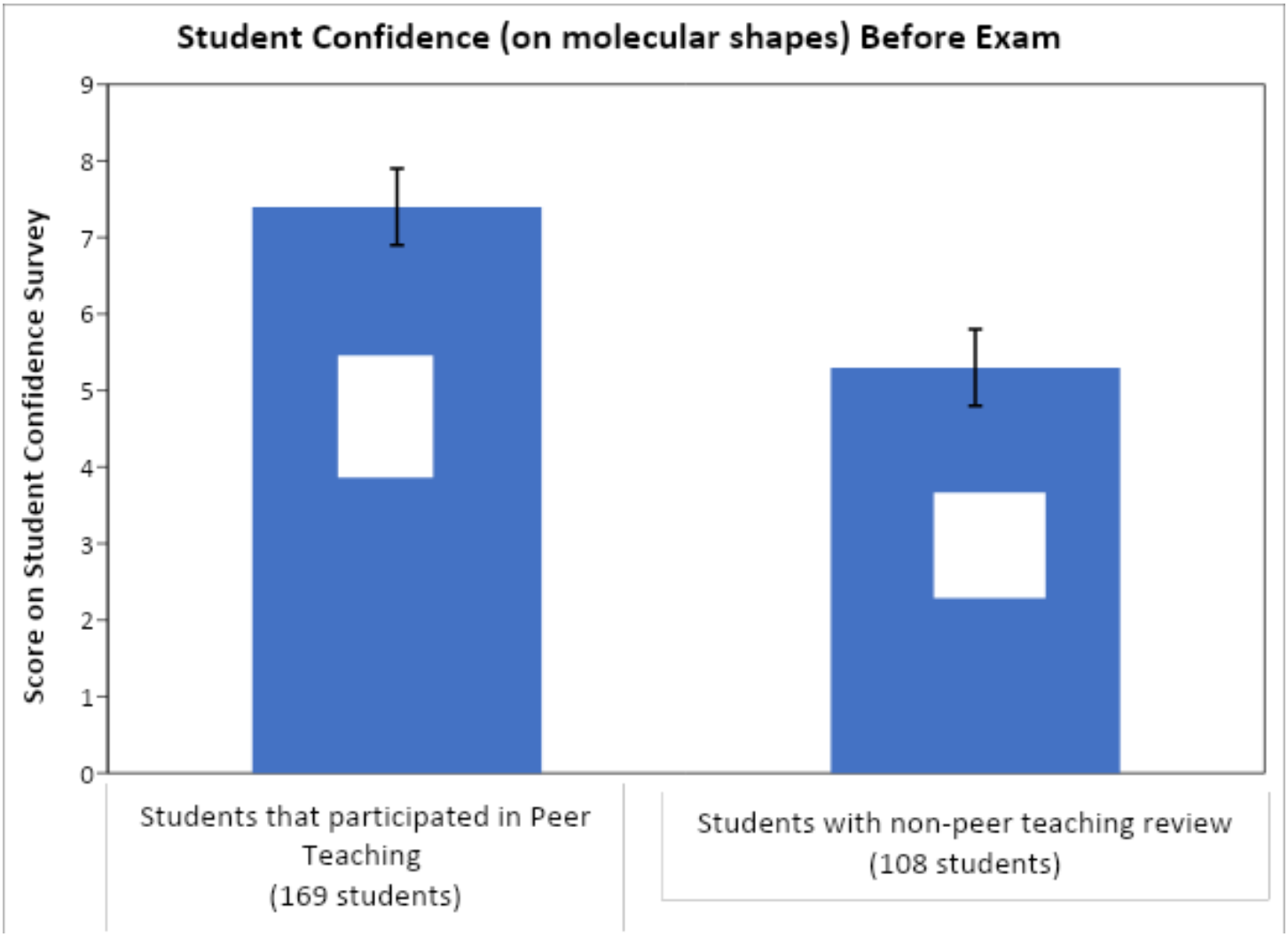

Figure 1

Comparison of Student Confidence Correlated with Review Method

Appendix B

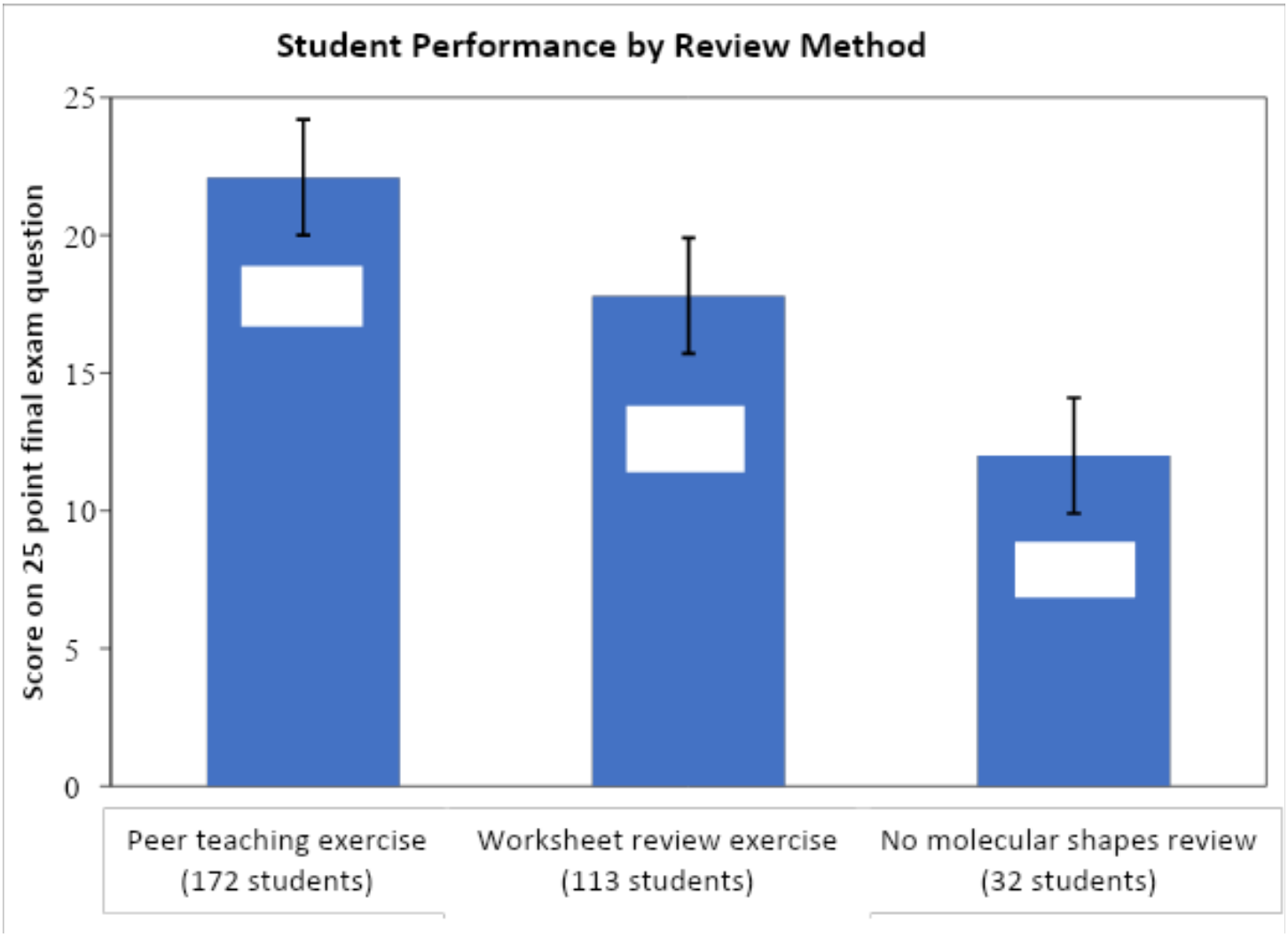

Figure 2

Comparison of Students' Exam Question Scores Correlated with Review Method

Appendix C

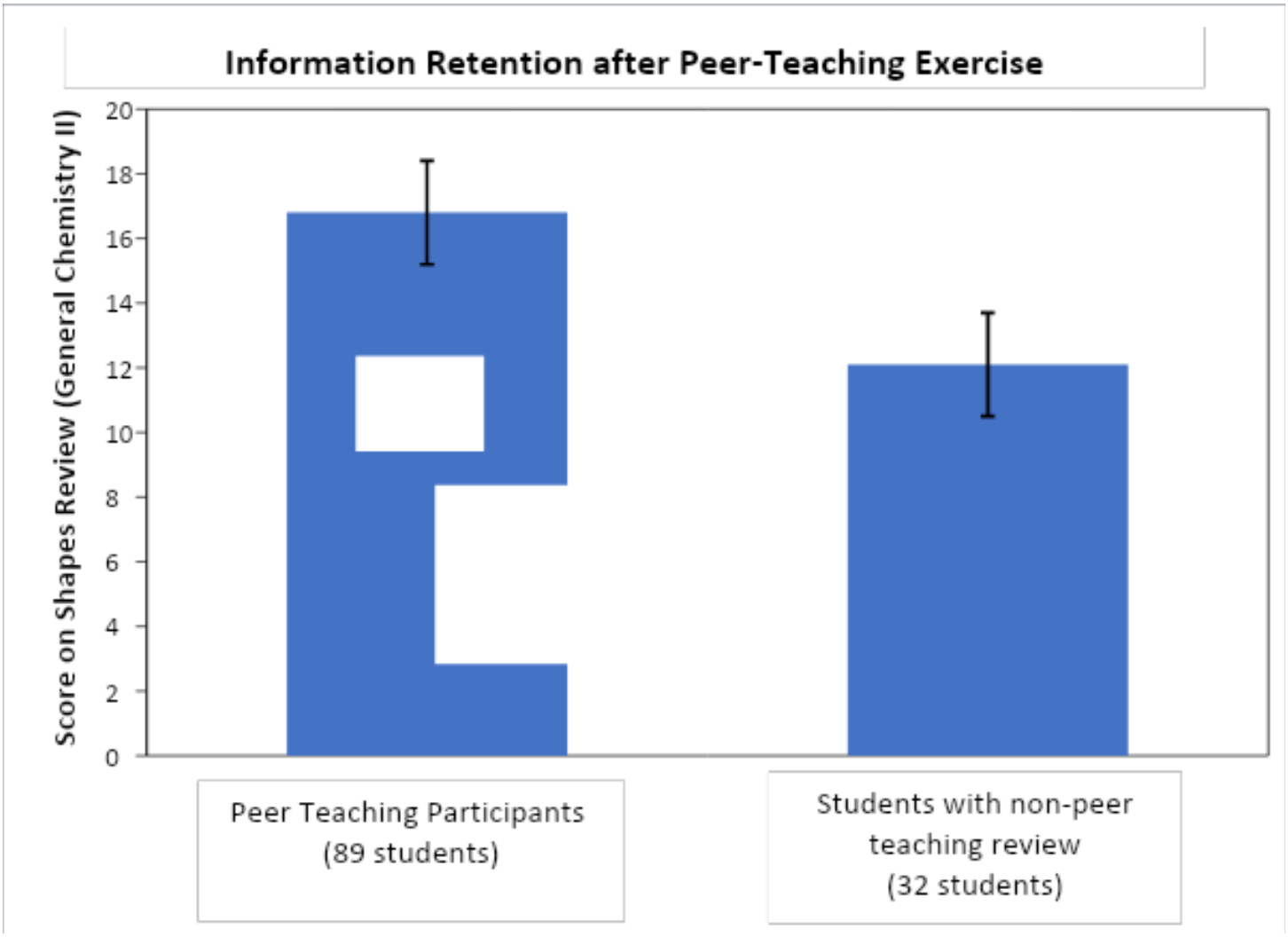

Figure 3

Comparison of Students' General Chemistry II Lab Exercise Scores Correlated with Review Method From employed in Their General Chemistry I Course