Clickers in a Community College Classroom: An Initial Foray into Community College Biology Education Research

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Abstract
One strategy to transform the high attrition rates among community college (CC) students is for CC instructors to utilize the teaching practices shown to most likely lead to student success. CC students and faculty are underrepresented in biology education research (BER), with only 3% of BER articles addressing CC-specific issues (Schinske et al. 2017). This study examines whether the addition of an electronic student response system (SRS), and its proposed ability to facilitate group discussion, would enhance the effects of peer instruction on student performance in a community college anatomy and physiology course. Unit exam scores of students utilizing clickers vs. written responses were compared to determine if the addition of clicker technology to peer instruction increased performance. A MANOVA test revealed no significant differentiation in exam scores between groups. This implies that CC students may respond dissimilarly to previously studied students and that more educational research must be done at community colleges. https://doi.org/10.21692/haps.2019.030

Key words: active learning, clickers, community college, educational research

Introduction
The community college (CC) student population is unique among undergraduate students (American Association of Community Colleges [AACC] 2019). They are more diverse in terms of race or ethnicity as well as socioeconomic background. Community college students tend to be older and have family obligations. Community colleges enroll a diverse population of military-affiliated students, including those on active duty, reservists, and veterans. CC students are more likely to enroll part-time and work while attending school. These factors may create challenges for college success.

Community colleges provide an essential pathway to postsecondary education for many who would not attend college otherwise. However, there is a high rate of attrition among CC students, and most do not complete a credential or degree (American Association of Community Colleges [AACC] 2019). One strategy to transform this outcome is for community college instructors to utilize the teaching practices shown to most likely lead to student success.

One teaching practice that has been shown to increase student performance in science, technology, engineering, and math (STEM) courses is active learning (Freeman et al. 2014; Hake 1998; Prince 2004), including anatomy and physiology (Rao and DiCarlo 2001; Michael 2006; Shaffer 2016). Generally, active learning is any learning activity in which the student participates or interacts with the learning process. One active learning technique, peer instruction (PI), involves the instructor asking students carefully designed questions related to known areas of confusion or misunderstanding. Students answer the question individually and then work in small groups to arrive at a consensus. This small group discussion results in students discussing the concepts and possibly providing clarification to group members. The instructor leads a full class discussion to review and provide further clarification. PI has been shown to be effective at community colleges (Fagen et al. 2002; Lasry et al. 2008).

One proposed method of enhancing peer instruction is to utilize electronic Student Response Systems (SRS). SRS are instructional technology tools that assist in generating engagement in the classroom by allowing the creation of interactive presentations. Students can respond to the questions or problems posed in the presentation by using a SRS device. The SRS gathers the data and can display summaries of students' responses as a histogram. Answers are also stored for later viewing, grade reporting, further analysis for both question and topic coverage, and educational research.

Studies have cited an improvement in class scores related to SRS usage (Freeman et al. 2007; Morling et al. 2008; Mayer et al. 2009). These studies introduced SRS in conjunction with an active learning technique, which resulted in comparing a traditional lecture-based classroom with a classroom utilizing

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SRS-assisted peer instruction. It is unclear as to whether improvements in student learning were associated with the clickers, the utilization of active learning techniques, or some combination. Other studies have indicated that additional gains in student learning occurred when SRS were used in conjunction with reliable active learning techniques (Duncan 2005; Knight and Wood 2005; Caldwell 2007). As the specific effect of SRS is still unclear, our study used peer instruction across all groups to parse out whether there would be a significant difference in unit exam grades among students who responded to questions by electronic SRS (clickers) or written response. The primary research goal of this project was to investigate whether the addition of SRS, and its ability to further facilitate group discussion, would enhance the effects of peer instruction on student performance in a community college anatomy and physiology course.

The secondary goal of this project was to expand the available pool of biology education research that can be used to increase community college student success. The studies mentioned earlier were conducted in large classrooms in four-year college and university settings, which are different from CCs in both student populations and faculty responsibilities. Community college instructors are often unique among post-secondary educators. For instance, CC faculty typically have heavier teaching loads. While their job assignments focus principally on pedagogy, they also include service and professional development with little to no expectation of conducting research (Cohen and Brower 2003). This heavy teaching load as well as lack of access to teaching and learning centers and professional development funds may complicate the creation and application of active learning techniques in CC classrooms (Smith 2007). According to Schinske et al. (2017), community college students and faculty are under-represented in biology education research. Only 3% of biology education research articles address CC-specific issues or are even authored by CC faculty (Schinske et al. 2017).

Methods

The participants in this study were voluntarily enrolled students in one of two traditional, daytime, face-to-face lecture sections of human anatomy and physiology at Anoka-Ramsey Community College (ARCC) during the spring semester of 2019. This course was the first half of a two-semester sequence, and included a comprehensive study of body organization: homeostasis, tissues, integument, skeletal system, muscular system, nervous system, special senses, and endocrine system. This human anatomy and physiology course was aimed primarily at allied health students. A passing grade of "C" or better in an introductory majors-level biology course was a prerequisite for enrolling in this anatomy and physiology course.

To be included in the study, students had to give their consent, participate in all five active learning exercises, and complete all five major summative assessments in the form of lecture unit exams. Sixty-two students fulfilled these criteria. Of the participants, 62.9% registered as pre-Nursing, pre-Physical Therapy Assistant, or other health related majors. An additional 4.8% registered for the course as an elective in a science major. The remaining 32.2% either were completing an Associate of Arts degree or had not yet identified a major (Figure 1).

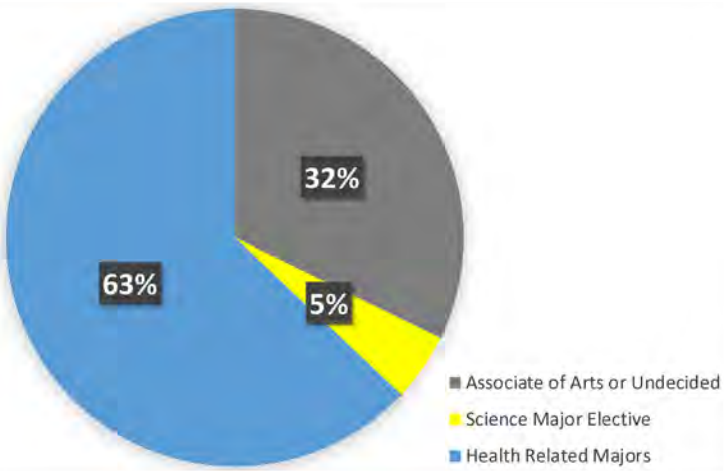

Figure 1. *The distribution of students participating in this study by major.*

The course consisted of two lecture sections, with approximately 48 students each, which were divided into two lab sections of approximately 24 people each (Figure 2). Each lecture section and its two corresponding labs were taught by the same instructor. Each lecture section met as a group for a total of 150 minutes per week, either for three 50-minute lecture periods or two 75-minute lecture periods. The lab sections met for an additional 160-minute laboratory session per week.

Peer instruction, a known effective teaching practice at CCs, was added to all lab sections. One lab from each section utilized SRS technology (referred to as clickers hereafter) and the other utilized a paper and pencil response (referred to as written response hereafter). The clicker sections consisted of 29 participants, 27 of which were female (93.1%) and two were male (6.9%). The average age was 24.4 years, with a range of 18–44. The written response sections consisted of

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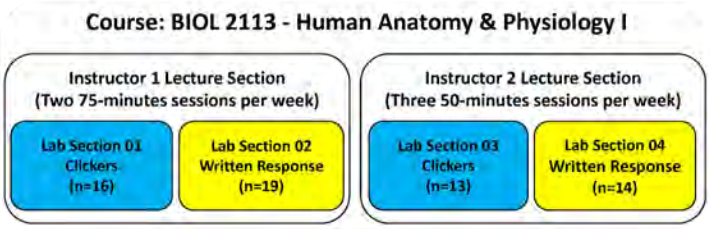

Figure 2. *The organization of students in this study.*

33 participants, 27 of which were female (81.8%) and six were male (18.2%). The average age was 25.7 years, with a range of 19-54 (Table 1).

At ARCC, faculty members have two options for SRS: a TurningPoint device provided by the information technology department or a mobile platform (e.g., Socrative, Kahoot). The TurningPoint device includes the "clicker" (for the student) and a receiver (for the instructor); a mobile platform allows students to respond using their own networked devices such as laptops, tablets, or smartphones. As our student population is socioeconomically diverse, we chose to provide clickers for the sake of fairness and equal access.

To ensure the same instructional conditions for all students, students in both the clicker and written response sections were presented with the same class materials and completed the same in-class activities and assignments prior to the experimental activities. By using the same experimental activity questions for both sections, any difference in unit exam score could be attributed to the effects of the SRS and

	Clickers	Written Response
Participants, n	29	33
Gender		
Female, n (%)	27 (93.1)	27 (81.8)
Male, n (%)	2 (6.9)	6 (18.2)
Age (years)		
Mean ± SD	24.4 ± 7.7	25.7 ± 8.9
Range	18 - 44	19 - 54

Table 1. *Demographics of the students in this study.*

not to the content addressed in the questions or merely to directing the student's attention to specific course content.

The students in each lab section self-selected into semester-long groups of three or four, depending on class size. Each individual student and each group in the clicker labs was assigned a uniquely labeled clicker for grading purposes. These students received clicker training prior to the first experimental activity to reduce anxiety regarding unfamiliar technology as well as to minimize user error.

Five experimental activities were conducted, one prior to each unit exam, throughout the semester. Each experimental activity consisted of five multiple-choice questions, similarly structured to those utilized in the lecture unit exams, pertaining to material covered in previous lectures (Figure 3).

A 65-year-old male, with a history of high blood pressure, presents with sudden, severe abdominal pain he describes as "sharp tearing or stabbing" in character. He complains of being lightheaded, has vomited twice in the last hour, and is sweating. A CT scan is ordered and an abdominal aortic aneurysm (AAA) is diagnosed.

The aorta is the major blood vessel that supplies blood to the body. It is about the thickness of a garden hose and runs from your heart through the center of your chest and abdomen. The aorta withstands high blood pressure as it directly receives blood ejected from the heart. The aorta must stretch or expand to accept this blood and then recoil or return to its original size, which continues to force the blood through the body.

An abdominal aortic aneurysm is a permanent localized dilatation (enlarged area) in the lower part of the aorta. If left untreated, the aortic wall continues to weaken and becomes unable to withstand the forces of the blood pressure. This results in progressive dilatation and rupture, which is a catastrophic event associated with a mortality of 50 – 80%.

Which component of the connective tissue of the aorta is most likely involved?

A) collagen fibers
B) elastic fibers
C) ground substance
D) reticular fibers

"Abdominal Aortic Aneurysm Location" by Bruce Blause is licensed under CC BY-SA 4.0

"Aneurysm Aorta With Arrows" by Bakerstmd is licensed under CC BY-SA 4.0

Figure 3*. An example of a PI question used in this study.*

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The students answered the questions individually, engaged in group discussion regarding the questions, and then answered the same questions as a group upon reaching a consensus. To ensure student participation and investment, the experimental activities were worth a total of 5% of the students' overall class score. Full credit was earned if the individual and group answers were correct, half credit was earned if either the individual or group answer was correct, and no credit was earned if neither the individual nor group answer was correct. This grading scheme was to encourage participation, presentation of arguments, and advocating for the right answer.

The students were given a maximum of three minutes to answer each question individually, and then a maximum of five minutes to answer as a group. Speaking was not allowed during the individual portion of the activity, and group discussion did not begin until all students had answered the question individually. The experimental activities typically lasted approximately 15 - 30 minutes.

The students in the written response sections recorded their individual and group answers on a paper answer form. The individual answer forms were visually examined to ensure that each student marked an answer before group discussion began. Following group discussion, a consensus response was recorded on the group answer form.

Like the written response sections, participants in the clicker sections answered the questions independently first; however, their anonymous responses were shown to the class as a histogram. Upon viewing the histogram, the students were allowed to discuss the questions with members of their group. Once a consensus was reached, a second response was submitted using the group clicker.

Subsequent to the completion of the five questions, all electronic and paper submissions were collected for grading at a later time. Instructors then reviewed each question with the class, explaining why each answer option was either correct or incorrect to ensure equivalent review and reinforcement of the material. Instructors utilized a common PowerPoint presentation to ensure consistent coverage of the material between lab sections. The review activities typically lasted approximately 15 - 30 minutes.

Each instructor's students, both clicker and written response sections, took identical multiple-choice unit exams during the same class period. The unit exam average scores of clicker and written response sections were then compared using the multivariate test (MANOVA). Demographic data and student grades were reported using descriptive statistics including mean and standard deviation.

This study was reviewed and deemed to be routine instructional research by the chair of the ARCC Institutional Review Board and was, therefore, exempt from IRB review.

Informed consent was obtained from all participants. All participants were 18 years of age or older and did not represent any known vulnerable populations.

Results

Unit exam scores of clicker vs. written response students were compared to determine if there was a relationship between clicker usage associated with the active learning exercises and increased performance on exams. The data collected from the clicker course sections and from the written response course sections were combined for this analysis (Figure 4). A MANOVA test revealed no significant differentiation between clicker and written response groups, $F<1$. Exam scores were also compared between the different instructors of the two lecture sections; these results indicated no differentiation, $F<1$ (Figure 5).

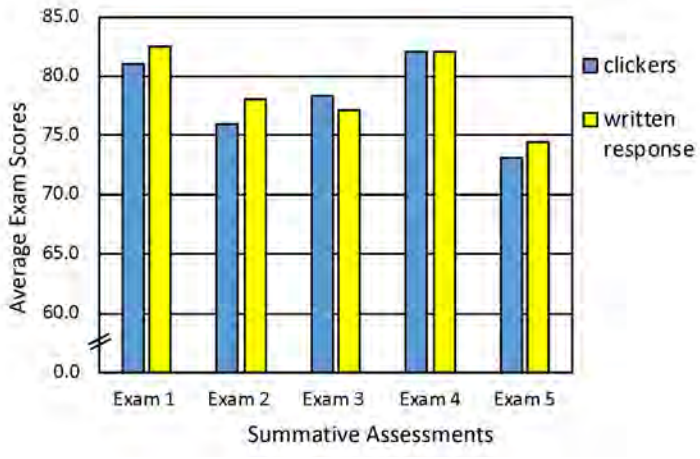

Figure 4. *Comparison of average exam scores by experimental method.*

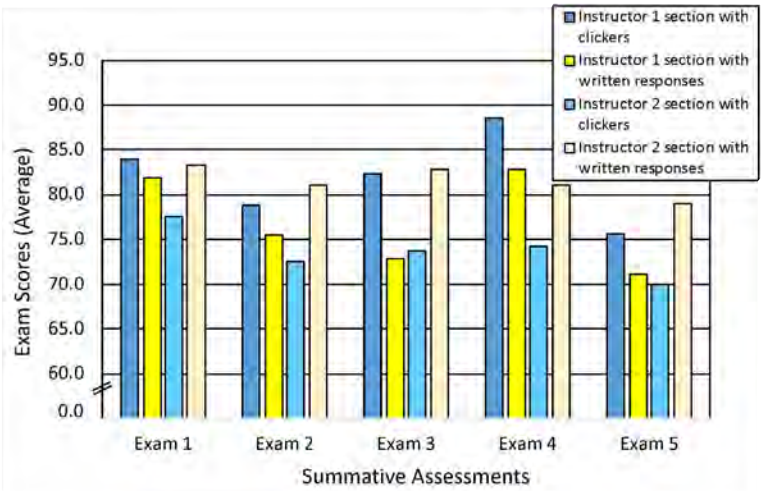

Figure 5. *Comparison of average exam scores by section.*

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Discussion

The primary mode of teaching in community colleges is traditional lecture or lecture utilizing PowerPoint (Smith and Valentine 2012). However, active modes of instruction have been shown to promote learning over traditional lecture (Freeman et al. 2014). Freeman et al. (2014) found that undergraduate students in classes utilizing traditional lecture were 1.5 times more likely to fail than students in classes employing active learning methods. Most studies concerning the use of active learning strategies and techniques have been primarily tested at four-year and research-based institutions. One exception, peer instruction, has been tried and shown to be effective at community colleges (Fagen et al. 2002; Lasry et al. 2008). For this reason, peer instruction was chosen to be the form of active learning to which clickers would be added for this research project.

The results of this study indicated that the students using the clickers did not receive any additional educational benefit when compared with students using the written response method. The lack of difference between the different instructors' lecture sections gave further credence to the conclusion that clickers, when utilized in this manner, do not produce an added benefit to active learning techniques.

Limitations

Since the efficacy of clickers has been supported in other environments (Freeman et al. 2007; Morling et al. 2008; Mayer et al. 2009), the authors propose several explanations for the lack of an increase in exam scores associated with the use of clickers in this project. First, this project had a small sample size, with only sixty-two participants ((N = 62, 29 with clickers and 33 written response). This may have had an impact on our results as it is well supported that a smaller sample size increases bias or at least undermines the reliability of one's conclusions. Second, this study may have used an ineffective implementation of clickers, as this was the authors' first foray into discipline-based educational research (DBER) and they were ignorant of the elements necessary to produce the beneficial effects of clickers. Thus, methodological flaws may have compromised the validity of this study's findings (Stains and Vickery 2017). Third, the use of peer instruction may have been so influential that it was not possible to see any additional beneficial effect from the clickers.

While the way in which clickers were implemented in this study was not found to be effective in positively influencing student scores, the differences between this study's findings and those of clicker studies conducted at four-year undergraduate institutions illustrates the importance of conducting research on the effectiveness of instructional tools, such as clickers, specifically within the CC environment.

Conclusions

The authors would like to offer the following insights for community college instructors interested in conducting educational research or adopting active learning into their courses. First, educational research does not require inventing novel methodology. Research conducted at four-year undergraduate institutions regarding the effectiveness of active learning instructional practices can also be conducted at community colleges. Furthermore, this research should be conducted at community colleges due to the unique student population. Second, active learning does not have to be expensive. The authors of this study used dormant instructional technology as well as pencil and paper. Third, adopting active learning in the classroom takes time, which can be taxing on the already heavy teaching load of a CC instructor. However, shifts toward active learning do not have to be incorporated into every class or all at once. Any change toward active learning may provide positive effects for your students.

About the Authors

Nancy Traiser Djerdjian and Shawn P. Magner teach Human Anatomy and Physiology I and II at Anoka-Ramsey Community College in Coon Rapids, Minnesota. They attended their first HAPS annual conference in 2019, and are members of year one (1) of the Community College Anatomy and Physiology Education Research (CAPER) Program.

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Back to TOC