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Evaluating the Effectiveness of Teaching Assistants in Active Learning Classrooms

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Active learning classrooms (ALCs) support teaching approaches that foster greater interaction and student engagement. However, a common challenge for instructors who teach in ALCs is to provide adequate assistance to students while implementing collaborative activities. This study examined the impact of teaching assistants in a large ALC. The results showed that incorporating teaching assistants increases students' access to expert advice during small group activities; further, students view the teaching assistants as supportive of their success in the classroom. Therefore, along with classroom design and pedagogical approach, availability of teaching assistants for instructors teaching in large ALCs must be considered.

Introduction

There is a large and growing body of research supporting the use of active-learning pedagogies to increase student learning, engagement, participation, attendance, social interdependence, and critical thinking (Freeman et al., 2014; Kim et al., 2013; Paulson, 1999; Slavin, 1996). According to Freeman (2014), "active learning engages students in the process of learning through activities and/or discussion in class, as opposed to passively listening to an expert. It emphasizes higher-order thinking and often involves group work" (p. 8413-8414). This approach contrasts with the traditional lecture method in which information is received passively. Active learning requires students to undertake tasks that invoke higher-order thinking, such as solving problems, writing, and having discussions. Active learning often utilizes a team-based approach where a deeper understanding of course content occurs. Although there is an abundance of evidence supporting active engagement, there are still barriers to widespread adoption of these teaching practices. Instructors often cite lack of time for redesigning the course, a decrease in course content, large class size, inadequate classroom space, and student resistance to non-lecture approaches as reasons for continuing with traditional, lecture-based instruction (Michael, 2007). Indeed, students perceive that they learn more in a traditional lecture setting when they actually learn more in an active engagement setting (Deslauriers, 2019). The negative correlation is due to the increased cognitive effort required in the active learning class. Instructors using student-centered pedagogies often need to spend time explaining the purpose and benefits of the alternate style of instruction.

Active Learning Classrooms (ALCs)

Over the past decade, higher education institutions have built new classrooms to overcome the barriers to active learning created by classroom design. Classroom space influences how instructors teach course content as well as how students and instructors act and relate to each other. Instructors can successfully engage students in collaborative exercises and peer instruction in traditional lecture halls with stationary seats (Deslauriers et al., 2011; Mazur 2009). However, these traditional classrooms were designed for a one-way transmission of information and restrict the possibilities for peer interaction and the ability of instructors to monitor the progress of groups. The design and layout of active learning classrooms (ALCs) break the traditional divide between teachers and learners (Baepler & Walker, 2014) and increase the interaction between faculty and students compared to traditional classrooms of similar size. ALCs typically arrange students around tables with a number of tools, such as whiteboards, projection systems for sharing group work on computers, and microphones, to facilitate collaboration and class discussion (see Figure 1). ALCs are designed to be student-centered, flexible in design, and technology-rich in affordances. Growing evidence

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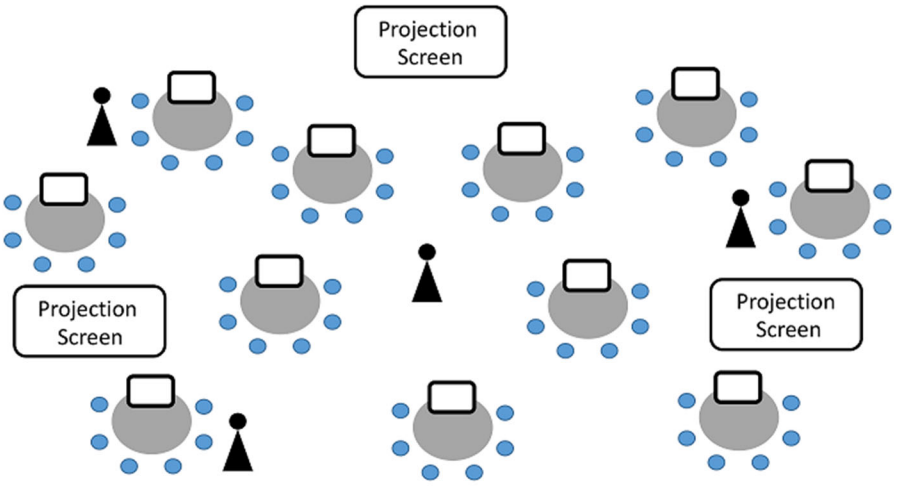
Figure 1. **A schematic of a large enrollment active learning classroom with several projection screens and tables with computers for group work. Instructors and teaching assistants are shown interspersed around the room facilitating small group activities.**



suggests that ALCs can enhance student learning in comparison to traditional classrooms (Brooks, 2011; Baepler et al., 2016). One study has shown that ALCs have an independent and statistically significant positive impact on student learning as measured by concept assessments and grades (Cotner et al., 2013).

While ALCs provide many opportunities, instructional barriers exist. Active learning spaces typically lack a central visual focal point compared to traditional lecture room environments. This arrangement forces the instructor to move around the room which at times causes the students' view of the instructor or projected materials to be obstructed. Since the physical layout of large ALCs impedes the ability of the instructor to provide a traditional one-way lecture to their students, classes must be modified to use the space and technology in the room effectively. However, the abundance of technology affordances in ALCs has been identified as distracting, overwhelming or wasteful (Peterson & Gorman, 2014). Additionally, the time required to address technology problems can reduce instructional time.

Teaching Assistants in Active Learning Classrooms

Another major challenge for instructors in ALCs is effective facilitation of student-centered exercises. Student groups must have adequate support for completing in-class activities and interacting with different groups may be particularly challenging in large enrollment classes. Ruder and Stanford (2018) suggested that the use of teaching assistants (TAs) during class time may be an effective strategy for providing a successful active learning experience to large groups of students. Additionally, the configuration of ALCs and the frequent use of active learning techniques may help to raise the visibility of TAs to more fully capture the advantages of their utilization. Teaching assistants in ALCs can facilitate both group work and the use of technology as well as answer questions about course concepts.

There is evidence that improved facilitation of small-group activities is necessary in ALCs. Although student-student relationships can have positive learning benefits (Pascarella & Terenzini, 2005), informal conversations can veer off topic and TAs can assist in keeping groups on task. Even if the instructor recaps the central concepts or provides the correct answers after an activity, small group discussion time may not be as productive without TA support. Furthermore, a strong negative relationship was found between student-student general relations and student learning outcomes (Baepler et al., 2016). Two hypotheses were proposed to explain this surprising result. In some cases, students may mislead one another on course concepts and students may be hesitant to criticize one another's ideas leading to overconfidence in knowledge. Using TAs to facilitate group work can direct conversation to key ideas and identify and correct misconceptions. It is critically important to properly train TAs to use guided inquiry and not simply provide answers to struggling student groups.

In general, the incorporation of TAs into courses can lead to greater student learning and performance (Crowe, Ceresola, & Silva, 2014). TAs are often viewed as the critical

link between professors and students by helping to eliminate barriers to understanding. TAs have the ability to explain the instructor's content to the students in new ways while communicating instances of confusion and lack of understanding to the professor from the student perspective. A TA can support both the students and the professor through enhanced communication and understanding of course material. Increasing the visibility of TAs in the classroom has the potential to "open students' minds to their own potential for contributing to the discovery and generation of knowledge" (Fingerson & Culler, 2001, p. 312).

In addition to the benefits for students taking the course, there is ample evidence that the TA experience can benefit TAs themselves by building their confidence levels, providing additional faculty mentoring, giving them new perspectives on what it means to be a student, placing them in leadership positions, and engaging them with the course content in new, deeper ways (Fingerson & Culley, 2001; Murray, 2015). To facilitate the acquisition of these skills and experiences, instructors should reflect on how to incorporate TAs into their courses so that the experience benefits both the students in the course and the TAs. To most effectively utilize TAs, instructors should solicit feedback from both the students in the course and the TAs.

Significance and contribution to knowledge about teaching in ALCs

Research on teaching in ALCs has primarily focused either on the faculty experience (e.g., Henshaw, Edwards, & Bagley, 2011; Peterson & Gorman, 2014) or on graduate TAs who are leading an independent discussion section (e.g., Chen et al., 2016), but has not examined how TAs in ALCs may facilitate learning alongside a faculty instructor. Other work has examined the traits that are important for the recruitment, training, and success of undergraduate and graduate TAs (Filz & Gurung, 2013; Moon et al., 2013), but this work has not considered how the classroom space and teaching approach may influence recruitment and training of the TAs.

In this study, we examined the impact of using TAs to facilitate student-centered pedagogical approaches in a large ALC. While the research study did not explicitly measure student learning, our data directly bear on the practices that support student learning, such as ensuring that the students are provided with the support and feedback needed to engage with in-class activities by encouraging a positive attitude towards the course content and discipline, and by peer modeling of collaborative learning (Chapin, Wiggings & Martin-Morris, 2014; Fingerson & Culley, 2001).

The courses involved in this research span departments and schools; thus, the cross-disciplinary nature of this work may produce findings that can be generalized for instructors teaching in the growing set of ALCs throughout higher education institutions. Our program of research aims to enhance the understanding of how to teach in an ALC by examining how using TAs can improve facilitation of classroom activities. In the first step toward achieving this goal, we examine the quantity and quality of teaching assistant to student interactions across multiple courses held within the same large ALC. Specifically, we addressed the following research questions:

(1) How much class time is spent doing active-learning exercises?
(2) How much time do instructors and TAs spend consulting with student groups?
(3) Do TAs increase access to expert advice during small group activities?
(4) Are student interactions with the TAs effective?
(5) Why do students find interactions with TAs to be helpful?

Method

To determine the quantity and quality of student and teaching assistant interactions, a mixed-methods design was utilized with both quantitative and qualitative methods. Three different courses, all taught in the same large active-learning classroom at a midwestern university, were included. The courses differed substantially in terms of both content and level but had similar student to TA ratios (see Table 1). Data collection included video recordings of class sessions and student surveys. Video recordings were analyzed for the types of interactions among students, teaching assistants, and instructors. The location of teaching assistants and instructors during the collaborative activities were documented and surveys were given to the students to determine perceptions of their interactions with the teaching assistants, both for specific class sessions and more broadly across the semester.

Table 1. Course characteristics

Course	Semesters offered	# of students	# of TAs	Student: TA ratio
Bioanalytical Chemistry	Spring 2017	60	5	12:1
	Spring 2018	44	5	9:1
Phonetics for Speech and Hearing Sciences	Spring 2017	42	3	14:1
	Fall 2017	54	4	14:1
Career Perspectives and Internship Preparation	Fall 2016	85	7	12:1

The classroom

The large active-learning classroom used in this study provides students with the opportunity to collaborate with one another at technology-enhanced tables (see Figure 2). The classroom has 16 tables with 6 chairs each, seating a maximum of 96 students. Each table has a computer screen and keyboard for group work, with additional laptop connections as well as a 'push to talk' microphone. The instructor lectern includes a computer with monitor, a document camera, laptop connections, wireless lavalier and handheld microphones, and a webcam. The classroom provides three touch-sensitive control panels that allow the instructor or teaching assistants to adjust audio and route video sources to any display in the room. There is a large 16 panel video wall and two additional projection screens. The multiple screens in different quadrants of the room are essential since students face different directions and there is not a central focal point for all students. In addition, there are document cameras and large white boards for each student table, which both facilitate student collaboration and sharing across student groups. The computers at student tables allow groups to share their work on the video wall (1, 4 or 16 groups simultaneously).

Courses

The study was conducted over four semesters (from Fall 2016 – Spring 2018). Three courses were included: a 300-level Bioanalytical Chemistry offered by the Chemistry Department, a 100-level Phonetics for Speech and Hearing Sciences offered by the Department of Speech and Hearing Sciences, and a 300-level Career Perspectives and Internship offered by the Department of Recreation, Park, and Tourism Studies. The specific semesters, enrollments, and student to TA ratios are shown in Table 1. All courses had similar student to TA ratios ranging from 9:1 to 14:1.

Video-based data collection

Across the courses, video recordings of 14 class sessions were obtained including classes from early, middle, and late portions of the semester. There were two video cameras mounted unobtrusively on either side of the video wall to enable video capture of the entire classroom space. These videos were time aligned and used to analyze two dimensions of activities: interactivity and location (see Table 2 for specific parameters). For each parameter within the two dimensions, the videos were coded at 30-second intervals. Each instructor provided a general lesson plan to the research assistant who coded the videos to help orient the video coder to the activities of the class.

Survey-based data collection

On each day in which the classes were videotaped, students completed a brief survey about their experiences in class that day. The broad goal of the survey was to evaluate student perceptions of the teaching assistants, in particular whether their interactions with the TAs facilitated

Figure 2. **A photograph of the large active learning classroom used in the study.**

completion of in-class activities. The surveys were administered anonymously via Qualtrics, an online survey platform that allows respondents to complete the surveys on any computer, tablet, or phone. For the questions and response options used in all classes and semesters of our study, see questions 1 – 3 in Appendix A. This survey was administered during the final 5 minutes of the class session. Response rates, based on the number of students in attendance during that specific class session, were between 42-81% across class sessions (average = 63%). This response rate suggests that the data provides a picture of student views that are representative of the students in the classes.

In addition to the questions based on single class sessions, students also completed an end-of-semester survey to reflect on their experiences throughout the semester, rather than only on specific class sessions. This survey was administered via Qualtrics in the first two semesters of the study (Fall 2016 and Spring 2017). Response rates were variable, and the sample size was not always large enough to accurately represent all students in the class. Response rates during this time ranged from 13% - 50%. Due to these generally low response rates, for the data collection in Fall 2017 and Spring 2018, the end-of-semester questions were moved to the University-sponsored course evaluation platform. This platform allows instructors to add six custom questions to the prepopulated questions required by the University and instructor's unit. The response rates in the next two semesters were much higher (76% and 57% in the two classes).

Table 2. Coding categories for video analysis

Interactivity	Location
Instructor or teaching assistant: • direct instruction • monitoring student activity • providing consultation to small groups • facilitating large group discussion • presenting content • no activity	*Instructor or teaching assistant:* • table location (1 - 16) • instructor station between tables
Students: • listening / taking notes / watching a video • individual activities • small group activities • whole class discussion	

Results and discussion

How much class time is spent doing active-learning exercises?

Videos were analyzed according to the categories for interactivity given in Table 2: whole class discussion, individual activities, listening/note taking/ watching a video, and small group activities. The analysis of this dimension shows the percent of class time spent using various pedagogical activities. In the 14 class sessions, the students were engaged in small group activities most often (average = 49%; range = 18 – 96%), followed by the listening-oriented engagement (average = 33%; range = 4 – 62%), individual activities (average = 12%; range = 0 – 35%) and whole class discussion (average = 6%; range = 0 – 31%) (Figure 3). It is not surprising that small group activities were most prevalent because students sit at tables in the active learning classroom, which is most conducive to small group discussion. Whole class discussion was the least prevalent, which is likely due to the large size of the room and lack of a central focus point. The variation in amount of time spent in listening-oriented engagement was most likely due to the nature of the course content and course level. Specifically, the Phonetics course included more listening-oriented time compared to the other two courses. This course is a 100-level course whereas the other two are 300-level courses. Therefore, the students in this course do not have a base of knowledge from introductory courses to draw from and need more time being introduced to new concepts before engaging in small group or individual activities. In terms of individual versus small group activities, there are

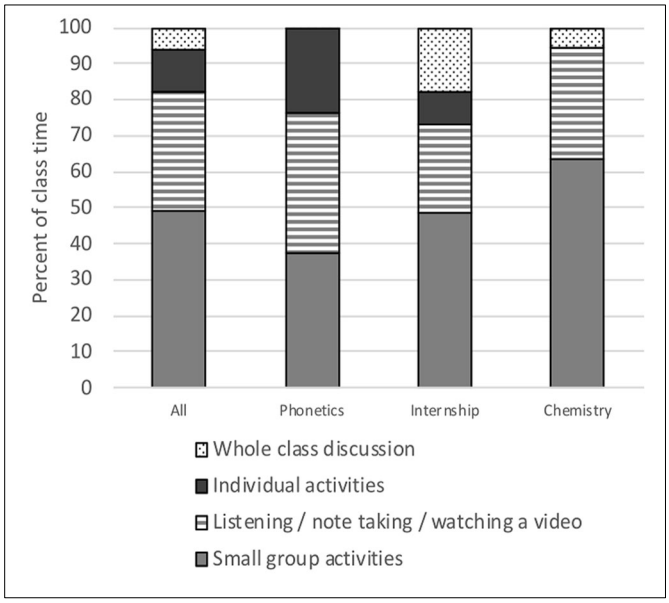


Figure 3. **Characterization of student activity.**

some types of activities in the phonetics course that lend themselves to being individually based (e.g., transcription listening exercises in which videos are presented and students transcribe the words phonetically).

This analysis broadly demonstrates that although students were engaged in more passive or listening-based pedagogical approaches for some class time, these courses took ample advantage of the room affordances and included active-learning approaches for 2/3rds of class time on average. It should also be noted that even with 1/3rd of class time spent listening, these segments tended to be distributed across the class sessions rather than being one long section in which students were more passive. The listening-oriented activities also included time in which the instructor went over the answers to individual or small group activities, showed video examples, or explained the instructions for an activity. Therefore, we expect that even in classes in which active-learning pedagogy is the focus, it is unlikely that any class would have 100% of the time spent in small-group or individual hands-on activities.

In addition to characterizing the amount of time spent in different types of activities, we also probed students' perception of the activities (small group and individual) through the Qualtrics surveys that were administered on days when class sessions were videotaped. This analysis allows for the contextualization of some of the following results as students may not need as much expert advice and support if they view the activities as being less challenging. Students responded about whether they believed that all the activities during that class session were challenging, some were challenging, or none were challenging. The results from this question show that overall students used the middle response category most often to indicate that some activities were challenging during that class session. These response distributions differed substantially across courses, however. In the phonetics and chemistry courses, students overwhelmingly indicated that some of the activities were challenging (76% and 86% of responses respectively) with substantially fewer students indicating that all activities were challenging (20% and 4% respectively) or no activities were challenging (4% and 10% respectively). In contrast, students in the internship course most frequently responded that none of the activities were difficult (61%).

How much time do instructors and TAs spend consulting with student groups?

The interactions between the instructor or TAs and the students were analyzed. For two of the categories of student activity, there were consistent roles for the instructor and TAs. That is, while students were engaged in listening-oriented activities, the instructor and/or TAs were typically providing direct instruction (e.g., lecturing) or presenting content (e.g., showing a video to demonstrate a concept). Similarly, during whole group discussion, the instructor and/or TAs were always facilitating the discussion. In contrast, the activities of the instructor and TAs varied considerably during the small group activities, suggesting

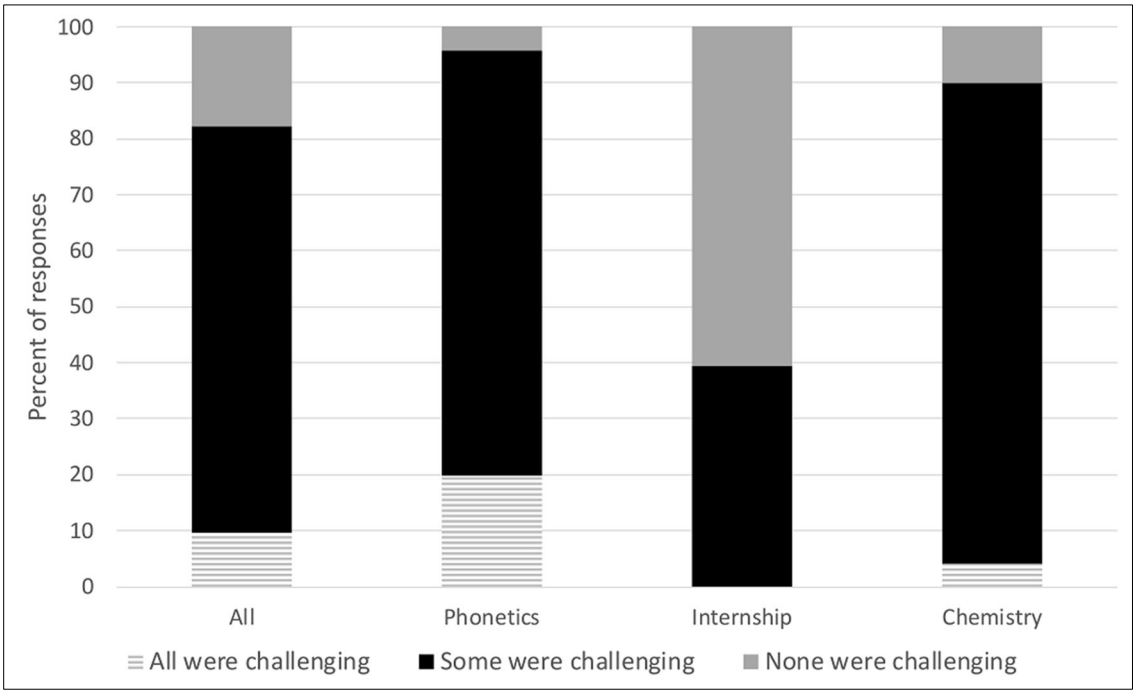


Figure 4. **Average ratings of the level of difficulty of activities for individual class sessions with the average for all courses as well as results for the specific courses.**

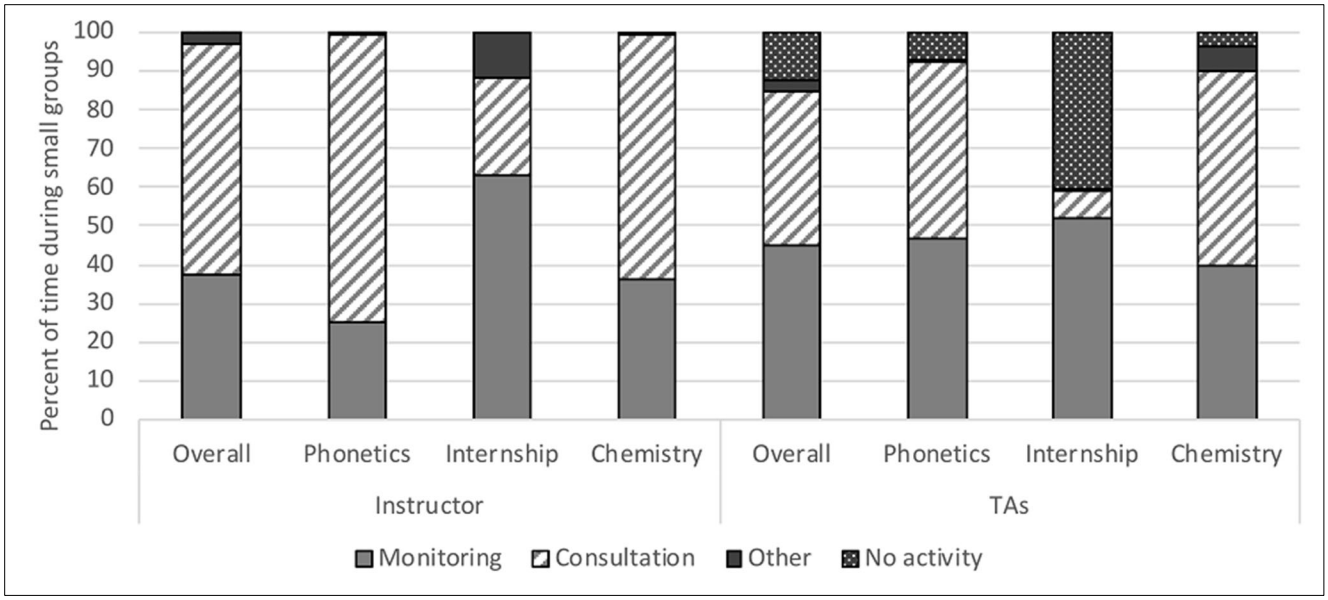


Figure 5. **Instructor and TA interactivity during small group activities.**

that this analysis would be a fruitful avenue for characterizing the ways in which TAs and instructors engage with the students. Furthermore, small group activities were included in all 14 class sessions, which provided a rich data set to analyze.

Overall, this analysis showed that both the instructor and TAs spent a substantial amount of time in consultation with the groups, although instructors generally spent a greater percentage of the time in direct consultation with the groups (average = 60%; range = 11 – 94%) than the TAs did (average = 40%; range = 2 – 72%) (see Figure 5). The instructors and TAs spent similar percentages of time monitoring, which involved walking around the room and observing the students as they worked on the exercises but not directly talking with the students (instructor: average = 37%, range = 6 – 73%; TAs: average = 45%, range = 21 – 69%). The instructors had very little time with no activity (average = 0.1%) or another activity (average = 2.7%). The TAs on the other hand did have some time during small group activities in which they were at the TA table and not engaging with students in the class (average = 12%) or engaged in another activity (average = 3%). Some inactivity by the TAs is to be expected due to the transitional period from direct instruction to small group activities. Whereas the instructor is typically already standing amidst the student tables when the small-group activities begin, the TAs are frequently seated at a table at the perimeter of the room during the lecture components.

Furthermore, differences across courses are also apparent in terms of TA activity. Specifically, in the internship course, the TAs were more frequently coded as “no activity”. The reason for this difference across courses is that some of the TAs in the internship course were developing educational resources during class time, which appeared on the videos as “no activity,” while other TAs were assigned to assist with small group activities. None of the TAs in the other two courses were tasked with development of resources during class time. Lastly, the level of challenge of the activities may also shape the extent to which instructors and TAs provide consultation versus monitoring the class. Both the instructor and the TAs in the phonetics and chemistry courses provided much more time consulting compared to the internship course. As was seen in Figure 4, the activities included in the phonetics and chemistry courses were also much more frequently rated as challenging. Therefore, students may need more hands-on support to successfully complete the activities in these courses compared to the internship course in which students may be able to complete the activities without facilitator intervention.

Do TAs increase access to expert advice during small group activities?

In addition to characterizing the amount of time the instructor and TAs spent in consultation with the small groups, we sought to characterize how instructor and TA engagement was distributed across the student groups through the use of location coding from the video analysis. To conduct this analysis, we first limited the analysis to time points that were coded as "small group activities" within the interactivity student parameter. From these portions of the classes, the instructors’ and the teaching assistants' locations were characterized as engaging with students at a specific table, walking between tables, or at the instructor station.

From there, the percent of time during the small group activities that the instructor was at each table was calculated. An additional analysis calculated the percentage of time that any of the teaching assistants or instructor were at each table. In these calculations, we did not note whether there was more than one instructor or TA at a table at a time, only whether a facilitator (instructor or TA) was present. The comparison of these two analyses gives a view into the extent to which incorporating teaching assistants into the large active-learning classroom provides students with additional expert support during small group activities. For the Spring 2018 chemistry course we were only able to analyze the movement data for one class session because one of the cameras was not operational for one class session.

Location of instructors and TAs during small-group activities

These analyses showed that, as expected, teaching assistants greatly increase the amount of support provided to students during activities. During small group activities, on average, each group consulted with the course instructor 7.7% of the time in the phonetics classes (range = 0 - 20.2% across tables), 4.5% of the time in the chemistry classes (range = 0 – 12.3% across tables), and 1.9% in the internship classes (range = 0 – 7.9% across tables). For the analysis in which support for any facilitator (course instructor or TA) was incorporated, groups received support for nearly a quarter of the time during small group activities in the phonetics classes (average = 23.3%; range = 4.1 - 57.1% across tables), with similar results for the chemistry classes (average = 24.5%; range = 6.9 - 54.7%), and substantially lower percentages for the internship classes (average = 5.5%; range = 0.8 - 16%).

To visualize these patterns within the context of the physical space, we created heatmaps of the locations of the instructor as well as the instructor and teaching assistants (Figures 6A-6F; see Appendix B). In these heatmaps, the percentage of time during the small group activities during which a facilitator (instructor or TA) was present was displayed in a yellow to red color scale. The amount of red saturation indicates the percentage of time there is a facilitator present at each table. The tables in pure yellow received no support and tables with full red saturation had support at least 50% of the time. The gradations of orange represent values between 0 and 50%.

The overall location analysis and example heatmaps clearly demonstrate that the inclusion of TAs in these classrooms increases student access to expert advice during small group activities. With only the instructor available to engage with students during these times, a number of tables received no support. With the inclusion of TAs, most tables had an expert available to answer questions about the activity, clarify instructions, explain concepts, guide students back to the activity who were engaged in off-topic discussion, or point out areas in which students needed to revisit their work. Of course, this analysis does not allow us to specifically determine which of these types of communications were happening during the times at which instructors or TAs were talking with student groups. Although the video cameras used in their study did record sound, the sound level and quality did not allow for an analysis of specific conversation types. This issue could be explored in future research.

Are student interactions with the TAs effective?

The video analysis allowed for the determination of the quantity of interactions among the facilitators and the students but does not provide a view into whether the inclusion of TAs into these courses was facilitative for student learning. To begin to answer the question of whether these interactions are effective, the results for the Qualtrics surveys were analyzed. Although these results do not show whether the inclusion of TAs directly impacts learning outcomes, these data provide a window into students' perceptions of TAs' effectiveness (Figures 7 and 8). This analysis included two questions specifically about the TAs: whether TAs were able to guide students to the answer without giving them the answer and whether TAs were effective in helping students move forward with the task. It should be noted here that in the first semester of the study during which the internship course was offered, the response option of "I did not interact with an TA today" was not provided. Therefore, some of the responses for that course of "never" may have been indicative of lack of interaction with the TA rather than the TA's unhelpfulness. The earlier analyses regarding location also support this interpretation.

The data from these two questions show that students perceive the TAs to be helpful in completing course exercises. Students overwhelmingly responded that the TAs were able to support them during in-class activities by guiding them to answers and moving forward with the task either all or most of the time. Putting together these responses with the location data from the video analyses shows that not only does the inclusion of TAs provided more time with an expert, but the TAs are viewed positively by students. Again, we cannot provide evidence that these interactions ultimately led to increases in student learning. A different design in which classes were held with and without TAs would be needed to definitely address the impact of inclusion of TAs on student learning. However, these data suggest that TAs are an important component to supporting students during an active-learning class, a pedagogical approach that has been shown to facilitate

student learning. Since the optimum ratio of facilitator to student ratio is likely to vary across course content, course level, and amount of student background knowledge, among other factors, we recommend using the survey questions in Appendix A to assess whether students are receiving adequate support during in-class activities.

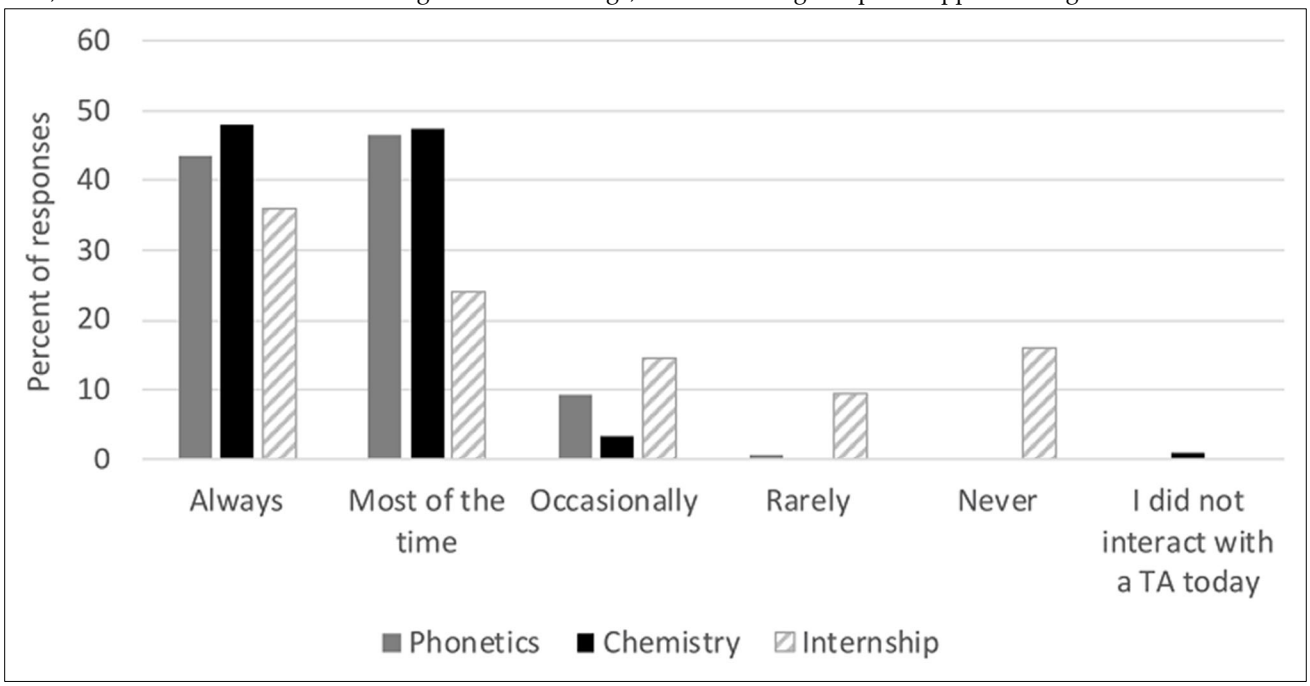


Figure 7. **Student ratings of how often the TAs were able to guide them to the answer without giving them the answer**

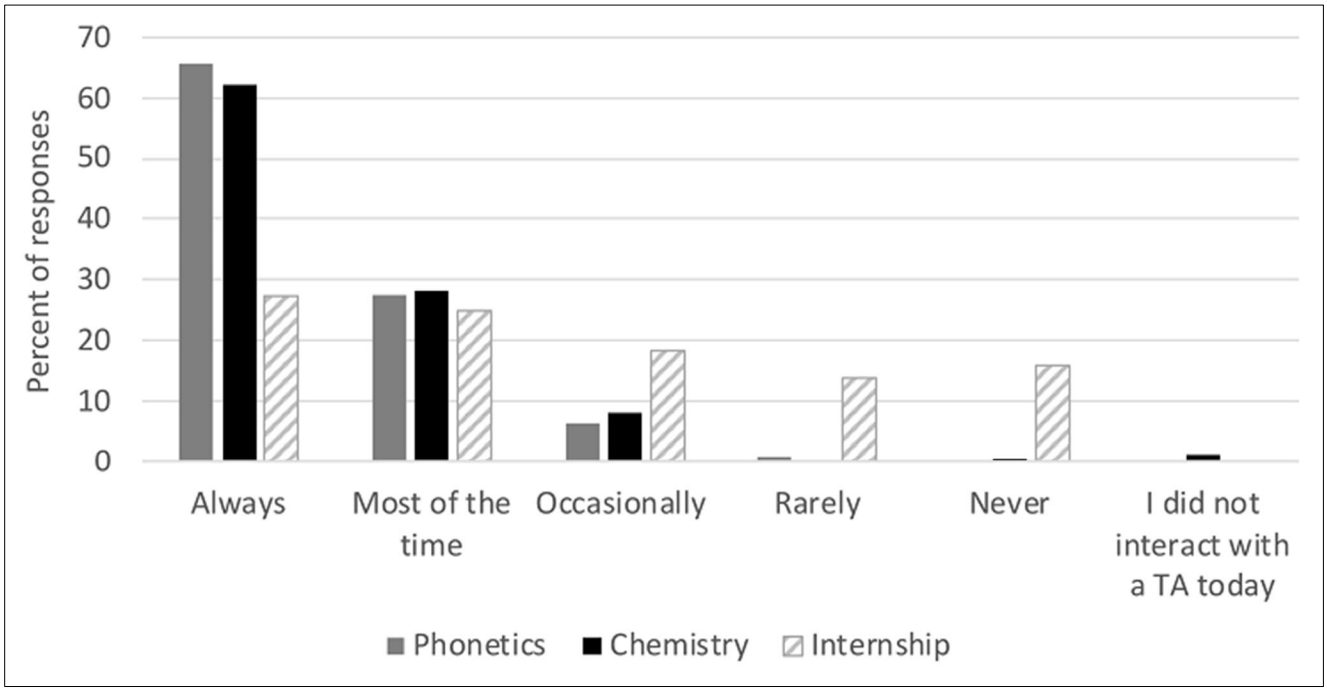


Figure 8. **Student ratings of how often their interactions with a TA allowed them to move forward with the task**

Table 3. Student identified benefits for having teaching assistants in their courses.		
Theme	**Example quote (edited only for punctuation)**	**Percent of comments including theme**
Someone else to answer questions (including answering questions more quickly)	In a class that large, it would have been much more difficult to get help if the instructor was the only person available. Having a TA made it easy to find assistance in a timely manner.	74.5
More individualized support (1-on-1)	You get more one-on-one help.	7.1
Different perspectives or ways of explaining concepts	A different perspective if something is hard to understand.	5.7
Made class operate more smoothly	Help facilitate class.	4.3
More thorough explanations of concepts	They were useful in explaining some of the course concepts in a more detailed way.	3.5
Holding additional office hours	Teaching assistants have more availability with office hours.	3.5
Providing student perspective	They went through the course themselves, so they understand what parts of the course are tricky or hard to figure out.	3.5
Feedback on assignments	They could help if we didn't know the assignment instructions.	3.5
Knowledgeable about class topics	They have taken the course, so they know the material well.	3.5
Assistance with administrative tasks	Handing out papers, making things more efficient in terms of timing.	2.8
Other	(1) Helping Julia with the damned technology room. (2) He was able to guide us through questions without giving away the answer	5.7

Why do students find interactions with TAs to be helpful?

At the end of the semester, through the use of the survey described above, students were asked to identify the benefits of having teaching assistants in their course. We conducted a thematic analysis on the responses to this open-ended question. There were 141 students who provided comments across all classes and semesters that we entered into the analysis. Two of the authors independently identified themes in the responses. We then compared our themes and determined a set of 13 themes that captured the vast majority of student responses. After determining the themes, we independently coded each student response for the presence of one or more of the themes. There was inter-rater agreement on 93% of the comments. For the 7% for which there was disagreement, most involved multiple codes (8/10); the two raters met and came to a consensus on which code(s) to use. Most of the comments included only one theme, but 25 included two or three themes. There were only two students who provided comments and could not identify any benefits writing, "*Nothing*" and "*I didn't see any benefits*". Two of the identified themes only included one or two comments fitting the theme; therefore, we moved those three comments to the "other" category and were left with 11 final themes. The themes, an example of each and the percentage of comments fitting with each code can be seen in Table 3. This final set of themes accounted for 94.3% of the data.

By far the most prevalent theme was "someone else to answer questions." The majority of students reference this theme in their comments (74.5%). Thus, from the student perspective, having teaching assistants allowed them to get answers more quickly. Another example of this theme was a student who identified timely feedback on questions as important: "They answered questions and concepts immediately in class which saved me time during homework and studying." The next set of most prevalent themes are related to having someone to answer questions but were more specific in terms of the perceived types of support. These themes included getting more individualized support (7.1%) and different perspectives or ways of explaining concepts (5.7%) as well as a few students who specifically noted that the teaching assistants could provide more thorough explanations (3.5%). Therefore, as a whole, most students saw concrete benefits to having the teaching assistants in the class and the benefits were related to facilitating learning of course content rather than more administrative benefits.

Conclusion

This study suggests that in large active learning classrooms, students are likely to receive inadequate support during small group activities if teaching assistants are not incorporated into the courses. In classes ranging from 42 to 85 students, instructors spent much of their time during small group activities engaging with students, but many groups received little to no instructor support. In the analysis of amount of support when the teaching assistants were added, the picture changes, showing that most student groups had access to expert advice for at a least a portion of the time they were engaged in small-group activities. Furthermore, students overwhelmingly indicated that the teaching assistants were beneficial both in their assessments of the course overall as well as in responses about group work during specific class sessions. Of course, many factors will influence the extent to which students need support during in-class work, including students' level of background knowledge and the difficulty of the activities. Instructors who do not receive support from teaching assistants may simply choose not to include as much active learning in their classes, but without the incorporation of these active-learning pedagogies, the central purpose of these active-learning classrooms cannot be met. Therefore, the decision-makers at institutions of higher learning should recognize that a successful move towards active-learning pedagogies requires not just instructor training and building of spaces to facilitate these pedagogies, but also investment in resources for providing instructors with properly trained teaching assistants. From our experiences, teaching assistants can be either at the graduate or undergraduate level, but the inclusion of TAs in these spaces is an essential element for a successful course. Furthermore, the inclusion of teaching assistants, particularly those at the undergraduate level, can provide benefits not only to students taking the courses but to the teaching assistants themselves. The TAs in our classes report deeper understanding of course content and improved communication and time management skills.

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Appendix A

Survey question for individual class sessions and end of semester questionnaire. Questions 1 – 3 related to specific class sessions and questions 4 – 9 were used in the end of the semester questionnaires. For questions 5 – 9, the response scale was from strongly agree to strongly disagree.

1. Classify the level of difficulty of the activities today:
    a. All were challenging
    b. Some were challenging
    c. None were challenging
2. How often were the TAs able to guide you to the answer without giving you the answer?
    a. Always
    b. Most of the time
    c. Occasionally
    d. Rarely
    e. Never
    f. I did not interact with a TA today
3. How often did the interactions with a TA allow you to move forward the with task?
    a. Always
    b. Most of the time
    c. Occasionally
    d. Rarely
    e. Never
    f. I did not interact with a TA today
4. What are the benefits of having teaching assistants in this course? (open ended)
5. My interactions with the teaching assistants increased my understanding of the subject.
6. The in-class group activities were effective in facilitating my understanding of course concepts.
7. There was sufficient support from the teaching assistants and instructor during small group activities.
8. The teaching assistants were knowledgeable on the course topics.
9. I was able to solve problems with my group that I would not have been able to answer on my own.

Appendix B

Figures 6A-6F. Comparison of student-instructor consultation times with and without TAs. Example heatmaps for one internship class session (A and B), one chemistry class session (C and D), and one phonetics class session (E and F). Heatmaps A, C, and E display the percentage of time each table had a facilitator (TA and/or instructor) during small group activities. Heatmaps B, D, and F indicate percentage of time for the course instructor only. The greater the red saturation the more time is indicated. Tables in gray did not have students seated at them.

Figure 6A.

Figure 6B.

Figure 6C.

Figure 6D.

Figure 6E.

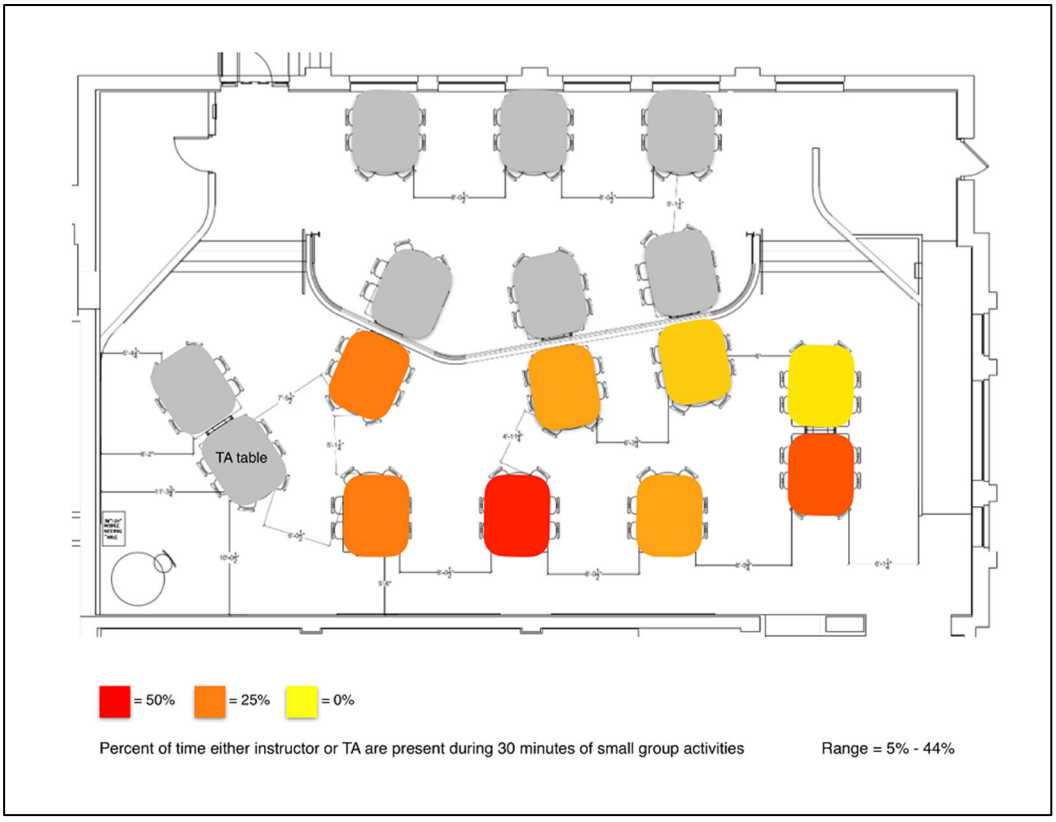

Figure 6F.