Graduate Student Perceptions of Community Building as a Precursor to Active Learning

Dr. Sarah A. Goodman, Stevens Institute of Technology

Sarah A. Goodman is a Teaching Assistant Professor in the Department of Chemical Engineering and Materials Science at Stevens Institute of Technology. Her research interests include the use of active learning in graduate courses, the use of virtual reality to teach crystal structure, and helping students develop a sense of community and belonging in the field of engineering. Prof. Goodman has experience teaching 4th, 11th, and 12th grade science, and has worked for two science education nonprofits.

Emily L. Atieh, Stevens Institute of Technology

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Abstract:

Active learning is widely understood to improve student outcomes, yet many active learning implementation efforts are focused only on undergraduate courses [1], [2], [3]. Factors that may inhibit active learning implementation in graduate courses include the belief that "rigor" and lecturing should go hand-in-hand in higher level courses, or a lack of community building more commonly seen in undergraduate programs. Here, we present an exploratory study that uses a focus group to examine the opinions of five students regarding the relationship between community building, trust, and active learning in a graduate Structure and Diffraction course in a Materials Science and Engineering program at Stevens Institute of Technology. Three central community building techniques were implemented throughout the course: a) the incorporation of a mid-class snack break, b) an optional weekend museum field trip, and c) the use of game-based student response systems such as *Kahoot!* and *PollEverywhere*. Active learning strategies such as small-group problem solving, hands-on instrument demonstrations, and student presentations were carried out in class, many of which also doubled as opportunities for students to build community.

Overall, students found the approachability of the professor to be a critical factor that promoted trust and community in the classroom, more so than any of the strategies that had been specifically introduced for the purposes of community building. Students responded enthusiastically to the instrument demonstrations and field trip in terms of the contribution to their content knowledge. In fact, content knowledge seemed to be at the forefront of students' responses; each time a community-building strategy was discussed, students shared how this strategy impacted their knowledge of the course content.

Introduction:

Recent decades in higher education have witnessed a paradigm shift in educational modalities, slowly transitioning from instructor-centered methods to student-centered methods, or active learning, wherein students become the protagonists of their own education. The advantages of employing strategies that allow students to become actively engaged in class and build their own understanding of the material are manifold; the use of active learning has been demonstrated to improve student outcomes [4], [5], [6], improve attendance [5], narrow achievement gaps for students from groups historically underrepresented in the STEM fields [7], [8], and decrease student anxiety when implemented in a low-stakes manner and when students are afforded the opportunity to choose their own groups [9], among other benefits [10].

Despite these advantages that span across subject matter and grade level, many active learning efforts are focused solely on undergraduate courses rather than graduate courses, and a 2018 study by Stains et al. found that lecturing is still the predominant instructional modality in North American universities [1], [2], [3], [11]. Implementation of active learning does not come without barriers, such as student hesitation and resistance to participating in class. For example, Hood et al. found that individual differences in students' levels of social anxiety and self-efficacy

impacted their course participation and perception of the educational value of some active learning practices [12]. Other studies have identified gender gaps in levels of participation in college classrooms, citing stereotype threat as a possible explanation for this [13], [14]. Lemelin et al. discuss how community building can lead to increased student resilience, which can in turn reduce student resistance to active learning [15]. Zumbrunn et al. found that when students perceived the classroom environment to be supportive, their in-class engagement increased [16]. Moreira et al. demonstrated that community building in the form of events, retreats, and online discussions contributed to the retention and positive career outcomes for students from groups historically minoritized in STEM [17]. Active learning can itself contribute to students' sense of community, as evidenced by Parrish et al.'s 2021 study which found that team-based learning furthered students' sense of community in both online and face-to-face settings [18].

Here, we implement community-building strategies in a graduate Structure and Diffraction course to investigate the impact of students' sense of community on their perceptions of active learning. Out of the many strategies to improve student buy-in for active learning, we focus on community building here because of the well-documented feelings of social isolation among graduate students, both pre- and post-COVID [19], [20], [21], [22], [23].

Methods:

This study was conducted in a graduate Structure and Diffraction course at Stevens Institute of Technology in Hoboken, NJ. Students in the Materials Science Masters and PhD program at this university have the option of taking Structure and Diffraction as one of their core requirements. Structure and Diffraction teaches the structure of crystalline materials and the experimental methods utilized to determine these structures. The Fall 2023 cohort of Structure and Diffraction in which this study was conducted consisted of five students: two PhD students and three Masters students, all in the field of materials science and engineering or closely related disciplines. The course met for one 2.5-hour session per week for fifteen weeks.

During the first half of the semester, about 50-75% of class time was spent in an instructor-centered modality in which the instructor lectured using slides or demonstrated example problems. The remaining class time was devoted to student-centered modalities of instruction, referred to here as active learning, in which students used game-based student response systems (GSRSs) to answer questions individually, solved problems in groups, or utilized 3D models for spatial visualization of crystal structures.

In the second half of the semester, about 75-100% of class time was devoted to active learning, in which students worked together to solve case studies using experimental data, solve practice problems, participated in lab demonstrations, and gave presentations on relevant literature. In the lab demonstrations, students observed the operation of an X-ray diffractometer, and both observed and used a Transmission Electron Microscope (TEM) for imaging and diffraction. This was not a lab course; the focus was on theory rather than experimentation, so the demonstrations were meant to provide additional context behind the principles learned in class.

Throughout the semester, various strategies were employed to create a sense of community among the class, with the goal of helping students to feel more comfortable participating in

active learning. These strategies included the use of GSRSs such as *Kahoot!* and *PollEverywhere*, an optional weekend field trip to the Hall of Gems and Minerals at the American Museum of Natural History in New York City, and a mid-class snack break during which the instructor provided food. Students from both Structure and Diffraction and an undergraduate course were invited on the field trip, and two out of five Structure and Diffraction students attended the trip. The cost of the trip was covered by the school.

Our past work surveyed the Fall 2022 cohort (N= 13) of Structure and Diffraction that was run in a similar format to gauge the impact of community building activities on student willingness to participate in active learning [24]. The students felt that the class field trip improved their sense of community, but they did not express these same sentiments about the mid-class snack break. Further, the majority felt that the GSRSs improved their sense of community and increased their willingness to participate in class discussions.

Although these survey results were helpful for understanding the impact of these active learning strategies on a larger scale, the smaller size of the Fall 2023 cohort enabled us to use a more open-ended format to dig deeper into students' thought processes. As such, we held a focus group to understand their perceptions of the following:

Overall experience with active learning: What expectations do students have surrounding active learning in graduate courses? What factors impact whether students are willing to engage in active learning?

Sense of community: What strategies employed in the course did students feel contributed to a sense of trust and community? Do students feel that having a sense of community within the class is important for active learning to take place?

GSRSs: Did the use of GSRSs at the beginning of the class period increase students' likelihood of speaking up later on in class? Did these exercises help students to feel more confident in their knowledge of the course content?

Student-directed activities: Did students feel comfortable participating in case-studies, problem-solving sessions, and presentations? Was there anything that could have been done to make students feel more comfortable participating?

The focus group was conducted in the last 40 minutes of the last class period of the semester, after students had finished their final presentations. The focus group was led by co-author Emily Atieh, who was not affiliated with the course, using the above questions as a guide. Upon obtaining written consent from students, the focus group was audio-recorded and transcribed using the online automatic transcription service Temi.[25] The five participants' names were removed and instead labeled A-E. The instructor was not present for the focus group and was only given access to the de-identified transcripts after all final grades were submitted. The quotes presented here from the focus group were edited to remove repeated or filler words such as "uh" or "um," but have been reviewed by both authors to check that each quote's overall meaning was unchanged. Colloquial language and grammatical errors were retained. IRB approval was obtained for the focus group.

Results:

Herein we present several key findings observed from our focus group. It is critical to note that the level of participation varied across individuals and not all participants chose to answer each question, though they had the opportunity to do so if desired. For each theme examined below, we will include the responses of all participants who provided input.

Student expectations surrounding active learning

To identify of students' understanding and perceptions of the term "active learning," students were first asked the following:

a) Do you know what active learning is?
b) What kinds of expectations, if any, do you have about active learning in graduate courses?
c) Are there any expectations that you have about active learning in this class?

Four of the five students (A, B, C, and E) stated that they had never heard of the term active learning and did not initially have any ideas as to what it might mean. However, after a moment, Student B suggested that active learning could mean "student centered or reverse learning," and Student A offered that active learning could mean "facilitating classroom discussion in an active manner," and "giving students a chance to interact and answer questions and come up with questions of their own." The interviewer confirmed these ideas and emphasized the centrality of student input and autonomy in active learning. Student D, who had not yet spoken, then asked if active learning could be defined as "communication between the student in the class and the teacher." This exchange suggests that students had only murky or partial understandings of active learning as a construct.

When asked about expectations surrounding active learning in graduate courses in general, Student A indicated that it should be a "big part," given the small course size and the diversity of experiences graduate students bring:

> *We're here for our understanding of the subject material in the class, and the best way to do that is to have conversation with the teacher because we are not completely new to this material. We have experiences, education, training, jobs. It's good [to] have a collaborative learning environment where everybody learns from everybody.*

In contrast, Student C said that it depended on the type of course, and that a heavily theoretical course may not offer much room for students to share ideas. However, they added that the applicable nature of Structure and Diffraction – and other engineering courses – made active learning suitable. Student B suggested that for certain topics, such as those that required three-dimensional thinking (e.g., symmetry), it was useful to be able to have a discussion.

Student D agreed with Student A, adding that they thought active learning was important for this course because each student was coming from a different background and could provide a unique perspective. Still, students' views differed on the level of active learning they expected to take place in this course. Despite their earlier statement, Student D indicated that they would have

liked for active learning to comprise only a small portion of total class time, saying “I would prefer that 80-90% of the time the professor talks, so that we can learn more from [their] knowledge.” Student A disagreed, arguing that “we have experiences of our own. I think that you can get more knowledge out of a discussion rather than just having somebody talk at you.” Later in the discussion, Student D brought up benefits of active learning, such as the utility of GSRSs in recalling knowledge from previous class periods, and the applicability of the field trip to understanding the applications of diffraction. Students B, C, and E also discussed the idea that more of the course could have been spent on lab content and reviewing homework problems.

Factors that impact student participation during active learning

Following the discussion on expectations surrounding active learning, students were asked to identify specific factors that impacted their willingness to participate in active learning. Student E quickly replied that class size played a major role in their comfort to participate. When probed further on that point, they brought up another course that they took with the same instructor, which saw an enrollment of >100 students. In that class, they insisted they would never speak up, attributing their hesitation to their anxiety about speaking in front of large groups. In contrast, they clarified “But here, with like, five people that I actually know, I have no problem like, talking.” Interestingly, Student A also credited their eagerness to participate to the course’s small size, but took a different approach:

> *I completely agree with [Student E]. I think it's class size. But I specifically think it's class size because it's, it's hard, right, if everybody wants to talk to a teacher in a hundred-person class, it's just not possible. For us, for a five-person class, it is very possible.*

Notably, both Student E and A seemingly equated active learning with speaking in front the whole class, rather than considering the other formats that might afford them the more intimate active learning environment they sought (e.g., small group activities). When reminded of the many formats by the interviewer, Student C chimed in with their own experiences of working in small groups within a large class. This class had multiple teaching assistants (TAs) to facilitate the group work, and Student C said they felt “very lucky, my TA is a very good one.” When asked if the professor or TA matters in these types of settings, Student C replied simply that they should be “someone that can answer my question.”

Taking the question in a different direction, Student D focused instead on their own confidence with the content:

> *For me, I like to participate in active learning if I have a good command on the subject. If I understand the subject well, and then if I think I can contribute to it, then I can participate in active learning. But if I could not get the topic very well and I have very, less knowledge about it, or no knowledge, then I would not prefer to participate in active learning.*

Strategies to promote community and student engagement

Several strategies were implemented in the course with the aim of creating a sense of community such that students would feel a sense of trust among their classmates. We postulate that these feelings of community and trust would lower the barrier for students to participate in active learning. The community-building strategies included the incorporation of a mid-class snack break, an optional weekend field trip to a museum, and the use of GSRSs. Before disclosing these motivations for the activities, the interviewer asked the students to offer their perspective on which aspects of the course contributed to their sense of community. Student E brought up activities in which the class broke into two groups to work though problems. They said that this "helped because some person might understand a certain piece of it you don't understand." Student D brought up the fact that the professor asked each student to meet with them during office hours, as part of the first homework assignment. Student D thought that assignment was "beneficial to get more used to the course and to participate in the course." Students E and A agreed. Student B added, "we know where the office of the professor [was] located so we can easily access [them]". Student C expressed further agreement, stating that it was important that they "actually knew where to find [the professor]."

Students were then asked to comment specifically on the impact of the mid-class snack breaks, instrument demonstrations, and museum trip on their sense of trust and community in the course. The snack break and museum trip garnered the least amount of discussion about community. Instead, the mention of the snack break prompted a discussion about how students would rather have the course meet on two different days of the week for a shorter amount of time, rather than meeting for one long block and needing to break in the middle. Students did not provide further comments on the efficacy of the snack break for creating community. Student D indicated that they appreciated the museum trip and that it was something different than was offered in other courses. The instrument demonstrations were perceived positively in terms of helping students to build knowledge. Students A and E explained that seeing the equipment in operation helped them to understand how the instruments work.

> *That really gives you an idea, I mean, of how these things work in the field and what processes you need to go through physically. It's one thing to just sit there and learn about it, but it's another thing to actually go there and experience it. And I think that helps you connect the dots more.* [Student A]

While students believed that the demonstrations contributed to their learning of the course content, students had no comment on the implications for building trust and community.

Students were then asked about the utility of GSRSs for community building, including whether these games made students more willing to speak up later on in class, and whether they helped students to become more confident in their knowledge of the course material. Student D reported that the GSRSs were helpful for recalling previous knowledge, which they felt enabled them to better communicate during class, and Student B felt they could potentially initiate conversation and therefore help increase participation. Student C felt that although these games were a good way to review content, they did not like this strategy due to negative experiences with other

courses. Student E thought the immediate feedback from these questions was helpful, but when asked whether the feedback made them more likely to speak up later in class, they instead insisted "it's just like a knowledge check for me". Student A agreed, offering that the GSRSs were helpful as a self-check and to get back on track if someone did not understand the material. Importantly, however, Students A, B, and E agreed that the GSRSs made them feel more confident in their knowledge of the material largely because these activities were low-stakes and ungraded. Speaking more generally, Student B also cautioned that *Kahoot!* in particular could have detrimental effects on students' confidence due to the possibility of students entering their name into the quiz. After each question, the quiz displays a ranking of the top students in the class. However, in the present course, it was not required for students to enter their real names.

Student comfort levels with class participation

Finally, students were asked to comment on activities that required the most active participation on their part: analyzing experimental data as part of various case studies, solving practice problems in small groups during class, and giving presentations based on papers relevant to crystal structure. Students were asked to comment on the extent to which they felt comfortable participating in these activities, and whether anything could have been done to make them feel more comfortable participating. All five students indicated that they were comfortable participating in the case studies based on the fact that the instructor clearly explained how to analyze the data. Student D suggested that their comfort with participation aligned with their confidence in their knowledge:

> *If we don't know how to do it, then I think it is not comfortable to participate in.*

Student C agreed, and added that the case studies were in line with what they had been learning in the course:

> *If we can really use our knowledge in that case, I would say it makes me feel very happy.*

Student A spoke about solving practice problems in groups, indicating that it was a low-stakes way to practice content and it gave students the creativity to develop their own unique solution to a problem. Students D and E felt that it was uncomfortable for them when they were not able to solve some of the problems, but they overall thought that the problem-solving was a positive learning experience. Student E commented that although it was low-stakes, "it was still uncomfortable though, because I couldn't solve one, and I was like, I'm so dumb, I can't figure this out." This student clarified that this feeling was internal, and not imposed by the instructor or peers.

In terms of the literature presentations, Student A expressed that they did not feel comfortable, due to their perceived misalignment of this activity with their career goals:

> *The presentations, like we did a very academia-focused, like research-focused. At least for myself, I'm not too interested in that. I don't see, I don't think there's as much value, at least for me. Maybe perhaps for someone else, sure. But for me, I didn't think there was that much value.*

Student D indicated that the presentation was a good experience because it was directly related to their research work. However, they agreed with Student A that their comfort in this activity was tied to the applicability to their research:

> *But if the topic was different as my research, then I think I will not be comfortable in doing this.*

Student B felt that giving the presentation was a "different experience and I liked that was like back to the future, like how the research is conducted 30 years ago."

Building trust as a means to learning via increased participation

Having established what did and did not contribute to students' sense of community, students were then asked if they felt that having this sense of trust and community played a role in their decision to participate in the class. Student A began by saying that trust in the professor – via their accessibility – was critical for active learning.

> *Because you don't want to view the professor as just some kind of, not a god, but you know what I mean? Like somebody who is inaccessible to you, who just is there to feed information to you. I think you have to trust them to respond to your inquiries and other problems and discussions and things and be approachable.*

Student D endorsed a similar message, whereby trust leads to more participation. After some additional questioning, they elaborated on their stance by saying that trust and a sense of community lead them to ask more questions, quickly adding that asking those questions is what leads to an increase in their knowledge. Student E expressed their agreement with this idea.

Discussion and implications:

We identified several themes that were present throughout the focus group, and here we describe how these themes could inform the way in which active learning is presented to students and carried out in graduate courses.

Student perceptions of active learning

When asked whether they knew what the word active learning meant, most students initially indicated that they did not know the meaning, although afterwards, two students came up with a reasonable definition of the phrase. When asked if active learning has a place in graduate courses, one student expressed the view that active learning should be used sparingly. However, after other students shared reasons why active learning could be beneficial in a graduate course environment specifically, this student began to share their perceived benefits of active learning. These discussions suggest that explaining to students what active learning is and how they can benefit from it may help to create student buy-in, which is also supported in the literature [26].

The students' general consensus that active learning should comprise a large portion of graduate courses and their discussion that more of the course could have been spent on demonstrations and problem-solving is in line with Gonsar's 2021 study, which found that graduate students generally desire more active learning then they are currently experiencing in class [27].

Sense of trust and community

When asked to consider aspects of the course that contributed to trust and a sense of community, the examples students cited were often not aspects of the course that had been purposefully designed to foster community. For example, students emphasized heavily on the approachability and availability of the professor, and the small class size came up as a factor that made students feel more comfortable participating. These were not aspects of the course that the authors had considered would impact sense of community, and part of our goal with this question was to understand what felt important to students that the instructor may not have realized. On the other hand, a number of elements that were included in the course for the purpose of community building were not noted by students as factors that had made a difference in this area. The students' lack of comments on the snack break was particularly surprising, given that, anecdotally, the instructor noticed students engaging in conversations around food that led to discussions about similarities and differences between students' cultural backgrounds and individual experiences. On a few instances, students brought in food to share with the class. Throughout the focus group, the students' interpretation of the questions seemed to center around content knowledge, and because the snack break did not directly further their knowledge, students may not have given it significant thought in their analysis of the course. In fact, when asked about the snack break, the students directed the conversation towards the duration of the course session, debating the pros and cons of meeting for one long session once per week, or multiple smaller sessions. These results are in line with our previous work, in which we surveyed 13 students in a previous iteration of this course and found that students were mostly neutral about the impact of the snack break on community building.

In the focus group, both students who attended the field trip spoke about it positively and student D mentioned that it helped build trust, which is also in line with our previous results, in which we found that the field trip improved students' sense of community.

Generally, students expressed positive feelings about active learning as a whole, as well as specific strategies the instructor implemented during class to promote community and participation.

Emphasis by students on content knowledge

For almost all questions asked during the focus group, students brought the discussion back to their understanding of the course content, even when that was not the intended focus of the question. When asked to describe factors that contributed to building trust and community within the course, Student E brought up how students could fill in each other's knowledge gaps during group problem solving. During the discussion about instrument demonstrations, four students either mentioned or agreed that the demonstrations were helpful because they allowed students to experience the content and "connect the dots more." Group problem solving allowed students to have conversations with their peers, possibly helping them to find people to study with outside of class. During the instrument demonstrations, the class got to go to a new location to experience something new together, and students assisted each other when trying out the TEM for the first time. Working together toward the shared goal of capturing an atomically-resolved image of gold

nanoparticles could have fostered a sense of camaraderie. However, whether these two activities did contribute to building community, students were more strongly cognizant of the ways in which these activities contributed to their content knowledge.

A similar theme of content knowledge appeared when discussing the GSRSs. Students at first generally disagreed that *Kahoot!* and *PollEverywhere* were helpful in encouraging them to participate, pointing mostly to the fact that these were opportunities for knowledge checks. When asked if the GSRSs made them more likely to participate in class, Student E reaffirmed that their decision to participate was more tied to the approachability of the professor. However, Student D does connect the GSRSs with participation, because being able to recall knowledge improved their ability to communicate in class. Students emphasized the low-stakes nature of the GSRSs as an aspect that made them feel comfortable participating. Student B thought of the GSRSs as conversation starters that promote communication at the beginning of class. This discussion agrees with our previous results, in which students indicated that GSRSs helped improve their sense of community and increased their comfort participating in class discussions. GSRSs were introduced in the course to serve as a "warm-up" for the students to allow them to participate in a low-stakes way. Due to the structure of these games, students would already know whether their answer was correct before volunteering an explanation. It seems as though some students saw value in the GSRSs for their role in facilitating communication in class, but the discussion centered around the utility of these activities in solidifying content knowledge.

When asked about their comfort levels during the class presentations, students' comments focused on their perceived applicability of the presentations to their work. Here, it seems that students closely associated comfort with their understanding of and applicability of the content, rather than their social interactions with the classmates in front of whom they are presenting.

Connection between active learning and community building

While students did not immediately draw a connection between community building and active learning, when prompted, this link was forged in a few instances throughout the discussion. Student A felt that trust and community building were important for active learning, since students are placing their trust in the professor when they reach out with questions:

> *I think you have to trust them to respond to your inquiries, and other problems and discussions, and things and be approachable.*

Student A also felt that if the professor is approachable, they would be more likely to ask the professor questions beyond the course content outside of class.

Student D referred to trust and sense of community as "some kind of force" that can make students more willing to participate. This student explicitly relates trust and community to their learning by stating that if trust is present, then students can ask more questions and therefore increase their knowledge. When asked what would make you ask more questions, the student replied, "It's trust between we and professor." Student A indirectly links trust to their learning, indicating that active learning, enabled by trust within the class, allowed students to go deeper into the content.

Conclusions and future work:

Our discussion with the five students enrolled in Structure and Diffraction provides insight into the way these students perceive active learning and the connections they identified between community building and class participation. Fundamentally, there was a consensus that active learning should be utilized in graduate courses to allow students the opportunity to think for themselves, to share their knowledge with the class, and to obtain hands-on experience that is typical of engineering programs.

Seemingly, students displayed a great sense of metacognition regarding their own learning, sharing deep insights into the ways in which various teaching strategies impacted their understanding of the course content. These insights were shared immediately without much prompting, suggesting that this is not the first time students have considered how they best learn. However, students seemed less aware of how they form community and the impacts of community building on their experience in the course. While students did ultimately create connections between sense of community and their attitudes towards active learning, this required more prompting, and these ideas were formed after more extensive discussion. This trend suggests that explaining the reasoning behind community-building activities in class could merit consideration, especially if a community-building activity does not appear to be directly relevant to the course content.

The small sample size is certainly a limitation of this work. This paper is meant to provide a detailed account of the perceptions of five students in one course.

Another limitation of this work is that terms such as “sense of community” and “trust” were not defined for students, so their responses to the focus group questions reflect their own understanding of what these terms mean. In future iterations of this work, we could ask students questions such as: In your view, what does it look like to have a classroom community? Is having a sense of community important to you in your graduate courses? Why or why not?

It could also be helpful to explain to the students the purpose of the focus group beforehand. Students seemed to be expecting to give feedback in a manner similar to a course evaluation and answer questions about the quality of the course and the instructor. Perhaps if students were given a list of the questions ahead of time, they may be more prepared to share their thoughts.

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