AC 2011-845: HOW INSTRUCTORS AND CLASSROOM CLIMATE CONTRIBUTE TO THE MOTIVATION OF FIRST-YEAR ENGINEERING STUDENTS

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How Instructors and Classroom Climate Contribute to the Motivation of First-Year Engineering Students.

Abstract
Student perceptions of faculty and Graduate Teaching Assistants (GTAs) are important factors for student retention and classroom engagement in engineering. As courses become more grounded in student-centered learning approaches through the addition of design projects, problem-based learning, and other student-centered learning activities, it is important that the interactions between the instructors and the students allow for a positive classroom environment. Grounded in self-determination theory, our study investigates the research question: How do students’ perceptions of instructors and learning environments contribute to student motivation? Using a mixed-methods approach including surveys and interviews, we compare students’ perceptions of faculty and GTA behaviors and the classroom environments that contribute to autonomy, competence, relatedness, and engagement in a first-year engineering course. Participants were surveyed at the end of their first-semester using a validated, pre-existing survey instrument. Using the survey responses, interview participants were selected to represent diversity in responses. Results show students’ perceptions of instructor behaviors and classroom environment do have an effect on student engagement and motivation. The smaller size of workshops and nature of having a graduate student as an instructor allows students to interact with peers and the workshop leader more effortlessly. On the contrary, the larger lectures and having a faculty member as an instructor produces a more intimidating environment. The study shows that there are practices that can be implemented to further contribute to students’ feelings of autonomy, competence, relatedness, and subsequently course engagement. For example, students found it easier to relate to professors that provided background information about themselves at the beginning of the semester.

Introduction
In response to calls to implement engineering and design activities across the undergraduate curriculum, first-year engineering courses are changing. While becoming more engaging through the addition of design projects, problem-based learning, and other student-centered learning activities, such courses also are becoming more resource intensive by promoting greater contact with instructors. Through this contact, instructors serve as mentors and role models to students and establish the classroom climate. Research shows that conducive learning environments, such as positive classroom climates, create positive experiences that are important factors in the retention of undergraduate engineering students. However, little research has situated these factors in motivation theory to better understand how engagement in learning engineering happens. Our research begins addressing this gap by examining student perceptions of faculty and Graduate Teaching Assistants (GTAs) behaviors and associated classroom climate factors in relation to students’ self-reported engagement in learning for a first-year engineering course.

Literature Review
Our study is grounded in self-determination theory, which posits that people act in ways that help them meet three basic psychological needs: autonomy, competence and relatedness. In accordance with self-determination theory, autonomy is the need to feel control and self-direction, competence is the need for mastery of a setting, and relatedness is the need to feel
connected to a group. Fulfillment of these needs lead to greater psychological well-being. As shown in Figure 1, we hypothesize that classroom instructors and environment factors contribute to students’ fulfillment of autonomy, competence and relatedness needs, which in turn contribute to greater motivation as measured through self-reported course engagement.

**Figure 1: Proposed relationship between classroom environment, SDT constructs and students’ engagement in lecture and workshop activities**

*Research on Student Autonomy, Competence, and Relatedness*

Although much of the work exploring self-determination among students is quantitative and focuses on primary and secondary school students, such research has shown promising ties between need fulfillment and indicators of course engagement. Middle school science students who reported fulfillment of their needs for autonomy, competence, and relatedness were more likely to continue enrolling in science courses and plan to pursue careers in science. In comparing junior-high and elementary students’ autonomous motivation to complete homework assignments, researchers attributed the older students’ decreased motivation to their teachers’ poor support of the students’ psychological needs, when compared to elementary school students and teachers. Students in physical education classes that perceived a more supportive environment reported greater need fulfillment and engagement in physical education activities.

While fewer researchers have utilized self-determination theory among college students, there are important findings. For example, one study found that parenting styles of the participants’ parents still significantly impacted college students’ self-determination. College students that reported more self-determination also tended to have higher grade point averages than students with low self-determination. A highly rigorous and extremely competitive pre-psychology program was found to thwart the autonomy, competence, and relatedness of students that were successful. These students, despite their success, reported high levels of stress, poor social lives, decreased interest in the subject, and a shift from intrinsic motivation to extrinsic motivation.
These findings may be particularly transferable to engineering given engineering students’ perceptions of the difficulty of completing engineering programs.\textsuperscript{11, 12}

A great deal of the self-determination theory research among college students is quantitative and focuses more on the broad factors that lead to overall feelings of self-determination. Little is known about how college students’ perceptions of individual instructors and learning environments contribute to the development of autonomy, competence, and relatedness, despite the importance of these factors as we have previously described.

Classroom Climate and Engagement in Learning
While not explicitly tied to self-determination theory, studies have found links between autonomy, competence, and relatedness constructs and student reports of classroom engagement. Students’ perceptions of autonomy support from their teachers have been linked to greater student engagement.\textsuperscript{13} Students also report higher engagement when faculty use collaborative and active learning techniques that can support all three basic needs.\textsuperscript{14} Smaller class sizes can contribute to more personalized attention, which can result in more relatedness, and have also been linked to greater course engagement.\textsuperscript{15}

Cabrera, Colbeck, and Terenzini\textsuperscript{16} explored the relationship between classroom practices and college engineering students’ gains in various professional competencies. Classroom practices of interest included collaborative learning, instructor interaction and feedback, clarity and organization of activities, and whether faculty and peers treat women or minorities differently than men or whites, respectively. Our work builds on the work of Cabrera et al. Instead of examining the relationship between classroom practices and learning outcomes (e.g. professional competencies), we consider classroom practices and self-reported engagement in learning. Our broad research question is: How do students’ perceptions of instructors and learning environments contribute to student motivation? To answer this question, we focus on students’ perspectives of the ways their instructors, both faculty and GTAs, contribute to developing autonomy, competence and relatedness in first-year engineering students. We consider students’ self-reported engagement in the course as a measure of motivation.

Methods
To address our research question, we adopted a mixed methods approach. Specifically, we used a Quant to Qual design as described by Creswell and Plano Clark.\textsuperscript{17} In this design, qualitative results are informed by but take precedence over quantitative results. We surveyed first-year engineering students at the end of a common first-semester course. With permission, we used scales from an existing, validated survey instrument\textsuperscript{16} for engineering student perceptions of classroom experiences, instructional practices, classroom climate and indicators of learning outcomes. Using the survey responses, we selected interview participants to represent diversity in cases. Our interviews probed for explanatory insights into student experiences, particularly with regard to understanding how faculty and GTAs contribute to satisfaction of students’ autonomy, competence and relatedness needs and student engagement in the course. The context of the course, participants and data collection and analysis methods are described in greater detail in the following sub-sections.
**Classroom Context**

The research site is a large public university in the southeastern region of the United States where all incoming engineering students enter a general engineering program. They typically spend a single year in the general engineering program before transferring to a specific engineering major. Our study focuses on a common course required of general engineering students that is usually taken in the first semester at the university. The course covers a variety of general engineering topics intended to help aid first-year students in choosing a major and in gaining hands-on experience in engineering activities.

This two credit hour course has two scheduled meeting times for students. At the time of data collection in 2009, the first meeting was a 50-minute lecture format with a faculty member and approximately 120 to 350 students. Multiple instructors taught the course using a common syllabus, instructional notes, assignments, and exams. In traditional lecture style, the instructor delivers content using slides with bulleted notes. Faculty-student interaction is enhanced through the use of tablet computers (required of all general engineering students) and interactive software. The combination of technology enables students to respond electronically to faculty-posed questions and carry out sketching or other problem-solving activities for real-time reviewing. Students can also take electronic notes on the faculty-provided slides.

The second meeting was in a GTA-led two-hour workshop with approximately 30 students. After an initial GTA-led introductory lecture or activity, students typically worked in three to five member groups to complete an interactive activity. The workshop activity supported the material covered in the lecture. GTAs continued to provide individual and group assistance throughout the workshop.

Clearly, there are inherent and intentional differences in the two classroom settings for this particular course. Most notable is that students have significantly more contact and teamwork in the workshop sections compared to lecture. By comparing students’ perceptions of the two settings, we can better understand the characteristics of each environment that promote students’ self-reported engagement in learning.

**Participants**

Survey - The online survey was sent via email to two large lectures, a total of 363 students. Potential participants were offered the opportunity to receive one of ten gift cards awarded by random selection for completing the survey. Reminders regarding the online survey were given in lecture and workshop slides and in a second email to all of the potential participants. However, the response rate was still low at approximately 19 percent. This may have been due to the poor timing of the survey, which was administered at the end of the semester while students were already completing course feedback and other departmental surveys. Despite the low response rate, the survey served the primary purpose of helping identify diverse perspectives to be probed via interviews.

Of the 69 responses received, only 61 were complete. Respondent demographics included 72 percent men and 28 percent women, with 81 percent Caucasian, 14.3 percent Asian American, 3.2 percent African American, and 1.6 percent Hispanic. The sample is mainly freshmen of
traditional college-student age. Women were intentionally overrepresented in this sample as one workshop contained predominantly women.

Interviews- A subset of participants, representing diversity in survey responses, were recruited for semi-structured interviews. A survey question allowed students to volunteer for interviews and offered compensation in the form of a gift card upon completion of an interview. Demographic information in interview participants is given in Table 1.

Table 1: Demographic information for interview participants

<table>
<thead>
<tr>
<th>Name</th>
<th>Gender</th>
<th>Intended Major</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jeremy</td>
<td>Male</td>
<td>Mechanical Engineering</td>
</tr>
<tr>
<td>Michael</td>
<td>Male</td>
<td>Computer Science</td>
</tr>
<tr>
<td>Stephanie</td>
<td>Female</td>
<td>Electrical Engineering</td>
</tr>
<tr>
<td>Amanda</td>
<td>Female</td>
<td>Electrical Engineering/Math</td>
</tr>
<tr>
<td>Denise</td>
<td>Female</td>
<td>Material Science &amp; Engineering</td>
</tr>
<tr>
<td>Jessica</td>
<td>Female</td>
<td>Mechanical Engineering</td>
</tr>
<tr>
<td>Christina</td>
<td>Female</td>
<td>Engineering Science &amp; Mechanics</td>
</tr>
</tbody>
</table>

* The provided names are pseudonyms used to protect the identity of the actual participants

Data Collection Instruments and Analysis Methods

With permission, we used scales from a survey developed by Cabrera, Colbeck and Terenzini" to examine student perceptions of course instructors and learning environments. This survey is appropriate for this study because it is grounded in concrete examples of behaviors and activities that students can easily observe or experience. Such concrete examples create a clear way to compare perceptions of lectures and workshops separately, despite them being part of the same overall course. We used three scales for instructional practices and two scales for classroom climate. The scales and sample questions are shown in Table 2. We also provide the reported internal consistency measured as Cronbach’s alpha since the instrument was previously tested and validated for engineering students.
Table 2: Survey Scales with example questions and reported internal consistency

<table>
<thead>
<tr>
<th>Scale</th>
<th>Example</th>
<th>Internal Consistency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Instructional Practices</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A: Collaborative Learning</td>
<td>How often do you discuss ideas with classmates?</td>
<td>0.88</td>
</tr>
<tr>
<td>B: Instructor Interaction &amp; Feedback</td>
<td>How often do you interact with your instructor as part of the course?</td>
<td>0.83</td>
</tr>
<tr>
<td>C: Clarity &amp; Organization</td>
<td>How often do you think that your instructor clearly defines expectations about assignments?</td>
<td>0.77</td>
</tr>
<tr>
<td><strong>Classroom Climate</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D: Faculty Climate</td>
<td>How often do you feel that your instructor treats women the same way as men?</td>
<td>0.86</td>
</tr>
<tr>
<td>E: Peer Climate</td>
<td>How often do you feel that in groups, some white students treat minorities differently?</td>
<td>0.89</td>
</tr>
</tbody>
</table>

We asked the questions from these scales twice, once for faculty (lecture instructors) and once for GTAs (workshop leaders). Responses were reported on a scale from 1 to 4, where 1 = “never,” 2 = “occasionally,” 3 = “often,” and 4 = “very often/almost always.” Because we administered several instruments at the same time, we modified the questions and response choices from the Cabrera et al. scale very slightly to be consistent throughout the survey as a whole. No impact on validity or reliability of the scales was anticipated.

The survey was administered online using commercially available software. For analysis, we used predominantly matched pairs t-tests to examine differences between students’ responses with regard to perceptions of interactions with instructors and GTAs. Some analysis by gender was also completed but the sample size was insufficient to yield statistically significant results. A frequency analysis was also carried out in order to provide additional insight into student response patterns.

Using a preliminary analysis of survey responses, we selected interview participants. A single interviewer, a graduate student research assistant, conducted one-on-one semi-structured interviews with each participant. The intention of the interviews was to probe more deeply into differences in perceptions of faculty and GTAs. Therefore, the interview protocol asked participants to provide his or her own examples of faculty and GTA behaviors that support or detract from learning experiences. Sample questions include:

1) Did your [instructor/workshop leader] do anything to help you feel confident of your ability in this course?
2) Did the [instructor/workshop leader] do anything that made you feel engaged?
3) What did your [instructor/workshop leader] do to help you feel in control of your learning?

4) Do you feel like you could relate or connect with your [instructor/workshop leader]?

Questions were repeated as appropriate, inserting “instructor” (or “professor”) then “workshop leader” where appropriate. In both cases, the interviewer probed for specific examples. This approach is consistent with the types of questions asked via the survey related to perceptions of general behaviors and classroom activities. Interviews were recorded and transcribed verbatim.

We used a combination of a priori and open-coding approaches to highlight patterns across participants. Significant statements were coded for the initial categories of autonomy, competence, relatedness and engagement. Later, these broad categories were re-coded into sub-codes as more selective, systematic codes. We used MaxQDA software to aid our analysis.

Results
To address our research question, “How do students’ perceptions of instructors and learning environments contribute to student motivation?”, we focused on students’ perspectives of the ways that instructors, both faculty and GTAs, contribute to developing autonomy, competence and relatedness. We hypothesized that satisfaction of these three basic needs would lead to greater engagement in the course. We therefore present our findings in terms of the three categories of basic needs with qualitative perceptions of behaviors and classroom climate summarized by categories and supported through quantitative results. We then present findings related to self-reported engagement.

Autonomy
We examined the student-reported ways that the instructors and course environment contributed to students’ sense of control over their own learning and performance. Overall, students believe control over their learning, i.e., they believe it is their responsibility to learn the materials and they can make choices in how they accomplish the learning. Generally, students reported two categories of factors contributing to this feeling, including: 1) class format, and 2) interactions with the instructor.

Class Format – The class format includes the structure of the course lectures, workshops and homework assignments, and students generally believe the format of the course contributes to control over their own learning. For example, although the lecture notes were provided, the students understood that they were responsible for what they wrote down. Amanda explained this by saying “you were in control of what information you left the class with.” The students also believed that they had everything they needed to accomplish the learning. Generally, students reported two categories of factors contributing to this feeling, including: 1) class format, and 2) interactions with the instructor.

While generally true, this was not true for all students. For example, Jessica did not feel in control much of the time and stated, “When I did the homework… I was just following
instructions and doing what they told me to do.” However, she felt more in control in workshop where she did hands-on activities.

**Interactions with the Instructor** – Interacting with instructors also contributed to students’ sense of control over their learning. For example, Stephanie gained a sense of control through a direct interaction with the professor. After a difficult test, she went to her instructor to see what she could do to do better on the next exam. Stephanie explains this experience by saying, “[The instructor] was very helpful…[through] evaluating how I learned and how I could use that, not to fix the handicap, but to figure out what I could do to overcome that obstacle of whatever learning block I had.” Stephanie felt more in control of her learning after this interaction with her instructor. It should be noted that such interaction is often a choice and many students do not seek out their instructors outside of class. Choosing to interact during class is also a choice. While the opportunity was there, students did not have to participate if they did not want to. Stephanie mentioned that in lecture there were times when she was ready to participate and times when she did not want to. While she mentioned it being easy to participate in class, she also acknowledges that “at the same time, if you really didn’t [want to] participate…. you could’ve just sat back in the corner and just come to class and take your notes and then leave.”

The survey data confirms that many students do not interact with faculty or GTAs frequently outside of the classroom. However, there is a small but significant difference in that students interact slightly more frequently with GTAs than with faculty. Figure 2 shows the frequency of interaction with faculty and GTAs outside of the classroom. A matched pairs t-test shows the average frequency to be slightly higher for interactions with GTAs, with a test statistic of 0.023 indicating significance at an alpha level of 0.05. To better understand why students might not visit office hours, we considered issues of gender and ethnicity. We looked at student responses to statements “My instructor treats all students the same regardless of gender” and “My instructor treats all students the same regardless of ethnicity” considering both faculty and GTAs. However, we found that no students believed there was a difference in treatment from either faculty or GTAs with regard to ethnicity as there were no responses rated as “occasionally” or “never.” Figure 3 shows that at least 95 percent of the students perceived that their interactions with their teachers were not affected by student gender. Similarly, there were no differences based on student ethnicity.
Survey Item: Interactions with instructor outside of the course

a.)  Frequency of student-instructor interaction outside of the classroom

b.)  Frequency of student-GTA interaction outside of the classroom

Figure 2: A comparison between student perceptions of student-teacher interactions outside of (a) lecture and (b) workshop. At least 56 of the 61 students did not interact with their teachers outside of the classroom frequently.

Survey item: Instructor treats all students the same regardless of gender

a.)  Frequency of gender not influencing student-instructor interactions.

b.)  Frequency of gender not influencing student-GTA interactions.

Figure 3: A comparison between student perceptions of whether student-teacher interactions were biased based on gender with regards to their (a) instructor and (b) GTA.
Competence

We looked at students’ perceptions of instructors and classroom contexts with regard to how they may contribute to students’ competence beliefs, i.e., their ability to master course content. Overall, students reported having the resources necessary to succeed in the class, which included course materials and feedback. Additionally, office hours provided support to students who chose to take advantage of this resource for both lecture and workshop settings. Students did, however, report that due to the smaller class environment, workshop leaders more easily provided feedback.

Resources and Feedback- Students responded positively about having the necessary resources, e.g., lecture notes, review sheets, etc., to succeed in the course. Moreover, students felt encouraged to succeed on tests and homework. Specifically, positive feedback helped students feel more confident and encouraged. For example, Michael recalled a time when the professor looked over an assignment which Michael solved differently than the provided solution. The feedback from the professor was encouraging “[the professor] just looking at my work and assuring me that I did the right thing, even though he didn’t collect it…just motivated me to do more.” Unfortunately, the course was also viewed as a weed-out course with faculty attempting to scare students into studying for the exams. For example, Christina reports the professor saying, “You have to study for [the test]” and “You just can’t [take the test] and expect to do incredibly well on it.” While this did not make her feel confident, she understood and explained by stating, “It’s the right thing to say. I don’t think you should necessarily make someone feel confident [that] they can ace a class…. [The instructor] can give them the information that they need, and that should make them confident that they can do well.” She felt it was not advisable to make students think they did not have to study for test and would still be able to do well on it. While feedback from faculty is important, participants found the immediate feedback received in the workshop setting more helpful. For example, Amanda’s workshop leader “was really helpful with clarifying what the graders…were looking for in the class, because a lot of times [the students] didn’t know exactly where things were going.” Students were comfortable asking the GTA for help during workshop activities and reported that unlike lecture, the GTA could walk around workshop and ask students if they needed help; this allowed students to ask questions and get feedback about their assignments. As noted by Jessica, “We could get help from our workshop leader really easily and he’d walk around while we were doing things.”

Findings from the survey confirm that students believe they have adequate course materials to succeed. The students were asked to identify how often the instructor (or GTA) has clearly defined expectations for assignments/activities and how often they are clearly explained. The histograms in Figures 4 and 5 showed that classroom activities were frequently well presented and explained by both the instructors and the GTAs. In each classroom context, at least 60 percent of the students believed that the classroom assignments were clear and that the instructors had clear expectations. A matched pairs t-test showed no significant differences between students’ perceptions with regard to faculty and GTAs.
Survey item: Classroom assignments and activities are clear

Figure 4: Histograms comparing student perceptions of how well their (a) GTAs and (b) instructors developed the instructions for classroom activities and assignments.

Survey item: Classroom assignments and activities have clear expectations

Figure 5: Histograms comparing student perceptions of how well their (a) GTAs and (b) instructors explained the expectations for classroom activities and assignments.

Office hours- Although students did not visit faculty office hours on a regular basis, the availability of the professor was obvious to each student. Denise noticed students going for help despite not taking advantage of this resource personally. She said that she “[knew] of many other
students, who if they needed the help, they would go and visit [the] teacher and they would not only receive help, but they also received great references and great other stuff.” If she needed the help, she said she would have gone but she “just didn’t go in to ask for help because... [she] understood a majority of the material very well.” As an alternative to office hours, some participants mentioned asking questions about the homework before or after lecture. Unfortunately, not all students seek the help they need in office hours. Jeremy did not seek help and explained it by saying, “I would have about 15 minutes of study time and the rest would be dealing with other students or questions pertaining to what I didn’t need to know.” Students also did not visit workshop leader office hours regularly, although they still found their workshop leaders willing to help and provide encouragement. Email was a primary source for students asking questions they had outside of class. The type of help sought from workshop leaders was clarifying instructions and grading practices for assignments.

Relatedness
We examined students’ perceptions of relatedness to faculty and GTAs. Generally, students reported relating to the workshop leaders more easily and interacting with them more often than with faculty. While many students reported few, if any, interactions with their professor, those that did found the professor to be helpful and approachable. Several factors contributed to this pattern including: 1) class size and format, and 2) power dynamics.

Class size and format- The small class size made the workshop leader more approachable to students and made interactions easier than with the instructor in the lecture setting. Christina mentioned that if students arrived to workshop early, they could actually have a conversation with the GTA since they were not in a large lecture and sitting in the back row. Conversely, the crowd of students made it hard for any of the students to relate to the lecturer on a personal level unless they intentionally sought out to do so. Additionally, the format for the workshop, as compared to the lecture, created a classroom environment where students would ask and answer questions in class, which made it easier for them to ask questions when they needed help. Since students were more involved in workshop, they thought they knew the GTA better than they knew their professor. In some instances, students talked about knowing their professor better when provided with background information about him or her. Michael recalls being able to relate to another teacher because he was provided with a “back-story to why [the teacher was] teaching at Virginia Tech.” He says if his engineering professor had done this, it “would’ve gave me at least an opportunity to see if I could connect with [the professor]. Depending on the story, I may have or may not have been able to relate.” Denise reinforces this notion by revealing how her professor “did tell a couple of stories...about how she [got] her job, reinforcing her qualification.” Denise goes on to say that this “gave you trust in [the teacher] as an engineer and as a professor teaching you these engineering principles, and that helped you relate to her as an engineer.”

Power Dynamics - The tension of the teacher-student relationship kept many of the participants from attempting to connect with the professor personally. Christina summarized it by saying, “She’s a professor and I’m in a classroom.” Although this did not make the students feel distance, it kept them from feeling a connection. Michael stated, “[I] just felt like [the professor] was knowledgeable about engineering stuff, and I am not at the moment. So I just kind of went to him for help.” Although Michael went to the professor for help, Michael still described it as “more like a student/professor...professor/student kind of relationship.” Stephanie said, “After
the first couple times talking to [the professor] after class, office hours, I definitely felt a connection that I could go to her a lot more easily than I did…with the initial tension of professor-student relationship…after a while, it got a lot easier to go to [the professor] and talk to her about class.” The teacher knew her name and this allowed her to relate personal experiences as far as being in school and class. Since the GTAs were not actual faculty members, the added pressure of speaking to an authority figure was not present. Michael recalled saying “I hope something horrible doesn’t happen” the first time he went up to his professor as oppose to when he spoke to the GTA, who was more laid back and casual. Stephanie mentioned that her GTA’s lack of enthusiasm was the only thing that kept them from relating. Participants tended to relate better to the GTA because of closeness in age or common engineering interests. For example, Christina mentioned relating to her GTA being easier because “[I] could call him by his first name. It wasn’t Dr. [Professor’s surname]; it was [GTA first name]. He was closer to [my] age…[and] also a student.” This was not true of all participants, as Amanda found the closeness in age to be a problem. Several participants mentioned not really relating to the GTA. For example, Denise stated that “[the] engineering in me related to him that way. But other than that, I didn’t relate to him at all”.

As already mentioned, the survey results show that respondents interacted with their GTAs outside of class slightly more often than they interacted with their faculty lecture instructor. Similarly, results show that survey respondents interacted slightly more often with their GTAs in class than their lecture instructors. Using a matched pairs t-test, these results are significant at a level less than 0.0001. Figures 6a and 6b show that the majority of the respondents believed that their interaction with the instructor was limited. A comparison of the data represented in Figures 2 and 6 shows that the student’s interaction with the GTAs and instructors, although infrequent, occurs mostly in class. These results are consistent with the findings from the qualitative data; students are interacting more often with their GTAs than their lecture instructors.
**Survey item: Interaction with the instructor as part of the course**

a.) Frequency of student-instructor interaction in the classroom

![Bar chart showing survey results for a. Frequency of student-instructor interaction in the classroom.](chart1)

b.) Frequency of student-GTA interaction in the classroom

![Bar chart showing survey results for b. Frequency of student-GTA interaction in the classroom.](chart2)

Figure 6: (a) 56 out of the 61 respondents felt that they did not interact with their instructor as part of the course. (b) 44 of the 61 students believed that they did interact with their GTA throughout their workshop.

**Engagement**

As a measure of motivation, we examined students’ self-reported engagement in learning in the lecture and workshop classroom contexts. Overall, interview participants reported more engagement in workshop than in the lecture. Primary reasons include the structure of workshop as activity-based and the smaller size of the workshops. Participants report that the smaller classroom environment of the workshop facilitates engagement because they are interacting with peers and the workshop leader. In contrast, the lecture is more of a listening activity and the large size makes it difficult for the faculty to interact with the class.

**Class Structure** - Participants report more engagement in workshop because it was more “hands on” than lecture. During workshop, they participate in different experiments and activities. Although DyKnow software and the use of tablet computers have been implemented in lectures to facilitate student engagement, participants report mixed results. According to Jessica, DyKnow allowed students to feel “more engaged than you would have if you were just in a class of 200 people normally.” When the lecturer has students do drawings and other things on the computer and submit, it gave them a chance to engage. Jessica explained it by stating, “We’d draw on the computer screen and submit it, so it wasn’t like other big classes where if they asked you to do something you don’t really have to if you don’t want to.” In contrast, participants said that having their laptop also detracted from their level of engagement. Christina states, “I took all of my notes on my computer and then I had a tendency to play games. So this semester, I switched, and the only [class] I bring my computer to is engineering because I have to.” Computer aside, Jeremy had a hard time staying engaged in lecture because he found it hard to “follow someone else’s train of thought” for an entire lecture when he was unable to engage in conversation with the person. He summed it up by saying “I just can’t stay focused that long.” On the contrary, the structure of workshop was perceived as really open to participation.
According to Stephanie, “there was always participation [in workshop] because there was an activity every class.” Denise also mentioned enjoying the “different experiments and fun activities” in workshop.

Class Size- Since the workshop was smaller, students reported that the atmosphere was more personable. The students spent a lot of time working with one another. According to Jeremy, “It was a smaller group [and I] could work with a team...I didn’t necessarily have to stare at the front the entire time”. Denise mentioned being able to find a number of people interested in the same engineering major since the workshop leader split them into groups based upon major. Christina states “I guess it just felt a little bit more relaxed than lecture; just the idea that if [I] messed up, it wasn’t a big deal.” She attributed it to the fact that “You don’t have however big the class is looking at you...You just kind of laugh it off because it’s only a couple of people.” Michael also mentioned that since only 20 students were in his section, “you [could] ask questions because every other student is basically [asking questions also].” He felt uncomfortable participating in some of the lecture activities due to the large class size. He mentioned seeing the capacity sign on the door and thinking “I don’t really feel like asking a question in front of the whole class now.”

The survey results support the findings from qualitative data reported above. Students were asked “How often do you: Actively participate in class?” The students were asked to rate their perception for both the GTA lead workshop and instructor’s lecture. This question directly measures the student’s perception of their engagement in the classroom as a function of classroom format. Figures 7a and 7b show that 54 percent of the students believed that they did not regularly participate in lecture, while 85 percent believed that they regularly participated in workshop activities. A matched pairs t-test showed this difference to be significant at an alpha level <0.0001.

Survey item: Actively participates in class activities

a. Frequency of participation in lecture activities
b. Frequency of participation in workshop activities

![Figure 7: (a) Responses regarding engagement in lecture (b) Responses regarding engagement in workshop section](image-url)
When asked how frequently they worked cooperatively with other students, respondents reported working with one another more often in workshop. Figure 8b shows that 57 of the 61 respondents perceived that they worked with other students in workshop. This matches the perception of the interviewees that the workshop’s smaller class size and structure encouraged students to work in teams to complete activities. Despite interview participants describing the lecture as a “listening activity”, Figure 8a shows 48 percent of the students also believed that they worked with other students in the lecture format. This high response rate may be attributable to DyKnow and classroom problem-solving activities. Despite students submitting their own responses through DyKnow, these activities often gave students the opportunity to discuss possible solutions to a problem with their classmates.

**Survey item: Worked cooperatively with students**

a.) Frequency of cooperative work between students in lecture

b.) Frequency of cooperative work between students in workshop

![Survey responses to cooperative work](image)

Figure 8: Student responses to whether they perceived that they worked with other students during (a) lecture and (b) workshop.

**Discussion and Implications for Practice**

Our results show that students’ perceptions of instructor behaviors and classroom environment do contribute to feelings of autonomy, competence and relatedness. Our results also show that there are differences among students’ experiences with faculty and with GTAs. By comparing what participants say about their experiences in lecture and in workshop, we can identify practices that would further contribute to students’ feelings of autonomy, competence, relatedness, and subsequently course engagement.

With regard to feelings of autonomy, participants reported feeling in control of and responsible for their learning. Class format and interactions with instructors were contributing factors. For example, although instructors provided notes, paying attention and deciding what notes to take is the responsibility of the student. Additionally, seeking help when necessary was entirely up to students. Having a sense of agency or control over one’s learning is linked to higher motivation and persistence in the literature.5-7
Although students in our study see learning as their responsibility, few students actually seek help from instructors outside the classroom. Students feel responsible for taking action, but they are not necessarily taking action. In this regard, equally important is what students did not say. Students did not talk about being encouraged to attend office hours or to interact with faculty inside or outside the classroom. While also contributing to relatedness, encouraging student-faculty interactions could support students’ sense of empowerment by encouraging them to take action.

So how could instructors support student autonomy? Instructors, both GTAs and faculty, could arrive early to class or stay a few minutes late and invite students to ask questions during this time; this will also give students who normally would not attend office hours or go to the professor for help the chance to see that instructors are approachable and other students are actually going to them without a problem. Also, it is possible that students do not really know what “office hours” are or what purpose they serve, as they may never have heard this term before. GTAs and faculty could explain how they conduct their office hours. While format may differ by instructor, being explicit about office hours would let students know what to expect. Given students’ mention of the power dynamic, students may be concerned that they are bothering faculty or wasting their time. Therefore, it is particularly important that faculty make it clear that they genuinely want to interact with students both in and out of the classroom; the invitation must be authentic.

With regard to competence, students believe they have sufficient course materials and instructor feedback to succeed in the course. However, participants reported that due to the smaller class environment, workshop leaders more easily provided feedback. Importantly, participants also indicated that the smaller size of the workshop made it a safer place to take chances by participating because mistakes would be less embarrassing than in the larger workshop setting. Outside of the classroom, few students attended office hours or interacted with faculty, but those who did reported positive contributions to competence beliefs about their mastery of course content.

So how can instructors support students’ competence beliefs? Continue to provide clear instructions on assignments and activities. Faculty can work towards giving more immediate and personal feedback regardless of class size. Research has shown that intermediate feedback is important in helping students indentify their strengths and weaknesses so they can best meet the goals of the course.\textsuperscript{10} Faculty also need to make the large lecture feel safe to the students as a place to ask questions and take chances. This could be accomplished by frequently seeking interaction with students and by being careful to correct wrong answers while maintaining a sense of competence and ability in the students.

With regard to relatedness, participants reported spending more time interacting with and interacting more easily with their workshop leader than faculty instructor. Many of the students reported few, if any, interactions with their professor. Although when they did, they found him or her to be helpful and approachable. The smaller class size and format of the workshops contributed to ease of interaction with GTAs as compared to the larger lecture format, where participants found it hard to approach faculty before and after class or even during class. Additionally, the power dynamic or status of the professor made it difficult for some participants to interact with faculty members.
So how can instructors support feelings of relatedness? The same suggestions offered for supporting students’ autonomy and competence would contribute to feelings of relatedness. Clear instructions, timely and personal feedback, and being available before and after class can all contribute to students’ feeling connected to instructors. While there is a power differential and it is important for students to respect faculty, faculty should also seem approachable to students. The study participants identified one way to do this is for faculty to talk about themselves, their expertise and their career paths.

As we might anticipate, based on findings related to autonomy, competence and relatedness, interview participants and survey respondents reported more engagement in workshop than in the lecture. Primary reasons include the structure of workshop as activity-based and the smaller size of the workshops which are features of the course design. While consistent with previous findings regarding relatedness, our results provide insight into how this engagement happens. Participants report that the smaller classroom environment of the workshop facilitates engagement because they are interacting with peers and the workshop leader. Related to competence, students also found the smaller course size to be a safer place to ask questions because it would be less embarrassing to make a mistake. In contrast, the lecture is more of a listening activity and the large size makes it difficult for the faculty to interact with the class.

References


