



# Work In Progress: Effects of COVID-19 Pandemic on Engineering Students' Sense of Belonging and Learning

## Matthew Sheppard

I earned my B.S. in Industrial Engineering and my M.S. in Mechanical Engineering; both at Clemson University. I have several years' experience as a Manufacturing Engineer supporting process improvements, machine design, and capital project management. Now, I have entered into the Engineering and Science Education PhD program at Clemson University with hopes of teaching hands-on engineering principles to students in Appalachia after graduation. The focus of my research is identification of factors that affect undergraduate engineering students' ability to excel and find a sense of belonging.

## Aradaryn Marsh

I am finishing up my first year as a PhD student at Clemson University in the Engineering and Science Education Program. I have a background in biology and I'm currently working on my masters in wildlife biology. I'm still exploring my research options, but hope to study some combination of metacognition and undergraduate research in the sciences.

## Lisa Benson (Professor)

Lisa Benson is a Professor of Engineering and Science Education at Clemson University, and the Editor of the Journal of Engineering Education. Her research focuses on the interactions between student motivation and their learning experiences. Her projects include studies of student attitudes towards becoming engineers and scientists, and their development of problem solving skills, self-regulated learning practices, and beliefs about knowledge in their field. Dr. Benson is an American Society for Engineering Education (ASEE) Fellow, a member of the European Society for Engineering Education (SEFI), American Educational Research Association (AERA) and Tau Beta Pi, and the 2018 recipient of the Clemson University Class of '39 Award for Faculty Excellence. She earned a B.S. in Bioengineering (1978) from the University of Vermont, and M.S. (1986) and Ph.D. (2002) in Bioengineering from Clemson University.

## **Work In Progress: Effects of COVID-19 Pandemic on Engineering Students' Sense of Belonging and Learning**

### **Abstract**

This work in progress paper reports on part of a larger project examining engineering students' learning experiences, sense of belonging, motivation, and engineering identity, specifically focusing on how the COVID-19 pandemic affected these attributes and students' connection to others. A survey was distributed in Spring 2021 to engineering students ( $n = 1565$ ) at a land grant institution in the southeastern U.S. that included open-ended questions about how the COVID-19 pandemic affected the students' learning experiences and sense of belonging. Likert-type questions asked students to rate the extent to which the COVID-19 pandemic affected their learning experiences, sense of belonging and connections to others (peers, instructors, TAs, other engineering groups). Our analysis of the qualitative data (open-ended survey responses;  $n=815$ ) used inductive, emergent coding to categorize students' responses. Descriptive statistics were calculated for the quantitative data (close-ended responses) to help visualize emerging themes. Analysis with respect to gender and race/ethnicity revealed significantly lower connections to peers for Hispanic/Latino students when compared to White students. Analysis also found that female students reported statistically higher effects of online learning on their sense of belonging in engineering compared to male students. First year students felt less connected and more stressed than they had prior to the pandemic. First-year and senior students reported lower connections with their TAs than sophomore and junior students. Some students said they relied on technology, such as social media platforms to connect with other students and groups

### **Introduction and Background Literature**

Recent research has documented the effects of the COVID-19 pandemic on college students' mental health [1, 2]. As a result, there is a need to examine students' experiences amid the transition from in-person learning to online and hybrid learning as a result of the COVID-19 pandemic in 2020 and 2021. In Spring 2021, a survey designed to assess undergraduate engineering students' sense of belonging in their courses, department, and university, motivations towards being engineering students and becoming engineers, and their engineering identity [3] was modified to include questions related to the effects of COVID-19 on students' educational experiences. It also included demographic questions such as race/ethnicity, gender, disability status, first-generation college student status, and veteran status.

Theories related to students' sense of belonging indicate that feelings of being connected, accepted, and validated at an institution and within courses are crucial to the success and persistence of undergraduate students [4, 5, 6]. Another study, which examines the association between undergraduate students' sense of belonging at various levels and their academic motivation, proposes a link between college students' motivation to learn and their sense of belonging within their institution [4]. Prior research has shown that engineering students with low feelings of belongingness tend to switch to non-technical majors [7]. The COVID-19 pandemic has been shown to decrease student motivation and accountability [2], which may, in turn, affect their sense of belonging. It has also led to increased difficulty in concentrating, which has previously been shown to adversely affect students' learning [2].

Given the potential effects of the pandemic on important factors for student success, this study seeks to answer the following research questions: In what ways did a transition to online

and hybrid courses during the COVID-19 pandemic affect undergraduate students' sense of belonging and learning in engineering? Are these effects different for different student demographic groups?

## Methods

### *Data Collection*

To answer the research questions, data were collected through a survey in which students were asked four free-response questions and six Likert-type questions on a scale from zero (no effect/never) to six (major effect/a great deal). These questions were developed based on prior findings about factors affecting students' sense of belonging in engineering (positive learning experiences, interactions with others outside of the classroom, and personal connections) [3]. The main portion of the survey asks students about their overall sense of belonging at different levels, while the COVID-19 questions focus on students' connection with others. With the understanding that sense of belonging is a complex construct, we asked students to reflect about one specific aspect of it - their connections with others - because we felt it was the most likely to be affected by online learning formats. The following 10 questions, as listed in Table 1, were added to the main survey after items asking about motivation, belonging and identity and before demographic questions.

Table 1. Survey questions related to COVID-19 effects on students' learning experiences.

<b>Survey Question:</b>	<b>Response Type:</b>
How has this transition affected your sense of belonging in engineering?	Open-Ended Response
In what ways are you connecting with each group?—Peers, Instructors, TAs, Other engineering groups	Open-Ended Response
What makes you feel most disconnected at this time?	Open-Ended Response
How has this transition affected your learning?	Open-Ended Response
To what extent has transitioning to online learning affected your sense of belonging in engineering?	Likert-Type Scale
To what extent are you connecting to your peers?	Likert-Type Scale
To what extent are you connecting to your instructors?	Likert-Type Scale
To what extent are you connecting to your TAs?	Likert-Type Scale
To what extent are you connecting to your other engineering groups?	Likert-Type Scale
To what extent has transitioning to online classes affected your learning?	Likert-Type Scale

Participants for this study included undergraduate engineering students at a land grant institution in the southeastern U.S. All students in the common first year engineering (FYE) program were invited to participate. Three upper-level (sophomore, junior, and senior) courses required in each engineering major were also identified for survey distribution, which took place over a three-week period prior to final exams in Spring 2021. Of the 1565 students in the selected courses, 815 students responded to the COVID-19 related survey questions (52% response rate). Of these, 390 were in the common FYE program and 425 were in upper-level courses. Survey data for all engineering majors were combined for this study due to low response rates (below 10%) for some majors. Student names and email addresses, collected to facilitate

follow-up interviews, were removed from responses and replaced with study numbers prior to data analysis in accordance with IRB guidelines.

### ***Data Analysis***

Responses to the four open-ended questions were analyzed by two coders who first conducted a review of responses to each question to identify trends. The two coders then developed an initial list of codes which they condensed into a set of 13 codes. The second round of coding was conducted using these codes. Codes that occurred frequently for each question were noted, and student responses associated with frequently occurring codes were examined to address the research questions. For the six Likert-type response questions, average response scores were calculated by level, student-identified gender, and student-identified ethnicity to examine trends within those groups. Single factor ANOVAs were conducted to identify significant differences within groups and a Tukey HSD test was performed on responses with significant differences.

## **Results**

### ***Open-Ended Response Findings***

Most students shared that they felt a lower sense of belonging in engineering due to the pandemic. They felt disconnected from the university, had difficulty developing relationships, and found professors less approachable outside of class; this was reported more for FYE students than upper-level students. Prior to COVID-19, labs had been a place where students often developed relationships through teamwork and collaboration, but online labs did not afford this opportunity. Students reported using technology to allow virtual collaboration with peers, instructors, TAs, and/or other engineering groups. GroupMe, Canvas, Zoom, and FaceTime were cited as ways to build friendships and stay abreast of coursework. Students noted reduced contact and relationship development with professors, but many mentioned strong connections with helpful TAs. Students also noted that teamwork was difficult to arrange and often felt risky because while sharing thoughts and ideas in the classroom could be viewed as collaboration, doing so in writing could be viewed as cheating.

Some respondents noted feeling less isolated than they had prior to COVID-19 because they had not developed strong relationships with peers, instructors, TAs and other groups, so they felt the playing field was more level.

Students identified a variety of factors that made them feel most disconnected amid COVID-19. Many centered around a lack of close interaction with people on campus. Students reported coming to campus less, and when they attended in-person classes, being seated far apart made organic conversation unlikely. An additional outcome was decreased level of commitment to their coursework because of a lack of accountability during collaborative work online and lack of relationships with instructors.

Students identified the hands-on aspect of labs as a source of solidifying concepts, and a lack of access to these labs negatively affected their learning. Lack of accountability and poor time management resulted in decreased performance. Although most students reported negative effects on their learning, a few reported positive effects, such as the ability to learn at their own pace and complete tests online. They felt they could better focus on showing what they truly knew without external pressures.

### ***Likert-Type Response Findings***

Overwhelmingly, participants reported negative impacts of online learning (97.2% reported negative effects on sense of belonging; 96.5% reported negative effects on their learning). Effects of online learning on students' sense of belonging in engineering were lower for each level from FYE to senior level, although there were no statistical differences between grade levels for responses to this question. Female students reported statistically higher effects of online learning on their sense of belonging in engineering than male students. No statistical differences in the effects of online learning on sense of belonging were found by race/ethnicity.

FYE students reported significantly lower connections to peers than junior- or senior-level students; Hispanic/Latino students reported significantly lower connections to peers than White students. No significant differences in connections to peers were found by gender, and no significant differences were found in students' connections with instructors by level, gender or race/ethnicity. While gender and ethnicity were not factors in students' ability to connect with TA's and other engineering groups, level was a factor for both. FYE and senior students reported significantly lower feelings of connection with TAs than sophomores and juniors. FYE students felt significantly lower connections with other engineering groups than juniors. Seniors reported significantly lower effects of transitioning to online classes on their learning than other student levels.

### **Connection Between Likert-Type and Open-Ended Responses**

Overall, trends in the quantitative data showed a decreasing effect of the pandemic on sense of belonging as student level increased. Upper-level students reported having stronger connections to peers in their open-ended responses. The following sample quotes illustrate this trend:

FYE: *"I just feel like the same opportunities that my friends had when they were freshmen here is not the same for me, which has made it kind of struggle to get through the years as I haven't gotten the ability to have the same academic and social experience they had with engineering."*

Sophomore: *"Without the ability to interact with classmates, TAs and professors in person on a daily basis in the classroom, labs or at the library the overall experience feels more lonely and overwhelming."*

Senior: *"I am a senior so I have had time to establish my sense of belonging"*

Quantitative results showed that the transition had less effect on seniors' learning than the lower-level students. Quantitative data also aligned with findings from qualitative analysis that FYE students reported more desire for relationship development, belongingness within campus, their courses, and friend groups than upper-level students. Below are examples of how students connected with peers, instructors, and other groups that aligned with the quantitative findings:

FYE: *"I really have not connected with anyone other than peers, for helping with studying or other issues that they have."*

Senior: *"Mainly in lab where I see them in person"*

## **Discussion**

The overall findings that emerged from this study related to negative effects of the pandemic on students' learning experiences were that students felt less connected and more stressed, particularly FYE students; students relied on resources such as technology for learning; and students were missing hands-on opportunities for learning. These findings support those of Son et al. in respect to COVID-19 adversely affecting learning [2]. Another finding that emerged indicated that some students did not feel negative effects of the pandemic on their learning; they felt that being disconnected leveled the playing field for those students who were already feeling like outsiders. Studies of the effects of change in modality on depressed students at other universities across the US have demonstrated similar findings as mentioned in Casper et al. [9]

In terms of the effects of the pandemic on students' feeling connected to others, FYE and senior students reported lower connections with their TAs than sophomore and junior students. FYE students have not yet transitioned into their major and may have yet to develop relationships with departmental resources, such as TAs, that upper-level students have in their major courses. Seniors may not feel as much need for support in their courses as they approach graduation. Upper-level students expressed stronger connections to peers during the pandemic and reported lower effects of the pandemic on their learning than FYE students. It could be that upper-level students are not attempting to build new connections and thus they do not feel the transition affected their sense of belonging. It is also interesting to note that upper-level students provided briefer responses about effects of the transition to online learning than FYE students, which could be an indication that they did not feel a strong effect of the pandemic on their learning. Freeman et al.'s study of sense of belonging in college freshmen supports this idea that sense of belonging relates to student learning [4]. Some students reported relying on technology, such as social media platforms, to connect with other students and groups. Upper-level students reported feeling more connected to engineering groups than FYE students. This may be because they have had time to build connections and join clubs, study groups, professional organizations, etc. The observation that the transition had less effect on upper-level than lower-level students' learning may be because there are more project-based courses in senior courses, such as capstone, than in FYE and sophomore courses, which tend to be more lecture-based.

## **Limitations and Future Work**

It is possible that a 52% response rate and the fact that all data is from one semester may have biased our data. For example, we did not have enough agender, genderqueer, or students identifying as "other" to conduct statistical analyses by gender. Students who were most negatively impacted by the COVID-19 pandemic may not be responding to surveys due to the struggles they are facing. Although we were unable to undergo a thorough validation and reliability verification process for the added survey items, we felt it was acceptable to move forward due to the fast-paced nature of the pandemic.

We plan to continue to collect survey data and as classes move to in-person and hybrid formats, recruiting participants will likely be more successful. We plan to conduct interviews with students, selecting participants based on their demographics and the depth of their original responses to the survey. For example, our results showed a statistical difference between students who identified as Hispanic/Latino and White in terms of connecting to their peers, so we will recruit interview participants from those groups. We will also explore the gender effect we

observed on students' sense of belonging. Interview questions will explore the effects of the pandemic on their learning experience and on their engineering identity, sense of belonging, and perceptions of their future in engineering. We also will be placing special attention on student responses that centered around the idea that online and hybrid learning had "leveled the playing field" for students who previously did not feel a strong sense of connection and belongingness. This particular outcome has drawn interest from academic leadership already, as has previous work centered around similar concepts such as accidental inclusivity by Lacy et al. [8] Additionally, we will calculate effect size for each statistically significant contributor.

## Conclusions

The transition to online and hybrid classes had a primarily negative effect on most students' learning and sense of belonging. However, some students felt the transition allowed for more control over their schedule and classwork and leveled the playing field for those who already felt disconnected from their peers, instructors, TAs and other groups. As students progressed through their curriculum, they appeared to be less affected by the change from in-person to hybrid and virtual learning environments. They also showed less interest in making new friends and more focus toward graduating. The only significant difference in students' perceptions of their connections to peers was between Hispanic/Latino and White students. Male students reported significantly lower effects of the pandemic on their sense of belonging than female students. FYE students reported significantly higher effects of the pandemic on their learning than upper-level students. The findings of this study allow insight into undergraduate engineering students' experiences amid the pandemic that could serve as a call to action for changes in policy, curriculum, course structure, and/or advising practices. For example, knowing that FYE students were likely more affected by the pandemic than upper-level students, curriculum changes in FYE programs could include flexibility in how often courses are offered to help students stay on track for graduation. To alleviate students' feelings of stress and confusion, course structures could be more flexible in terms of due dates, optional exams, or late penalties. Advising practices may change in the number of credit hours suggested per semester, and guiding students to university resources for mental health and wellness when needed.

## Appendix:

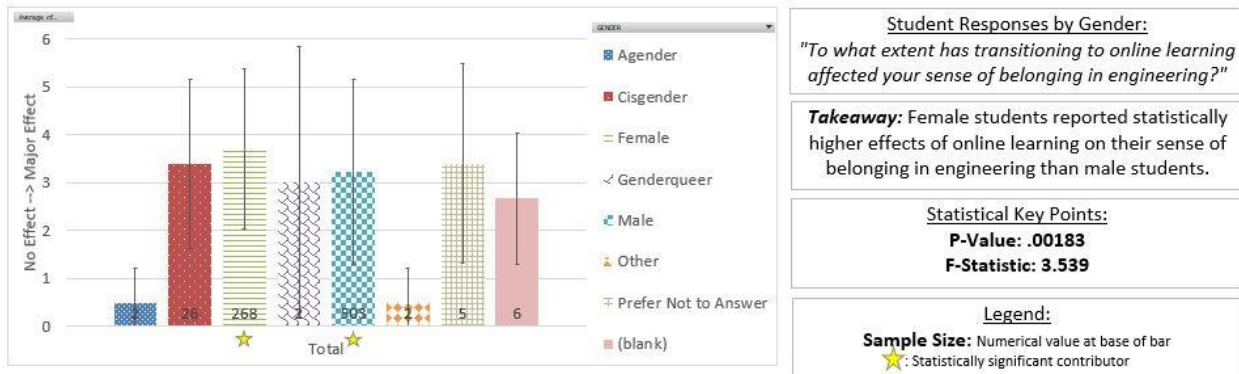
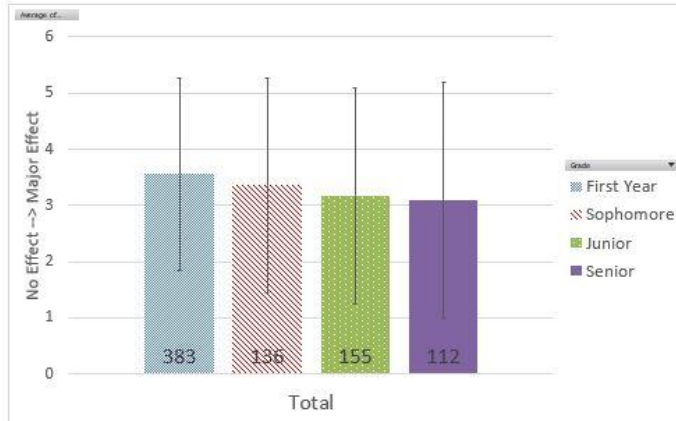


Figure 1: Effect on Sense of Belonging by Gender



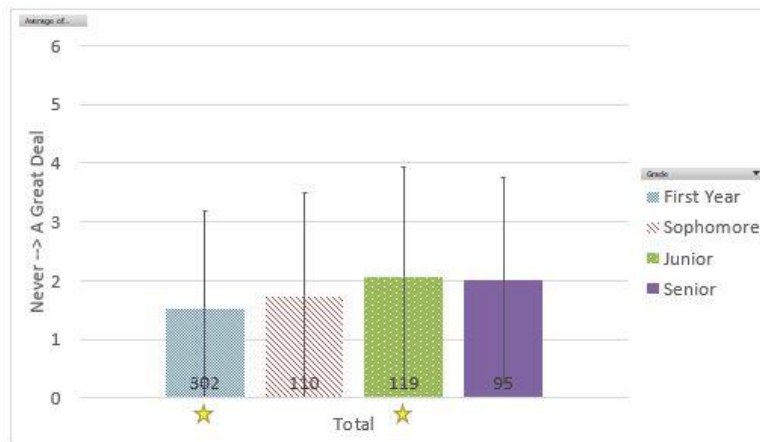
**Student Responses by Grade:**  
*"To what extent has transitioning to online learning affected your sense of belonging in engineering?"*

**Takeaway:** Effects of online learning on students' sense of belonging in engineering steadily declined from FYE to senior level, although there were no statistical differences between grade levels for responses to this question.

**Statistical Key Points:**  
**P-Value: .0466**  
**F-Statistic: 2.668**

**Legend:**  
**Sample Size:** Numerical value at base of bar  
 : Statistically significant contributor

Figure 2: Effect on Sense of Belonging by Grade



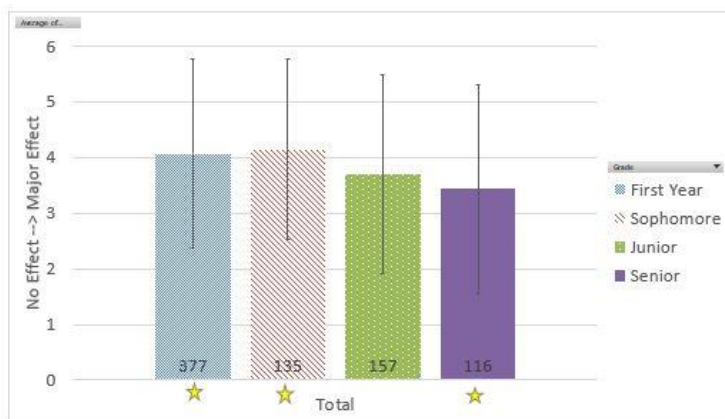
**Student Responses by Grade:**  
*"To what extent are you connecting to your other engineering groups?"*

**Takeaway:** There is a difference in First Year vs. Junior's ability to connect with their TAs

**Statistical Key Points:**  
**P-Value: .0123**  
**F-Statistic: 3.663**

**Legend:**  
**Sample Size:** Numerical value at base of bar  
 ☆: Statistically significant contributor

Figure 3: Effect on Connection with Engineering Groups by Grade



**Student Responses by Grade:**  
*"To what extent has transitioning to online classes affected your learning?"*

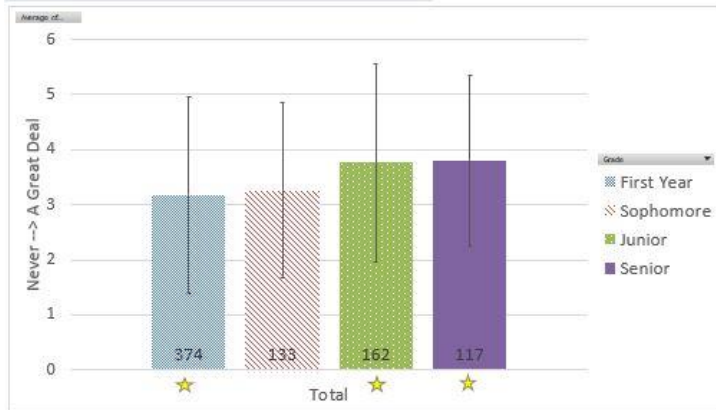
**Takeaway:** Seniors reported significantly lower effects of transitioning to online classes on their learning than First Years and Sophomores.

**Statistical Key Points:**  
**P-Value: .000853**  
**F-Statistic: 5.589**

**Legend:**  
**Sample Size:** Numerical value at base of bar  
 ☆: Statistically significant contributor

Figure 4: Effect on Learning by Grade





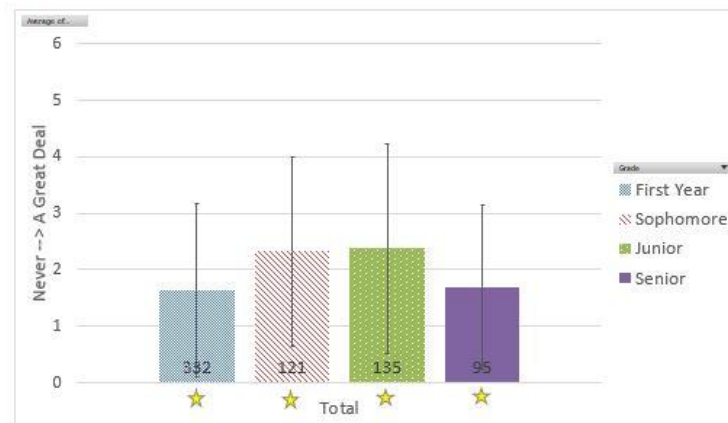
**Student Responses by Grade:**  
*"To what extent are you connecting to your peers?"*

**Takeaway:** First year engineering students reported significantly lower connections to peers than junior- or senior-level students

**Statistical Key Points:**  
**P-Value: .000129**  
**F-Statistic: 6.946**

**Legend:**  
**Sample Size:** Numerical value at base of bar  
 ☆: Statistically significant contributor

Figure 5: Effect on Connection with Peers by Grade



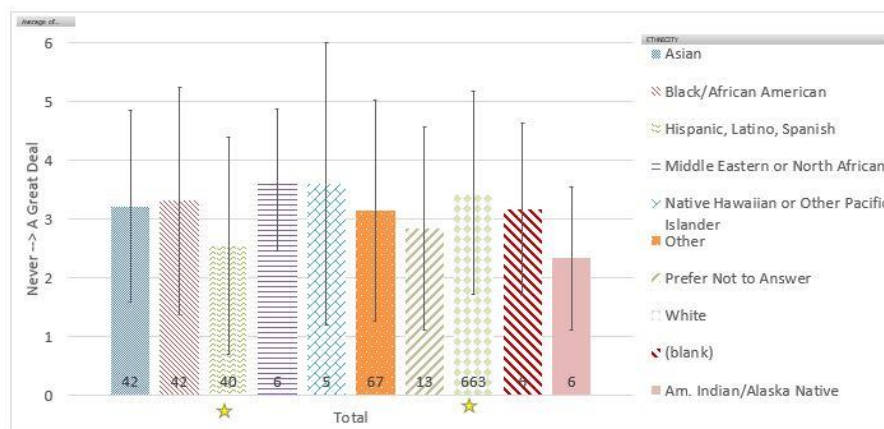
**Student Responses by Grade:**  
*"To what extent are you connecting to your TAs?"*

**Takeaway:** Grade level (for all four grades) is a factor in students' ability to connect with their TAs

**Statistical Key Points:**  
**P-Value: 1.495E-06**  
**F-Statistic: 10.159**

**Legend:**  
**Sample Size:** Numerical value at base of bar  
 ☆: Statistically significant contributor

Figure 6: Effect on Connection with TAs by Grade



**Student Responses by Ethnicity:**  
*"To what extent are you connecting to your peers?"*

**Takeaway:** Hispanic/Latino students reported significantly lower connections to peers than White students.

**Statistical Key Points:**  
**P-Value: .0578**  
**F-Statistic: 1.893**

**Legend:**  
**Sample Size:** Numerical value at base of bar  
 ☆: Statistically significant contributor

Figure 7: Effect on Connection with Peers by Ethnicity

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