The Role of Teaching Assistants and Faculty in Student Engagement

Dr. Denise Wilson, University of Washington

Denise Wilson is a professor of electrical engineering at the University of Washington, Seattle. Her research interests in engineering education focus on the role of self-efficacy, belonging, and other non-cognitive aspects of the student experience on engagement, success, and persistence and on effective methods for teaching global issues such as those pertaining to sustainability.

The Role of Teaching Assistants and Faculty in Student Engagement

Abstract
Students who have greater contact and interaction with instructors learn more and learn more deeply in college. In the early undergraduate years at large institutions, instructional support comes from multiple types of instructors including teaching assistants (TAs) and regular faculty. Yet, a disproportionate amount of research has focused on faculty rather than TAs and other contingent instructors. Given the importance of TAs in engineering education, evidence from previous studies that TAs were less effective than tenure track faculty in teaching undergraduates is concerning. But little is known as to how the efforts of TAs predict immediate student outcomes like engagement compared to the efforts of faculty, particularly in the context of individual courses.

In this study, engagement is studied in the context of individual courses in order to more directly compare the impact of what TAs do with what faculty do. Two engagement measures (attention and participation) were measured in the context of seven large undergraduate engineering courses at a large public institution ($N = 781$). Students responded to a survey containing multiple items that represented previously validated scales of both attention and participation. Across the board, TA support and faculty support positively and significantly predicted attention and participation. Student-TA interactions, however, predicted engagement with mixed results. Stronger and more frequent student-TA interactions negatively predicted attention while positively predicting participation. Interaction effects between student-TA interactions and faculty support were also significant, suggesting that what TAs do moderates the influence of faculty on student engagement.

Given the importance that interactions play in facilitating academic integration, the distinct contributions of TAs vs. faculty to student engagement are important and merit future research to assess their generalizability across other disciplines and institutions.

Background: The Importance of Engagement

Student engagement is most frequently measured in terms of what students do, is measured broadly across multiple courses and academic activities, and has been linked to a range of positive academic outcomes. For example, a study of over 1,000 students attending a diverse range of institutions [1] evaluated engagement in terms of the nature and amount of academic work a student performed, the frequency of student participation in class, and the degree of participation in other educationally fruitful activities. Bivariate correlations between these engagement measures and GPA were significant for all three forms of engagement ($p < 0.01$) and bivariate correlations between RAND test scores (representing critical thinking and student learning) and student engagement were significant for two of the three forms of engagement (academic work and participation in other educationally fruitful activities). The results of this study also indicated that students with lower abilities benefited more from engagement than

classmates with higher abilities and that relationships between engagement and learning and engagement and grades are different for seniors than for freshman. Consistent with this study, Kuh et al. [2] found in a study of 18 institutions that *participation in educationally fruitful activities* was positively related to first year grades and persistence into the second year of college. This study also found that such links were stronger for students of color and for lower ability students, providing a compensatory effect for these students in bolstering their likelihood of academic success. In both studies, engagement was measured using items from the National Survey of Student Engagement (NSSE) [3], an annual survey of undergraduate students administered electronically or on paper to randomly selected first-year and senior students attending four-year institutions across the United States. The engagement scale that captures *participation in educationally fruitful activities* contains 19 items that evaluate a broad range of engagement behaviors across students' academic experiences. These behaviors include asking questions in class, contributing to class discussions, making a class presentation, coming to class having completed readings, working with classmates out of class, tutoring other students, receiving prompt feedback from an instructor, working harder than anticipated, working with faculty members on non-course related projects, and others [2].

Consistent with these studies, a meta-analysis of eight individual research studies conducted over ten years showed that students who interacted with faculty and peers experienced significant gains in critical thinking [4] compared to those who were not as engaged in those interactions. In this meta-analysis, Gellin et al. [4] concluded that studies which focus on more specific activities (as opposed to looking at student engagement on campus more broadly) can provide administrators with opportunities to invest in engagement where it matters most.

This study narrows the focus of engagement to more specific activities by studying engagement in the context of specific undergraduate courses in engineering. It also seeks to compare what students do (measured in the form of class *participation*) which corresponds to the types of measures employed by NSSE and a vast majority of engagement studies in education to how much they are motivated (in the form of *attention*). Given practitioner interest in how to influence student engagement, this study evaluates *participation* and *attention* in the context of what instructors (both faculty and TAs) do in these courses.

Background: Faculty and TAs

Faculty and TAs are tasked with engaging students and facilitating student learning in a range of contexts, whether in the lecture hall, the lab, the quiz/recitation section, or office hours. In most but not all cases, faculty play the role of primary instructor while TAs fulfill the role of secondary instructor, supporting a course via laboratories, recitations, grading, and other teaching activities. Whether faculty or TA, primary or secondary, instructors employ a range of instructional approaches to engage student learning and interact with students to develop rapport, answer questions, and further scaffold instruction. Although there remains some confusion in the literature regarding terms, faculty support generally refers to teaching technique (both teacher-centered and student-centered) while faculty interactions refer to more informal exchanges with students which include both curriculum and course-based interactions as well as conversations about career and other intellectual matters. In this paper, we will refer to teaching technique within a particular course as *faculty support* and informal exchanges that relate to the course content as *faculty contact* (to distinguish it from broader exchanges with students that

extend beyond discussing a particular course). *TA support* and *TA contact* will refer to similar actions and interactions on the part of a TA or TAs who are supporting a particular course.

Faculty Interactions: Lamport's (1993) extensive literature review highlights the multi-dimensional importance of student-faculty interactions [5]. Just as the value of college is greater than the transmission of factual material, so the value of the student-faculty relationship extends beyond the formal exchanges that occur in the classroom. Faculty and peers are largely regarded as the two primary agents of socialization on a college campus, and despite the powerful influence of peer groups on student values, attitudes, and development, informal interactions can be sufficiently powerful to exceed the influence of the general student culture. Lamport's review also points out that multiple studies have linked student-faculty interactions with overall satisfaction in college, although studies of the impact of such interactions on academic achievement have produced mixed results. Not surprisingly, student-faculty interactions also positively influenced the intellectual and personal development of individual students [5]. For example, in a study of over 4,500 students at various doctoral and master's level institutions, Lundberg and Schreiner [6] found that the quality of faculty-student relationships significantly predicted learning for all ethnic groups. A more recent study of over 43,000 students from 119 majors across nine campuses confirmed the influence of student-faculty of interactions by demonstrating significant links between these interactions and cognitive development [7]. Furthermore, the strength of these interactions increased in departments that were more organized, had a higher level of positive faculty support, and whose curriculum focused on developing critical thinking and reasoning skills among their students [7].

Faculty Support: the teaching practices that faculty use to support students are also influential in student academic outcomes. For example, Umbach & Wawrzynski [8] demonstrated that in a large multi-institutional sample of over 22,000 students, students reported higher levels of engagement at institutions where faculty tended to use active and collaborative learning techniques and also challenged students academically. In a study that focused on behavioral and emotional engagement rather than on more traditional measures of engagement associated with what students do, longitudinal data across five institutions demonstrated mixed results with formal, course-related faculty support in STEM disciplines predicting positive emotional engagement and behavioral effort at smaller, teaching-oriented institutions but not at larger research institutions [9]. In engineering, student satisfaction with faculty availability and the quality of instruction and advising was found to be negatively correlated with student disengagement across a broad range of engineering majors at four different institutions [10].

TA Interactions and TA Support: the literature contains far fewer studies that focus on the impact of teaching assistants (TAs) on student engagement compared to those that focus on faculty interactions and faculty support. TAs play significant roles in undergraduate instruction in the United States. In 2017, the Bureau of Labor Statistics estimated that 131,490 graduate students were employed as teaching assistants in the United States, and of these, 126,340 individuals were employed at colleges, universities, and professional schools, comprising 4.15% of the university workforce [11]. In undergraduate engineering courses, TAs performed a wide variety of tasks including lecturing, leading lab sections, conducting review sessions, facilitating discussions, holding office hours, and providing technological support. A study of biology courses demonstrated that TAs provided a more personalized experience for students that acted

as an essential and valuable complement to the more aloof, authoritative, and strict control that undergraduates perceived of instructional faculty. A similar study of high-enrollment biology courses at a research-intensive Australian university [12] found that consistent TA-student pairings were positively associated with gains in student motivation and learning. While sparse, these studies speak to the unique role that TA support and TA interactions can play in facilitating student engagement and learning particularly with regard to how TAs play more of a peer support role to students while faculty act more in an authoritative role in the student's experience.

This Study

This single-institution, cross-sectional study investigates the role of both TA and faculty support and interactions on student engagement as measured both in traditional contexts (what are students doing?) compared to what they are thinking (are they paying attention?). Three research questions guided the analysis in this study.

Research Question #1 (RQ1):
Do TA behaviors influence student engagement?
Based on the powerful influence of peer support demonstrated in the existing literature and the fact that TAs are often regarded more as peers than authority figures, we expect that TA support and interactions will predict student engagement, although to different levels than faculty support and interactions.

Research Question #2 (RQ2):
Do faculty behaviors influence student engagement?
Based on results in the existing literature on faculty support and interactions, we expect that such support will strongly predict engagement, although differences in the relationships among the independent faculty variables and the two dependent engagement variables are likely to provide insight into how faculty behaviors manifest into student engagement.

Research Question #3 (RQ3):
Are the relationships between these (faculty and TA) behaviors and engagement dependent on the course type, TAs, and other course-level variables?
A limited number of studies in the existing literature have explored whether what faculty do in their courses is influenced by the discipline/major or department in which they teach. Some differences do emerge with positive department climate and institutional emphasis on student-centered teaching playing a role in the relationships between faculty interactions and student learning and engagement [7]. This research question looks at the same issue but within the smaller contexts associated with individual courses and TA-led sections. If TA-led sections and courses do not influence the links between instructional behaviors and student engagement, then it is more likely that these links will be generalizable across other engineering courses, engineering majors, and institutions.

Research Methods

This cross-sectional study is based on a survey that was specifically designed to measure TA and faculty behaviors alongside student engagement. The study was conducted at a single large public university classified as a doctoral university with very high research activity [13] across

seven large undergraduate engineering courses. Class enrollment ranged from 60 to 250 students. A majority of students were male, Asian or White, and U.S. citizens or permanent residents. Demographics describing the survey population are summarized in Table 1.

Table 1: Survey Participant Demographics (*N* = 781)

Demographic	Group: N (%)*	
Gender	Males: 585 (74.9%)	Females: 184 (23.6%)
Race	Asian: 357 (45.7%) Black: 27 (3.5%)	Caucasian/White: 311 (39.8%) Other (non-Black) URM: 67 (8.6%)
U.S. Status	U.S. citizen/ Permanent resident: 633 (81.0%)	International student: 137 (17.5%)

* Percentages within a demographic group do not necessarily add up to 100% because not all participants responded and some responded as Other.

Participants and Procedures

Students from the seven different sophomore-level engineering courses (four in electrical and computer engineering, three in mechanical engineering) involved in this study were recruited between Fall 2016 and Spring 2018 to complete a survey about the course. The courses surveyed represented a broad range of faculty, instructors, and teaching assistants. The instructor for each course was given the choice of offering the survey to students in paper-and-pencil or electronic form. Students in one course were offered the paper-and-pencil version and completed this version in class. Students in the other six courses were offered the electronic version and completed it outside of class.

Participation in the study was voluntary. At the discretion of the instructor, students were offered an incentive for completing the survey, which was usually a form of extra credit in the course. Students were also offered an alternative to completing the survey which provided the same amount of extra credit in order to avoid any perceptions of coercion or undue influence.

781 students completed the survey, representing 85% of students enrolled overall in the seven courses and between 50% and 91% of students in each course, with no duplications (i.e. no student was enrolled in more than one of the courses studied). In addition to demographic questions, the survey contained a range of items related to how faculty were behaving in the course and how TAs were behaving. Additional scales related to belonging, emotional engagement, identity, task value, and other affective measures were included in the study but were not used in this analysis.

Data Analysis

The data were analyzed using SPSS 19. Descriptive statistics (mean, standard deviation) were computed for all instructional support (independent variables) and engagement measures (dependent variables). Exploratory factor analyses using principal component analysis with varimax rotation were performed on the instructional support items in the survey to identify

suitable scales to represent TA and faculty behaviors. Pearson bivariate correlations were evaluated between engagement variables and between instructional support variables to identify the possibility that multiple scales could be measuring the same thing.

Once the scales were finalized, a three-level linear regression model was constructed for each of the two measures of engagement (*attention* and *participation*). The first level of the model contained TA behavior scales, the second level of the model contained faculty behavior scales, and the third level of each model contained any relevant interactions. The most parsimonious regression model containing TA behaviors, faculty behaviors, and relevant interactions was then selected based on finding a minimum Bayesian (BIC) criterion by adding TA variables, faculty variables, and then interaction variables to the model one at a time to evaluate their impact on the BIC. The model with the minimum BIC was selected as the final regression model for each form of engagement.

Finally, a mixed model, equivalent to HLM (hierarchical linear modelling), was constructed to understand whether nesting of students within TA sections and within courses affected the engagement variables. Significant results of a null mixed model (no independent variables) at the TA level or at the course level would suggest that predictive relationships in a linear regression might be present in some courses or with some TAs and not others. Significance in the HLM null model would bring the results of the linear regression model into question and necessitate further analysis using an HLM approach to the data.

Measures

The dependent engagement variables used in this analysis were based on students' *attention* and *participation* in the courses studied. All engagement scales used items that were adapted for use in higher education [14] from previous studies in K-12 [15]. Items for both engagement scales were assessed using a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The original scales measuring behavioral engagement have demonstrated adequate internal consistency and construct validity. Items belonging to each of the two scales are listed in Table 2.

Table 2: Engagement (Dependent) Variables

Primary Scale	*Items*
Behavioral *attention* ($\alpha = 0.83$)	When I'm in this class, my mind wanders.
	When I'm in this class, I think about other things.
Behavioral *participation* ($\alpha = 0.64$)	In this class, I participate in class discussions during lecture with my classmates and instructors.
	In this class, I participate in class discussions during <quiz, lab> section with my classmates and instructors.

Attention measures to what extent students are thinking about other things besides the topics at hand in their classes. *Participation* measures how students view their participation in class discussions with peers or with instructors. Although in this dataset, *participation* had an internal reliability of less than the standard 0.7, there is evidence that reliability between 0.6 and 0.7 is adequate [16]. Therefore, *participation* was retained for analysis.

Table 3: Instructional Support (Independent) Variables

Scale	*Items*
Faculty Support ($\alpha = 0.90$)	The professor in this class is willing to spend time outside of class to discuss issues that are of interest and importance to me.
	The professor in this class is interested in helping me learn.
	The professor in this class cares about how much I learn.
	The professor in this class treats me with respect.
	The professor in this class is available when I need help.
	The professor in this class has clearly explained course goals and requirements.
	The professor in this class often teaches in an organized way.
	The professor in this class often uses real-world examples or illustrations to explain difficult points.
	The professor in this class often stops to ask questions during class.
	The professor in this class is often funny or interesting.
Faculty Contact ($\alpha = 0.92$)	I have discussed career plans with the professor in this class.
	I have discussed academic work with the professor in this class.
	I have had intellectual discussions outside of academic work with the professor in this class.
	I have discussed course selection with the professor in this class.
	I have discussed my academic performance with the professor in this class.
	I have attended office hours to see the professor in this class.
	I have e-mailed the professor for assistance in this class.
TA Support ($\alpha = 0.92$)	*All of the items on the Faculty Support Scale (adapted to TAs) and:*
	The TA for my recitation or lab section in this class often arrives at least five minutes before section begins.
	The TA for my recitation or lab section in this class often stays after class to answer questions.
	At least one of the TAs in this class has often provided feedback on a draft or work/homework in progress.
TA Contact ($\alpha = 0.92$)	I have discussed career plans with at least one of the TAs in this class.
	I have had intellectual discussions outside of academic work with at least one of the TAs in this class.
	I have discussed course selection with at least one of the TAs in this class.
	I have discussed my academic performance with at least one of the TAs in this class.
	I have e-mailed at least one of the TAs in this class for assistance.

The independent variables used to represent the behaviors of faculty in this study were adapted from previous measures of academic support, teaching practices, faculty contact, and observations of instructor behavior in engineering classrooms. Four items were used from engagement indicators related to teaching practices in the National Survey of Student Engagement [3], five items were adapted from the teacher academic support subscale developed by Van Ryzin et al. [17] and six items were adapted from the faculty contact scale used by Einarson and Clarkberg [18]. An additional six items were also added to assess faculty support based on observations of classrooms and interactions in a previous study [19]. In total, 21 items were developed to assess

faculty behaviors, a majority of which were adapted from scales used to measure primary instructor (e.g. faculty) support in the classroom. These same 21 items were also adapted for measuring TA behaviors. Exploratory factor analyses (EFA) were conducted independently on the 21 faculty behavior items and on the 21 TA behavior items using varimax rotation to identify usable scales for this study. The number of factors was initially determined by an eigenvalue threshold of 1 while also considering the point at which the scree plot for the eigenvalues levelled off and adding additional factors explained little additional variance in the data. Items that demonstrated communalities of less than 0.5 *and* failed to demonstrate a strong (>0.6) loading on any single factor were discarded. Items that loaded onto more than one factor (>0.4) were also discarded. After items were discarded, any remaining factors which contained at least two items were retained for analysis. The results of this EFA produced four measures: faculty support, TA support, faculty contact, and TA contact (Table 3).

Results & Discussion

Skewness and kurtosis of the engagement variables were first calculated to confirm the normality of the dependent variables. Results indicated that both engagement variables were sufficiently normally distributed to proceed with analysis [16]. The Pearson bivariate correlations between the two engagement variables was below .5. Therefore, both engagement variables were retained. Descriptive statistics for these two engagement variables and the four instructor behavior variables are summarized in Table 4.

Table 4: Descriptive Statistics

	Faculty		*TA*		*Engagement*	
	Support	*Contact*	*Support*	*Contact*	*Attention*	*Participation*
N	690	696	696	755	762	736
Mean	3.96	1.72	3.56	1.58	2.76	3.21
Standard Deviation	0.64	0.90	0.78	0.87	0.99	0.95

Table 5: Summary of Linear Regression Models

	Model 1	Model 2	Model 3
Independent Variables	TA Support TA Contact	Faculty Support	Interaction Variables
Attention	$R^2 = 0.033$ SE = 0.973 BIC = -17.022	$R^2 = 0.052$ SE = 0.964 BIC = -22.774	$R^2 = 0.096$ SE = 0.942 BIC = -45.423
Participation	$R^2 = 0.268$ SE = 0.825 BIC = -218.7	$R^2 = 0.280$ SE = 0.819 BIC = -222.4	$R^2 = 0.292$ SE = 0.813 BIC = -226.0

To better understand how instructor contact and instructor support contributed to both *attention* and *participation*, two three-level regression models were constructed. A summary of the characteristics for each of these models including the BIC information criterion for the most parsimonious model obtained as described in the Data Analysis section is provided in Table 5.

The R^2 goodness of fit measure for the first model was low for *attention* explaining only 3.3% of the variability in the data but a much higher 26.8% of the variability in the data for *participation*. R^2 increased for subsequent levels of each model, but the improvement in fit was greatest for *attention*.

Research Question #1 (RQ1):
Do TA behaviors influence student engagement?
Results for the most parsimonious regression models are summarized in Tables 6 and 7 for *attention* and *participation* respectively. In Model 1 (TA behavior only) and Model 2 (TA and faculty behavior), TA support consistently and positively predicted both *attention* and *participation*. However, while TA contact also positively and significantly predicted *participation*, TA contact negatively and significantly predicted *attention*.

The results show that TA support was a consistent and positive predictor of engagement. Students who reported that their TA is organized, prepared for class, arrives early, answers questions and provides feedback also paid more attention and participated more in the course overall, presumably in both lecture (faculty-led) and TA-led (lab, recitation, etc.) sessions. This result is consistent with faculty-based studies that have demonstrated significant links between engagement (or alternatively reduced disengagement) and teaching quality [10], teacher's use of student-centered teaching techniques [8], teacher availability [10], and overall course support [9]. In this study where faculty and TAs were studied as individual participants in the teaching process, the emergence of TA support as a distinct predictor of engagement is noteworthy and speaks to the unique importance of what TAs do to facilitate student engagement and achievement.

Table 6: Hierarchical Regression Models for Attention

Predictor Variable	Model 1			Model 2			Model 3		
	B (SE)	*p*		B (SE)	*p*		B (SE)	*p*	
Constant	2.297 (0.18)	0.000	***	1.592 (0.27)	0.000	***	1.298 (0.27)	0.000	***
TA Support	0.206 (0.05)	0.000	***	0.152 (0.05)	0.005	**	0.177 (0.05)	0.001	**
TA Contact	-0.168 (0.05)	0.001	**	-0.170 (0.05)	0.002	**	-0.086 (0.05)	0.093	
Faculty Support				0.227 (0.07)	0.001	**	0.251 (0.06)	0.000	***
TA Contact X Faculty Support							-0.184 (0.03)	0.000	***

* $p<0.05$; ** $p < 0.01$; *** $p < 0.001$

In contrast to TA support, student contact with TAs demonstrated mixed associations with engagement. In our regression models, while student-TA contact positively predicted *participation* (Table 7), it negatively predicted *attention* (Table 6). The positive influence of student-faculty interactions on engagement demonstrated on a large sample of students across multiple institutions by Umbach & Wawrzynski [8] would suggest that student-TA contact would also be positively linked to engagement. While this is the case for *participation*, it is not the case for attention. Why? One possible and logical explanation for this negative link between

the two is that students are using contact with their TAs to compensate for not wanting to or not being able to pay *attention* in class. Such a conclusion adds further weight to the importance of TAs, as not only do the ways in which they teach positively predict engagement but their frequent contact with students may offset other shortcomings in the overall teaching team.

Table 7: Hierarchical Regression Models for Participation

Predictor Variable	Model 1			Model 2			Model 3		
	B (SE)	*p*		B (SE)	*p*		B (SE)	*p*	
Constant	0.999 (0.15)	0.000	***	0.457 (0.23)	0.045	*	0.064 (0.23)	0.009	**
TA Support	0.551 (0.16)	0.000	***	0.509 (0.05)	0.000	***	0496 (.05)	0.000	***
TA Contact	0.159 (0.04)	0.000	***	0.158 (0.04)	0.000	***	0.115 (0.04)	0.009	**
Faculty Support				0.175 (0.06)	0.002	**	0.163 (0.06)	0.003	**
TA Contact X Faculty Support							0.092 (0.03)	0.002	**

* p<0.05; ** p < 0.01; *** p < 0.001

Research Question #2 (RQ2):

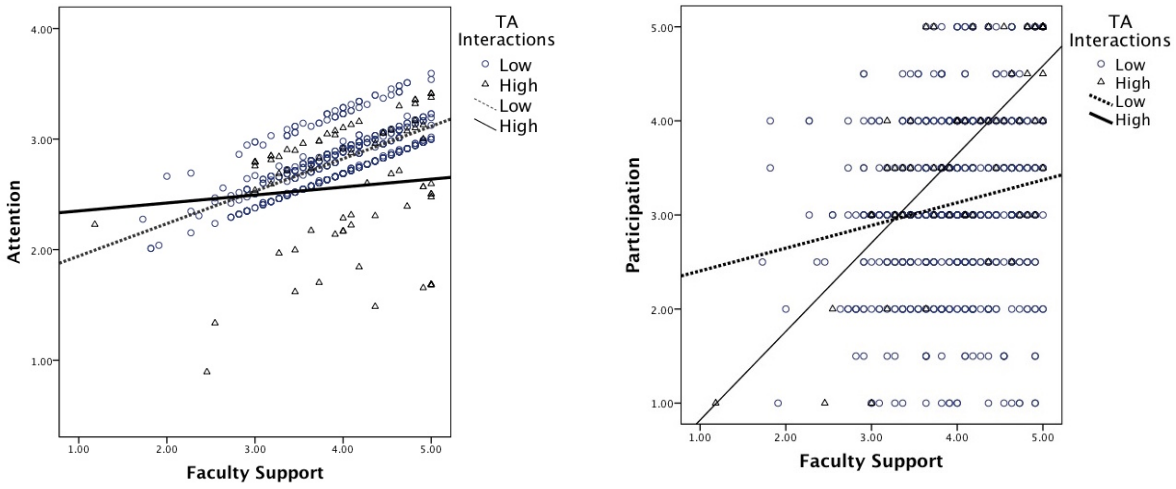
Do faculty behaviors influence student engagement?

In both sets of regression models, faculty support was a positive and significant predictor of both *attention* and *participation*. This is not surprising considering other research studies that have also demonstrated such positive relationships between what faculty do and improved student engagement [8][9] and reduced student disengagement [10]. In most previous studies, engagement was measured differently as an observable measure related to hours spent on certain academic activities to represent worthwhile engagement. This study adds to the previous research by supplementing the importance of faculty support not only in observable measures but in motivational levels of engagement represented by *attention* in this study.

An interesting result from the regression models is that faculty support tended to be a stronger positive predictor of *attention* (B= 0.227) than TA support (B = 0.152) while for *participation*, TA support was a stronger predictor (B = 0.509) than faculty support (B = 0.175). This result adds more support to the hypothesis that student-TA contact compensates for a lack of *attention* (in faculty-led classes). It may also be a logical outcome of the fact that most lectures in engineering remain teacher-centered and the predominant role of the student in these traditional lecture-based settings is to pay *attention*, while in TA-led sections such as laboratories, activities are more student-centered and the primary role of the student shifts more to *participation* in the activities at hand rather than to paying *attention* to the TA. The hypothesized relationship between TA contact and faculty support is further strengthened by the fact that in both regression models, the interactions between TA contact and faculty support are both significant (negative for *attention* and positive for *participation*).

The negative interaction effect between TA contact and faculty support in the model for *attention* suggests that for high levels of TA contact, faculty support was not as strong a predictor of

student *attention*. TA contact may be moderating the impact of faculty support on *attention* by reducing the effect of faculty support on *attention*. For *participation*, however, the interaction effect between faculty support and TA contact was positive (Figure 1b). Stronger or more frequent student-TA contact results in a stronger and more positive relationship between faculty support and *participation*. In contrast to the *attention* model, TA contact may be moderating the impact of faculty support on *participation* by increasing the effect of faculty support on *participation* rather than reducing it which appears to be the case for *attention*.



(a) Attention *(b) Participation*

Figure 1: Interaction Effects between TA Interactions/Contact and Faculty Support

For low levels of faculty support, student-TA contact seems to be reducing the impact of that support and levelling *attention*. In contrast, for moderate to high levels of faculty support, students participated more overall when student-TA contact was also high. These results speak consistently to the positive and supportive role that TAs can play not only in the support they provide through quality of teaching but also in the frequency and substance of their contact with engineering students.

Research Question #3 (RQ3):
Are the relationships between these (faculty and TA) behaviors and engagement dependent on the course type, TAs, and other course-level variables?
This study has students nested within sections led by individual TAs and nested again in courses. In order to validate the choice of hierarchical linear regression to study the influence of TA and faculty behaviors on engagement, the effects of nesting must be considered. To do this, a null mixed model looked at the covariance associated with individual students, TAs, and courses within the data collected in this study. This null HLM model indicated that the covariance associated with TAs and with different courses was not significant (Table 8). Thus, nesting was not considered a concern in this analysis, making hierarchical linear regression a viable option for considering the initial two research questions (RQ1 and RQ2).

Table 8: Covariance Parameters Associated with HLM Models

Attention				
Nesting Level	Estimate	Standard Error	Significance	
Student	0.9606	0.052	0.000	***
TA	0.0000	0.000		
Course	0.0017	0.010	0.867	
Participation				
Nesting Level	Estimate	Standard Error	Significance	
Student	0.8508	0.047	0.000	***
TA	0.0500	0.037	0.175	
Course	0.0127	0.015	0.384	
* $p<0.05$; ** $p < 0.01$; *** $p < 0.001$				

Limitations and Implications

While this study has provided confirmations of the importance of both TAs and faculty in their support of and contact with students, the study is cross-sectional and causality cannot be definitively proven. The data is also limited to a single institution, and therefore these findings may not generalize to other institutions of higher education. Nevertheless, the results of this study highlight some important nuances in how TA and faculty behaviors may influence engagement differently and how TAs and faculty can complement one another in the effort to increase engagement among all students. In particular, this study suggests that TAs should pay particular attention to the quality and frequency of their contact with students who are not paying sufficient *attention* in class. TAs can also emphasize synchronizing activities in TA-led sessions with activities or examples provided in faculty-led sessions to strengthen overall *participation*.

Concluding Remarks

This study took a narrow but deep look into large engineering courses to discern differences in how the behaviors of TAs and faculty predict student engagement as represented by *attention* and *participation*. The results show not only that student-TA contact and TA and faculty support significantly predicted both forms of engagement, but that student-TA contact does so in a negative way for *attention*. This suggests that TA assistance can compensate for reduced *attention* in the classroom. Significant interactions between TA contact and faculty support also suggest that student-TA contact can increase *participation* among students and moderate *attention* in the classroom to more stable levels. Future research should investigate these effects in a broader range of classrooms within engineering and across related STEM disciplines. Evaluating engagement at a fine-grained level (by TA and by course) provides an opportunity to reduce confounding effects and illuminate distinct effects of faculty vs. TA support in large courses.

Acknowledgments

The author would like to gratefully acknowledge the National Science Foundation for their support of this work (DUE grant number 1504618). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily

reflect the views of the National Science Foundation. The author would also like to thank the statistical consulting resources provided by the Center for Statistics and the Social Sciences, University of Washington.

References

[1] R. M. Carini, G. D. Kuh, and S. P. Klein, "Student Engagement and Student Learning: Testing the Linkages," *Res. High. Educ.*, vol. 47, no. 1, pp. 1–32, Feb. 2006, doi: 10.1007/s11162-005-8150-9.

[2] G. D. Kuh, T. M. Cruce, R. Shoup, J. Kinzie, and R. M. Gonyea, "Unmasking the Effects of Student Engagement on First-Year College Grades and Persistence," *J. High. Educ.*, vol. 79, no. 5, pp. 540–563, 2008.

[3] "NSSE Engagement Indicators." http://nsse.indiana.edu/html/engagement_indicators.cfm (accessed Mar. 06, 2019).

[4] A. Gellin, "The effect of undergraduate student involvement on critical thinking: A meta-analysis of the literature 1991-2000," *J. Coll. Stud. Dev.*, vol. 44, no. 6, pp. 746–762, 2003.

[5] M. A. Lamport, "Student-faculty informal interaction and the effect on college student outcomes: A review of the literature," *Adolescence*, vol. 28, no. 112, p. 971, 1993.

[6] C. A. Lundberg and L. A. Schreiner, "Quality and frequency of faculty-student interaction as predictors of learning: An analysis by student race/ethnicity," *J. Coll. Stud. Dev.*, vol. 45, no. 5, pp. 549–565, 2004.

[7] Y. K. Kim and L. J. Sax, "Are the effects of student–faculty interaction dependent on academic major? An examination using multilevel modeling," *Res. High. Educ.*, vol. 52, no. 6, pp. 589–615, 2011.

[8] P. D. Umbach and M. R. Wawrzynski, "Faculty do matter: The role of college faculty in student learning and engagement," *Res. High. Educ.*, vol. 46, no. 2, pp. 153–184, 2005.

[9] D. Wilson, D. C. Jones, R. A. Bates, T. F. Smith, M. Plett, and N. M. Veilleux, "Sometimes, Faculty Matter: The Contribution of Faculty Support to Future Engagement," in *ASEE American Society for Engineering Educaiton Annual Conference*, Seattle, Washington, 2014, vol. 26, p. 1.

[10] H. L. Chen, L. R. Lattuca, and E. R. Hamilton, "Conceptualizing engagement: Contributions of faculty to student engagement in engineering," *J. Eng. Educ.*, vol. 97, no. 3, pp. 339–353, 2008.

[11] Bureau of Labor Statistics, "Graduate Teaching Assistants," *Occupational Employment Statistics, May 2018: Graduate Teaching Assistants*. https://www.bls.gov/oes/current/oes251191.htm#(3) (accessed May 30, 2019).

[12] J. Good, K. Colthorpe, K. Zimbardi, and G. Kafer, "Research and Teaching: The Roles of Mentoring and Motivation in Student Teaching Assistant Interactions and in Improving Experience in First-Year Biology Laboratory Classes.," *J. Coll. Sci. Teach.*, vol. 44, no. 4, p. n4, 2015.

[13] Center for Postsecondary Research, "Carnegie Classification of Institutions of Higher Education." http://carnegieclassifications.iu.edu/ (accessed Mar. 05, 2019).

[14] D. Wilson *et al.*, "Belonging and Academic Engagement Among Undergraduate STEM Students: A Multi-institutional Study," *Res. High. Educ.*, vol. 56, no. 7, pp. 750–776, Nov. 2015, doi: 10.1007/s11162-015-9367-x.

[15] M. Miserandino, “Children who do well in school: Individual differences in perceived competence and autonomy in above-average children,” *J. Educ. Psychol.*, vol. 88, no. 2, pp. 203–214, 1996, doi: 10.1037/0022-0663.88.2.203.
[16] D. George and P. Mallery, *SPSS for Windows Step by Step: A simple guide and reference*. Boston, Massachusetts: Allyn and Bacon, 2014.
[17] M. J. Van Ryzin, A. A. Gravely, and C. J. Roseth, “Autonomy, belongingness, and engagement in school as contributors to adolescent psychological well-being,” *J. Youth Adolesc.*, vol. 38, no. 1, pp. 1–12, 2009.
[18] M. K. Einarson and M. E. Clarkberg, “Race Differences in the Impact of Students’ Out-of-Class Interactions with Faculty.,” *J. Profr.*, vol. 3, no. 2, 2010.
[19] J. Wright, D. Wilson, and L. Summers, “It’s Not Just What TA’s Know: Exploring the Role of Teacher Efficacy among Engineering TA’s,” in *Proc., ASEE Annual Conference and Exposition*, Tampa, Florida, 2019.