# Impact of First-Year Programming for Underprepared Students

**Prof. Petra Bonfert-Taylor, Dartmouth College**

Petra Bonfert-Taylor is a Professor and an Instructional Designer at the Thayer School of Engineering at Dartmouth College. She received her Ph.D. in Mathematics from Technical University of Berlin (Germany) in 1996 and subsequently spent three years as a postdoctoral fellow at the University of Michigan before accepting a tenure-track position in the Mathematics Department at Wesleyan University. She left Wesleyan as a tenured full professor in 2015 for her current position at Dartmouth College. Petra has published extensively and lectured widely to national and international audiences. Her work has been recognized by the National Science Foundation with numerous research grants. She is equally passionate about her teaching and has recently designed and created a seven-MOOC Professional Certificate on C-programming for edX, after previously having designed a MOOC "Analysis of a Complex Kind" on Coursera. The recipient of the New Hampshire High Tech Council 2018 Tech Teacher of the Year Award, the Binswanger Prize for Excellence in Teaching at Wesleyan University and the Excellence in Teaching Award at the Thayer School of Engineering, Petra has a strong interest in broadening access to high-quality higher education and pedagogical innovations that aid in providing equal opportunities to students from all backgrounds.

**Dr. Alicia Betsinger, Dartmouth College**
**Ms. Holly Wilkinson P.E., Dartmouth College**

Holly Wilkinson is Assistant Dean of Academic and Student Affairs at the Thayer School of Engineering at Dartmouth. She previously served as Director of Career Services at Thayer School, Director of Recruitment at Colorado School of Mines, and Director of Engineering Admissions at Norwich University. She holds a Master of Business Administration from Norwich University and a Bachelor of Science in Civil Engineering from Union College.

**Mr. Ray Helm, Dartmouth College**
**Dr. Yanmin Zhang, Dartmouth College**
**Pritish Ponaka, Dartmouth College**

# Impact of First-Year Programming for Underprepared Students


## Abstract

This Complete Evidence-Based Practice paper addresses an intervention started two years ago at the Thayer School of Engineering at Dartmouth college aimed at improving the first-year experience and retention of underprepared students in the engineering major. Program components, program analysis and retention results are presented.


## Background and Motivation

The percentage of students from underrepresented groups earning degrees in engineering remains low nationally (NSF, 2015). While women earned close to 60% of all bachelor's degrees in 2012, less than 20% of those degrees were in engineering (NSF, 2015). And Hispanic, Native American, and African American students combined earned less than 14% of the engineering degrees in 2012 (ASEE, 2014), though they comprised over 30% of the population (NSF, 2015).

For the purpose of this paper a student is considered "retained" in engineering if they matriculate with an interest in engineering and ultimately end up declaring an engineering major. With this definition, the Dartmouth engineering retention rate for women (58%) has been slightly higher than the rate for men (54%); however, the rate for minority students has been lower (46%) while the lowest rate is found among female minority students (40%). Also, campus data shows that the majority of students who were initially interested in engineering but subsequently switched out did so after poor performance in a prerequisite mathematics or science course in their first year; hence they left the engineering program often before they had the chance to take a single engineering class. For example, of all students with engineering interest who place into an introductory calculus course, 68% leave the major, and nearly half are minority students. The students who make up this large drain out of the engineering program are termed "underprepared" in what follows. "Underprepared" is to be understood as compared to the majority of students entering the institution (who typically place out of introductory calculus.)

During the summer of 2016, a new program, the "Dartmouth Emerging Engineers" (DEE) program was launched aimed at supporting underprepared students through their prerequisites, both academically and emotionally. The program was designed after interviewing many students, both those who persisted and those who left engineering, researching programs at other schools, and building upon prior experience. The main program goals include an increased retention rate in engineering amongst underprepared students and the creation of meaningful relationships and networks for

these students within their engineering experience.

Specific program goals:

- *Support the development of meaningful relationships for underprepared first-year students within their engineering experience*. A student survey about interpersonal experiences with peers as well as interpersonal experiences with teaching assistants (TAs) was employed to assess program effectiveness in this regard.
- *Increase the retention rate in engineering at Dartmouth*. Student persistence on the path towards the major was tracked via course registration data.
- *Promote the use of the variety of resources offered for underprepared first-year students*. First-year sign-ups for the program and study session attendance were tracked.

The program, designed around these goals, has several components:

(1) Daily drop-in group study sessions: Every night (Sunday - Thursday) from 7-10pm drop-in help sessions are offered to students seeking help with any of the engineering prerequisite courses (all forms of calculus, from single variable to multivariable vector-valued functions, introductory physics, introductory programming, introductory chemistry). Each session is staffed with 2-3 upper-class students (termed teaching assistants or TAs in what follows) who provide academic as well as emotional support. During nights with high numbers of visitors, TAs group incoming students by subject and encourage them to discuss their questions amongst each other while TAs are otherwise occupied. Often this practice helps students (a) see that they are not the only ones struggling, (b) clarify their thinking by explaining what they are confused about, (c) learn to use available resources in order to make some progress.

(2) Individual tutoring sessions: Every term one or two students do not seem to benefit from the group study sessions in the same way as other students. For these students additional one-on-one tutoring sessions are offered.

(3) Course selection advising: During course registration periods special advising sessions are offered, staffed both by faculty and upper-class students.

(4) Special events: Two to three times per term special social events are organized, aimed both at showcasing what it is like to be an engineering major at Dartmouth as well as strengthening students' social networks.

(5) TA selection: TAs are carefully selected so as to be both empathetic as well as knowledgeable of the engineering prerequisite classes. Many TAs have themselves experienced struggles during their first year or two and are encouraged to share their experiences with our students. Care is taken to have

TAs mirror the diversity of the group of students seeking help so as to serve as role models.

(6) TA training: At the beginning of each term a TA training session is held to onboard new TAs and remind returning TAs of the mission and key components of the program. Throughout the term bi-weekly meetings are furthermore held during which arising issues are discussed and additional training is provided.

(7) Impact on TAs: As mentioned before, many TAs were themselves underprepared upon matriculation and experienced related academic and emotional struggles. While they all have completed the engineering prerequisites and are pursuing an engineering major, many TAs still feel insecure about their knowledge and mastery of the prerequisite material.

The following sections present the methods, results, and discussion of the evaluation efforts of the program and its goals. The subsequent discussion section examines the observed results.

## Methods

### Data collection

Administrative data, attendance logs, and surveys were the data collection methods used. Administrative data consisted of demographic, admissions, and course information extracted from our student information system and data warehouse. In addition, the administrative data were used to examine retention.

Student attendance at group study sessions was logged using a sign-in system collecting students' names, attendance dates, subjects for which help was sought as well as potential notes from the TAs who assisted. The first time a student signed into the system, additional information, such as the reason for registration and who referred them, was collected.

Finally, two post-only surveys were implemented - one for student participants and one for the TAs. The student survey contained 8 items drawn from three surveys: 1) the Pittsburgh Freshman Engineering Attitudes Survey (PFEAS); 2) the Student Evaluation of Advising Survey (SEAS); and 3) Mosher, 2017. See Appendix A for details.

The TA survey contained 4 items and also relied on items from the SEAS and Mosher surveys (2017) as well as a couple of items from the case study approach used by Kiyama, Raucci, Crump-Owens, and Luca (KRCL), 2014. See Appendix B for details.

## Participants

### Students

Incoming first-year students were invited to participate in the program. The first cohort (Cohort 1) was invited at the beginning of academic year (AY) 2016-17 and totaled 88 students. The second cohort (Cohort 2) was invited at the beginning of AY 2017-18 and totaled 97 students. Invitations were issued to students with an interest in engineering (as indicated in their matriculation documents) who were underprepared as compared to the majority of incoming students. For Cohort 1 "underpreparedness" was determined based upon mathematics placement into an introductory-level calculus class.

Table 1: Cohort Demographic Characteristics of students invited to participate in the survey

| | **Invited** | | **Uninvited** | | **Overall** | |
|---|---|---|---|---|---|---|
| | N | % | N | % | N | % |
| Female | 83 | 44.86% | 62 | 54.87% | 145 | 48.66% |
| Male | 102 | 55.14% | 51 | 45.13% | 153 | 51.34% |
| American Indian or Alaskan Native | 7 | 3.78% | 4 | 3.54% | 11 | 3.69% |
| Asian | 17 | 9.19% | 16 | 14.16% | 33 | 11.07% |
| Black or African American | 36 | 19.46% | 18 | 15.93% | 54 | 18.12% |
| Hispanic or Latino | 36 | 19.46% | 20 | 17.70% | 56 | 18.79% |
| Native Hawaiian or Other Pacific Islander | 1 | 0.54% | 0 | 0.00% | 1 | 0.34% |
| Two or more races | 11 | 5.95% | 6 | 5.31% | 17 | 5.70% |
| Unknown Race | 1 | 0.54% | 3 | 2.65% | 4 | 1.34% |
| White | 76 | 40.54% | 46 | 40.71% | 122 | 40.60% |
| **Grand Total** | **185** | **100.00 %** | **113** | **100.00 %** | **298** | **100.00 %** |

An analysis of Cohort 1 revealed a strong correlation of underpreparedness to lower SAT/ACT mathematics scores and these results were used to select invitees for Cohort 2 (as well as subsequent cohorts). Specifically, students with an academic interest in engineering and lower standardized test scores in mathematics (SAT Math equal to or less than 740 or ACT Math equal to or less than 33) were selected for a formal invitation from the program. In addition to formal invites, campus wide advertising through posters, flyer and word of mouth also drew students to drop-in consultations. For Cohort 1, a total of 55 “uninvited” students attended at least one consultation session while for Cohort 2, the total was 58. See Table 1 for participant highlights.

Participation by students in the program was determined by the number of study sessions attended. Students who attended one or fewer study sessions were categorized as non-participants (<=1). One-time attendees were possibly simply curious about the program but decided it was not valuable to them and did not return. Students attending two or more sessions were considered to be program participants (>=2).

Both cohorts and “uninvited” students with at least one consultation were invited to participate in the student survey. In total, 298 students were invited to participate in the survey. A $5 incentive from Amazon was provided to those who completed the survey.

Teaching Assistants (TAs)

A total of 33 teaching assistants offered consultation help for both student cohorts with 11-13 TAs serving during any particular term. While most TAs stay on for multiple terms and even multiple years, there is natural TA turnover due to graduation, study-abroad, off-terms, etc. For the TA survey, a total of 33 TAs were invited to participate. A $5 incentive from Amazon was provided to those who completed the survey.

## Design: Propensity Score Matching

A comparison cohort consisting of students who matriculated 1-2 years prior to initiation of our program was sought. To reduce the impact of selection bias, propensity score matching (PSM) was employed. This statistical approach balances groups when random selection of participants is lacking. In this assessment context, propensity matching, based on the program selection criteria noted above as well as gender and race/ethnicity, was used to identify a group of pre-program students with a distribution of observable characteristics similar to program participants (>=2 sessions). The race/ethnicity categories used were a modified version of those used in the Integrated

Postsecondary Education Data System (IPEDS). The IPEDS definition includes a separate category for international students which was not used in this analysis.

## Results

### Retention

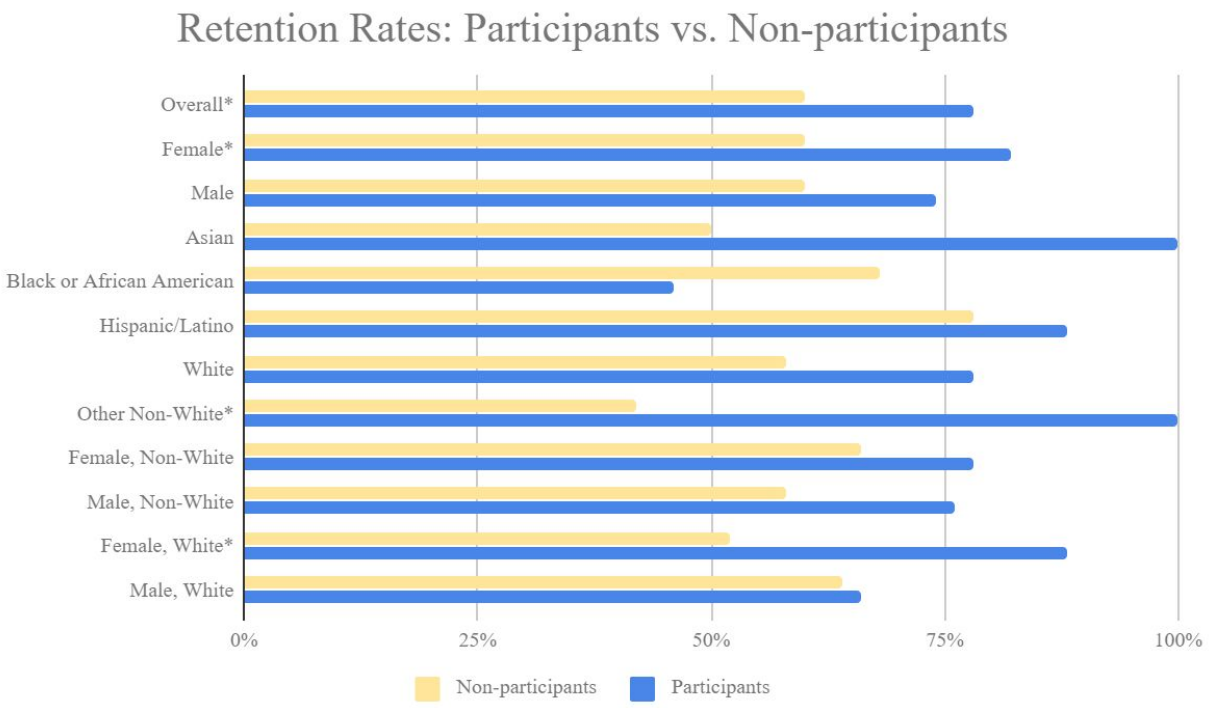
The primary goal of the program is to increase retention of students in engineering. Students are not required to declare majors until the end of their sophomore year; as of this writing most of the program participants have not yet officially declared a major. Since major declaration cannot be used to measure retention, for the purposes of this study, retention in engineering was measured by continued enrollment in the prerequisite courses on the path to an engineering degree during the sophomore year. Sophomores enrolled in prerequisite courses were considered retained on the engineering path.

To evaluate program effectiveness across various demographic groups, students were categorized by gender and race/ethnicity. Additionally, due to small N's in certain categories, the following IPEDS categories were aggregated into a single, Other Non-White, group: American Indian or Alaskan Native (n=70); Native Hawaiian or Other Pacific Islander (n=1); Two or more races (n=110); and Unknown race (n=2).

A Chi-square test was run to identify significant outcomes on engineering retention rates. Comparisons were run by overall population, gender, racial/ethnic groups, and combinations of gender and racial/ethnic groups. Significant ($p<=0.1$) differences were found in the overall population (retention rate of 78% for program participants vs. 60% for non-participants), women (retention rate of 82% for participants vs. 60% in non-participants), and White women (88% vs. 52%). While not statistically significant, the retention rate among virtually all other program participants was higher than non-participants in every cohort evaluated, with the exception of the Black or African American group participants whose retention rate was 22% lower than the non-participants. See Figure 1 below and Appendix C for further details.

A group of pre-program participants was selected, using propensity score matching noted above, from first-years entering two academic years prior to the program's introduction. Of the 34 invited program participants, 33 could be paired with the pre-program cohort. Chi-Square analysis was used to test for significant differences in engineering retention between the pre-program and invited participant groups.

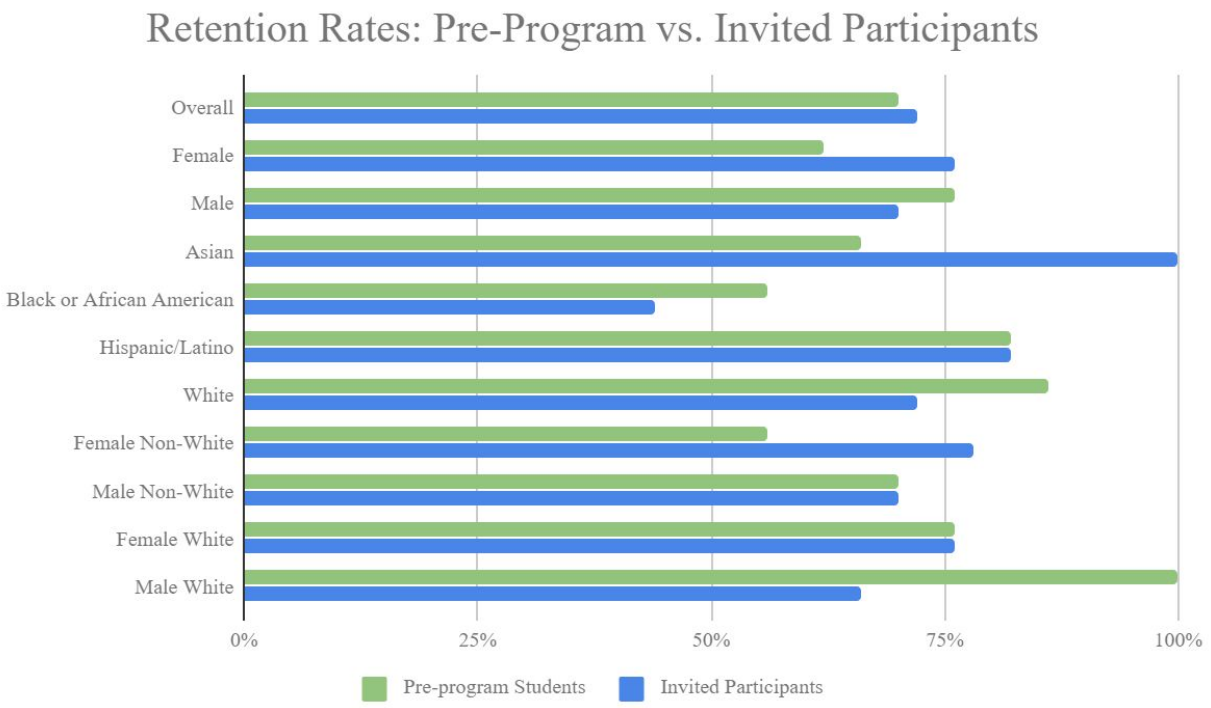
Figure 1: Engineering retention rates: Non-participants vs. program participants




Notes:
**Other Non-White**: American Indian or Alaskan Native, Native Hawaiian or Other Pacific Islander, Two or more races, and Unknown race.
*Chi-Square significance at p<=0.1

This comparison yielded no significant differences between the pre-program and invited participants, likely due to the small population sizes. The overall retention showed only a modest (+2%) difference between invited participants as compared to the pre-program group. Sizable differences in retention rates were observed among all females and non-white females (+14% and +22%). Lower retention rates were observed among males (-6%), the Black or African American group (-12%), and Whites (-14%). Other groups (Asians and White males) had very large differences but these were due to very small sample sizes and are not considered noteworthy. See Figure 2 below and Appendix D for further details.

Figure 2. Engineering retention rates: Pre-program students and invited participants




Note:
**Other Non-White:** American Indian or Alaskan Native, Native Hawaiian or Other Pacific Islander, Two or more races, and Unknown race.

## Student Survey

Among the 298 students who were sent a survey invitation, eight emails bounced back. The final response rate was 35% (101/290). Of all respondents, 55% were female and 62% were minorities (those who were not White or Unknown race). Sixty-four percent of the respondents attended zero consulting sessions or went only once (and are thus considered non-participants in this study), and 36% attended two or more sessions (and are thus participants of the program).

### Overall

Over ninety percent of the respondents agreed that "*The future benefits of studying engineering are worth the effort*" (94%) and "*Engineers need good communication and writing skills*" (96%). Over two thirds thought "*An engineering degree will guarantee me a job when I graduate*" and 56% agreed "*I have no desire to choose / change to a non-engineering major*".

More students were confident in their Calculus abilities (76% “Confident” or “Very confident”) versus Physics (52%), Computer Skills (45%), or Chemistry (36%).

Eighty-nine percent of the respondents thought they had strong problem-solving skills, 75% felt confident in their ability to succeed in engineering and 70% thought they needed to spend more time studying. Over half planned to join a student engineering organization. Interestingly, 42% did not feel they knew what an engineer does and 62% tend to procrastinate, putting off the things they need to do.

Overall students gave very positive feedback to the DEE program and to the teaching assistants. Nearly all respondents (98% “Agree” or “Strongly agree”) would recommend DEE to other students like them. Ninety-four percent agreed DEE sessions were offered at convenient times. Over two-thirds (85%) agreed DEE was valuable and helped them continue on a path towards an engineering major (84%). With respect to teaching assistants, over ninety percent of respondents agreed “*The teaching assistants were approachable*” (95%) and “*The teaching assistants encouraged me to ask questions*” (96%), Slightly smaller percentages indicated TAs had the necessary content knowledge to answer their questions (88%) and provided resources when they did not know the answer (82%).

<u>By Participation (Consultations <=1 vs. >=2 times)</u>
Analysis of Variance (ANOVA) was used to test the differences between participants ( >=2 consults) and non-participants ( <=1 consults). Significant differences are noted in this section and Appendix E.

Program participants were less confident in their Chemistry ability than non-participants (22% vs. 43% “Confident” or “Very confident”). Meanwhile, more non-participants than participants reported higher levels of procrastination (71% vs. 46%) and agreed they need to spend more time studying than they currently do (79% vs. 53%).

Program participants held more favorable views of the DEE program than non-participants. Specifically, more of them would recommend DEE to other students like them (100% vs. 95%), agreed participating in DEE was valuable (89% vs. 79%), and DEE helped them continue on a path toward an engineering major (88% vs. 75%). Finally, this participant group also planned to join a student engineering organization at significantly higher rates (70% vs. 47%).

Open-ended comments

Four open-ended items at the end of the survey provided students with the opportunity to describe how the TAs most helped them, list program strengths, suggest how the program could be improved, and detail other tutoring services used on campus. These qualitative results are summarized below.

### Helped students most

Overwhelming, students noted the TAs helped them with problem solving. The next most often mentioned categories were academic and emotional support.

- *Explaining a problem fully to me and then having me solve it step by step with their guidance.*
- *They were able to guide me through problems so that I could better understand them. If they could not help me, they directed me towards resources that could.*
- *Making time for each student and making one feel comfortable with asking questions. They were patient, and I feel they are what made the space safe.*

### Program Strengths

The teaching assistants, hours, group effort, accessibility/availability, and “great people” were the most frequently mentioned strengths. Students also mentioned getting help from other students who have also struggled, meeting other engineers, and guidance through prerequisite courses.

- The TAs are quite helpful, giving free tutoring to students to help them study or complete their homework.
- The students who run the sessions are approachable, which makes students feel less isolated in their struggles.
- Awesome hours.
- Not only do the TAs offer help, but other students in the room assist each other with problems.
- How accessible the program is and the TAs that can act as a resource.

### Areas for program improvement

Of the nearly 40 student comments, nearly equal amounts recommended improving specific program components and the specialization/utilization of TAs during consulting sessions. The program components mentioned included increasing the number of TAs, holding sessions at a different location, and outreach. TA specialization/utilization included comments on assigning TAs based on their area of expertise and concerns about the recency of the TAs knowledge for earlier courses.

- *Making it accessible 7 days a week and during finals, if possible. Also hiring more TAs since the study sessions can get very crowded at times. Finally, adding an extra hour to the length of the sessions would be very helpful.*
- *Communication on what DEE is to new students and when help sessions are available.*
- *Having specific TAs assigned for a subject and being clear about which TA specializes in what subject, at least one of each every night or even two but I know that might be difficult.*
- *I think maybe having TAs who have taken the classes more recently. I sometimes found that the TAs were very bright graduates who hadn't taken the classes for a long time and therefore couldn't always remember the topics.*

**Other Services Used**

The academic skills center was the most often mentioned "other" service used. The skills center offers a variety of services and tutors and study groups were frequently used. Students also used office hours and course TAs either one-on-one or through review sessions. The writing center and learning fellows in the house system were also mentioned as resources for students outside of the program.

### Teaching Assistant (TA) Survey

The final response rate for this survey was 73% (24/33). Sixty-two percent of the respondents were male and 38% were female. Nearly half (42%) were White while 33% were Minority and 25% were International.

One hundred percent agreed that "Participating in the program as a teaching assistant was valuable" with over two thirds (82%) agreeing **strongly**. Ninety-six percent agreed that being a TA improved their sense of belonging at Dartmouth.

Four items from the SEAS were modified to allow a comparison between student and TA survey responses (see Table 2). Across all four items, TAs agreed more strongly with the statements than students (*1=strongly disagree to 4=strongly agree*). The differences were statistically significant for all but the second item on necessary content knowledge. Specifically, TAs more strongly agreed that when they did not know the answer to a question, they provided other resources, they were approachable, and that they encouraged students to ask them questions.

Table 2: Mean comparisons between Student and TA Surveys

| Students | Mean | Teaching Assistants | Mean |
|---|---|---|---|
| The teaching assistants were approachable. | 3.37 | I was approachable during consulting sessions. | 3.82 ** |
| The teaching assistants had the necessary content knowledge to answer my questions. | 3.12 | I had the necessary content knowledge to answer questions. | 3.32 |
| The teaching assistants encouraged me to ask questions. | 3.36 | I encouraged students to ask me questions. | 3.77 ** |
| When a teaching assistant did not know the answer to a question, they provided other resources to help. | 3.09 | When I did not know the answer to a question, I provided other resources to help. | 3.64 ** |

** $p < .01$

Open-ended comments

The three open-ended items at the end of the survey provided TAs with the opportunity to describe how they most helped students, what new skills they learned, and how the program could be improved. These qualitative results are summarized below.

**Helped students most**

Problem solving and academic support were the most frequently mentioned manner in which TAs helped students, followed by emotional support.

- *Helping walk through the problem. A lot of times, students just have to take a step back and take the problem one step at a time. I also would ask them guiding questions like "Why would you do it this way?" which would help them become critical about their thinking.*
- *Reviewing important foundational concepts and providing insight into how these concepts are applicable to core engineering courses and careers*.

- *Providing kindness, support, and help in either the form of actually being able to help with the questions for the classes the student is working on, or referring students to other TAs, talking about office hours, TA sessions, online help, other resources; and providing study strategy help, such as being able to look things up online or doing the problems you can do first.*

**New skills learned**

TAs most often mentioned improvement in their communication skills. Other skills included, better understanding of others, improved problem solving, simplifying difficult concepts, and reinforcing materials for the TAs themselves.

- *I greatly improved my communication skills. The program helped me to be able to confidently answer and explain questions to a diverse body of students who came to the sessions. Being a TA helped me to reinforce some concepts that I had partially forgotten (e.g. knowledge of C), which helped me in some more advanced classes.*
- *Explaining difficult concepts in a simpler manner. Understanding other's methods of solving problems in very different ways than myself.*
- *How to figure out the answer to something when I don't immediately know working backwards and using examples to figure it out.*

**Areas for program improvement**

Increasing awareness and/or outreach was most often mentioned by TAs. They also recommended more resources for TAs, TA specialization, community-building activities, and individual (one-on-one) attention.

- *I think that we need to make Professors aware that the program exists as a resource and even expand it to the community outside of Thayer. I would suggest we could send out emails to the Math and Physics department and they could reach out to students that they believe could be a good fit to be a TA.*
- *If at all possible, it would be great to have an extensive database that TAs can reference ahead of time to become aware of what topics the students' homework assignments and projects will contain. In addition, some more community-building activities could benefit the students' experiences and hopefully inspire them to continue pursuing engineering.*

- *More specialization with regards to which classes which TAs know best.*

## Discussion

The results support the conclusion that this new program, aimed at supporting underprepared students through their prerequisites, both academically and emotionally is having the desired impact, especially among those actively participating in the program (>=2 consulting sessions).

### Retention rates

Program participants had higher engineering retention rates compared to non-participants. Survey results highlighted how the program helped over three-fourths of respondents continue on a path towards an engineering major (84%). Although non-significant, and the one exception, the retention rate for Black or African American active participants was lower than for non-participants. Additional analyses and review of survey comments did not yield a clear reasoning for this difference. Researchers will keep a close eye on this challenge as additional student cohorts are brought into the program.

### Academic and emotional support

The survey results highlight the meaningful relationships and networks these students are establishing. Eighty-five percent agreed the program was valuable, more so among active participants. The open-ended comments provide the clearest articulation of how the program is helping these students: 1) improve their problem-solving skills, 2) meet other engineers, 3) receive guidance through prerequisite courses, and 4) receive exposure to students with similar struggles.

In addition, the TA survey shows the strong, positive, impact of mentoring on their skills related to communication, understanding others, problem solving, and simplification of difficult concepts.

### Programmatic Lessons Learned

Given that many students found their own way to the program and not through formal invitation and that over three-quarters of invited students have not actively participated, one goal is to refine the program invitation criteria by re-running analysis of participants and correlating participation to student data. Assuming that those students who frequent the program benefit from the program it is reasonable to assume that students with similar backgrounds and preparation would benefit as well, especially if they knew about the program upon matriculation.

Attendance logs reveal that during their first term at our school students only start attending the program after their first midterm exam in a prerequisite course. Given the fast-paced term structure it is likely too late by this time to make up knowledge gaps. Better ways to publicize the program to potential beneficiaries need to be found so as to engage with participants as early as possible.

Program improvement suggestions, across students and TAs, showed certain consistencies. Both groups recommended hiring more TAs and trying to align TA knowledge and skills more closely with participant consulting needs, although both admitted this may be challenging. Indeed, all of the TAs have taken all classes for which help is provided. Replication of "regular" TA office hours for any specific class in such settings are not always favorable for underprepared and/or underrepresented students. Anecdotal evidence suggests that such regular office hours are being attended by students who have already completed their assignments and are simply looking for pointers on how to fine-tune their work. Underprepared students, who may not know how to even start an assignment, can be easily intimidated in such situations and respond by avoiding office hours altogether in the future. The program's TA model purposefully attempts to target sessions at those who are underprepared rather than looking to fine-tune. Rather than hiring TAs whose content knowledge may be more closely aligned with specific courses, the researcher's proposal moving forward is to provide better training for TAs to help them teach participants how to find appropriate resources in situations where their own background may be lacking.

Survey suggestions also included more outreach to both professors and students to help them better understand the program's purpose and goals. This finding is unsurprising to researchers who continue to grapple with optimal communication modes since varied approaches have been used, including email trickle campaigns, posters, fliers, visits to classes and booths at First-Year Open Houses.

### Limitations

While the results support the program goals, it should be noted, there are certain limitations with the interpretation of these findings.

First, students are exposed to varied academic support efforts across campus, especially in their first year. While survey respondents clearly noted the impact of the program, many also stated they used other campus services which included peer tutoring and course TAs. Hence, any evaluation of the impact of this program must be

tempered by the knowledge that students are using various other academic support systems.

Second, the academic interest data does not allow a differentiation of pre-matriculation first, second, or third choices of major. A student indicating engineering as their first choice is more likely to be interested and influenced to persist while a student indicating engineering as a third choice, may already be predisposed to choose a different major; hence, this stronger or weaker interest would influence engineering retention.

Finally, while retention is indeed higher for program participants (>=2 consults) than for non-participants (<=1 consults), a causal relationship cannot be established. One could argue for example that students who are more strongly interested in persisting in engineering will seek help for engineering prerequisites at a higher rate.

## Conclusion

The challenges facing this institution are not unique given the national context surrounding the underrepresentation of minority students in STEM fields. Evaluations of this type are critical to inform the field of promising programs and/or techniques which can be modified for use on different campuses. These results show retention rate improvements for students actively participating in the program as well as vital academic and emotional support. The results also contribute to the smaller research literature on mentor impacts with respect to the communication and problem-solving skills gained through being a teaching assistant. However, the results also clearly highlight active participation challenges which need to be addressed, especially among certain minority student groups. The program will continue to hone its invitation criteria, broaden outreach efforts, and expand data collection to include focus groups and interviews, in addition to the continuation of surveys of both students and teaching assistants.

## References


ASEE (2014). *Going the Distance: Best Practices and Strategies for Retaining Engineering, Engineering Technology, and Computing Students*. Retrieved from https://www.asee.org/papers-and-publications/publications/college-profiles

Besterfield-Sacre, M., Atman, C., J., & Shuman, L., J. (1998). Characteristics of freshman Engineering Students: Models for Determining Student Attrition in Engineering, *Journal of Engineering Education*, *87*(2), 133-141.

Kiyama, J.M., Luca, S.G., Raucci, M., & Crump-Owens, S. (2014). A cycle of retention: Peer mentors' accounts of active engagement and agency. *College Student Affairs Journal, 32*(1), 81-95.

Mosher, G.A. (2017). Professional Advisers in engineering and technology undergraduate programs: Opportunities and challenges. *The Journal of Technology Studies*, *43*(1), 26-34.

NSF (2015). *Women, Minorities, and Persons with Disabilities in Science and Engineering 2015*. National Center for Science and Engineering Statistics Directorate for Social, Behavioral and Economic Sciences. Retrieved from http://www.nsf.gov/statistics/2015/nsf15311/digest/nsf15311-digest.pdf

Pittsburgh Freshman Engineering Attitudes Survey (PFEAS). Retrieved from https://www.engineering.pitt.edu/uploadedFiles/_Content/Sub_Sites/Centers/EERC/_Documents/Reference_Materials/Pittsburgh%20Freshman%20Engineering%20Attitudes%20Survey.pdf

U.S. Department of Education. Institute of Education Sciences, National Center for Education Statistics**.** *Integrated Postsecondary Education Data System (IPEDS)*. Washington, DC.

Zimmerman, A., & Mokma, A. Developing a student evaluation of advising survey instrument. (2004). *NACTA Journal*, *48*(3), 2-6.

**Appendix A:**
**Student Survey Items and Sources**

| Item | Source |
|---|---|
| The future benefits of studying engineering are worth the effort. | PFEAS |
| I have no desire to choose / change to a non-engineering major (ex. Biology, English, Chemistry, Art, History, etc.). | PFEAS |
| My parent(s) is/are making me study engineering. | PFEAS |
| An engineering degree will guarantee me a job when I graduate. | PFEAS |
| Engineers need good communication and writing skills. | PFEAS |
| Anyone who wants to be an engineering major has the ability to graduate in engineering. | PFEAS |
| Confidence in abilities in: Chemistry | PFEAS |
| Confidence in abilities in: Physics | PFEAS |
| Confidence in abilities in: Calculus | PFEAS |
| Confidence in abilities in: Computer Skills | PFEAS |
| I feel I know what an engineer does. | PFEAS |
| I need to spend more time studying than I currently do. | PFEAS |
| I have strong problem solving skills. | PFEAS |
| I feel confident in my ability to succeed in engineering. | PFEAS |
| I tend to procrastinate, putting off the things I need to do. | PFEAS |
| I plan to join a student engineering organization. | PFEAS |
| I followed through on advice provided by the teaching assistant(s). | SEAS |
| The teaching assistants were approachable. | SEAS |
| The teaching assistants had the necessary content knowledge to answer my questions. | SEAS |
| The teaching assistants encouraged me to ask questions. | SEAS |
| I would recommend DEE to other students like me. | SEAS |
| When a teaching assistant did not know the answer to a question, they provided other resources to help. | Mosher |
| The teaching assistants helped me most by… | Mosher |
| What are the strengths of the DEE program? | Mosher |
| What areas of the DEE program could be improved? | Mosher |

**Appendix B**
**Teaching Assistant (TA) Survey Items and Sources**

| Item | Source |
|---|---|
| Being a DEE teaching assistant improved my sense of belonging at Dartmouth. | KRCL |
| I was approachable during DEE sessions. | SEAS |
| I had the necessary content knowledge to answer questions. | SEAS |
| I encouraged students to ask me questions. | SEAS |
| I would recommend DEE to other students like me. | SEAS |
| When I did not know the answer to a question, I provided other resources to help. | Mosher |
| I helped students most by… | Mosher |
| New skills I learned include... | KRCL |
| What areas of the DEE program could be improved? | Mosher |

**Appendix C**
**Engineering retention rates: Non-participants vs. program participants**

| | Non-participants (<=1 Consults | | Participants (>=2 Consults) | |
|---|---|---|---|---|
| | % | N | % | N |
| Overall* | 60% | 153 | 78% | 48 |
| Female* | 60% | 69 | 82% | 22 |
| Male | 60% | 84 | 74% | 26 |
| Asian | 50% | 14 | 100% | 3 |
| Black or African American | 68% | 28 | 46% | 11 |
| Hispanic/Latino | 78% | 23 | 88% | 16 |
| White | 58% | 71 | 78% | 14 |
| Other Non-White[1]* | 42% | 17 | 100% | 4 |
| Female, Non-White[1] | 66% | 36 | 78% | 14 |
| Male, Non-White[1] | 58% | 46 | 76% | 20 |
| Female, White* | 52% | 33 | 88% | 8 |
| Male, White | 64% | 38 | 66% | 6 |

[1]American Indian or Alaskan Native, Native Hawaiian or Other Pacific Islander, Two or more races, and Unknown race
*Chi-Square significance at p<=0.1

**Appendix D:**
**Engineering retention rates: Pre-program students and invited participants**

| | Pre-program Students | | Invited Program Participants | |
|---|---|---|---|---|
| | % | N | % | N |
| Overall | 70% | 33 | 72% | 33 |
| Female | 62% | 13 | 76% | 13 |
| Male | 76% | 20 | 70% | 20 |
| Asian | 66% | 3 | 100% | 3 |
| Black or African American | 56% | 9 | 44% | 9 |
| Hispanic/Latino | 82% | 11 | 82% | 11 |
| White | 86% | 7 | 72% | 7 |
| Other Non-White[1] | - | - | - | - |
| Female Non-White[1] | 56% | 9 | 78% | 9 |
| Male Non-White[1] | 70% | 17 | 70% | 17 |
| Female White | 76% | 4 | 76% | 4 |
| Male White | 100% | 3 | 66% | 3 |

[1]American Indian or Alaskan Native, Native Hawaiian or Other Pacific Islander, Two or more races, and Unknown race

## Appendix E

| For each statement about engineering, please indicate your level of agreement.<br>Scale: 1 = Strongly disagree to 4 = Strongly agree | | | |
|---|---|---|---|
| | **Overall Mean** | **2 or more Consults** | **0 or 1 Consult** |
| The future benefits of studying engineering are worth the effort. | 3.39 | 3.47 | 3.34 |
| I have no desire to choose / change to a non-engineering major (ex. Biology, English, Chemistry, Art, History, etc.). | 2.72 | 2.87 | 2.65 |
| My parent(s) is/are making me study engineering. | 1.52 | 1.37 | 1.6 |
| An engineering degree will guarantee me a job when I graduate. | 2.87 | 2.83 | 2.9 |
| Engineers need good communication and writing skills. | 3.48 | 3.5 | 3.47 |
| Anyone who wants to be an engineering major has the ability to graduate in engineering. | 2.81 | 2.63 | 2.9 |
| **For the following subjects and skills, please select the option that best describes how confident you are of your abilities.**<br>**Scale: 1 = Not confident at all to 4 = Very confident** | | | |
| | **Overall Mean** | **2 or more Consults** | **0 or 1 Consult** |
| Chemistry | 2.21 | 1.94 | 2.35 |
| Physics | 2.42 | 2.5 | 2.37 |
| Calculus | 2.99 | 2.83 | 3.08 |

| | | | |
|---|---|---|---|
| Computer Skills | 2.49 | 2.53 | 2.46 |
| **Please indicate your level of agreement with the following statements.**<br>**Scale: 1 = Strongly disagree to 4 = Strongly agree** | | | |
| | **Overall Mean** | **Two or more Consults** | **0 or 1 Consult** |
| I feel I know what an engineer does. | 2.64 | 2.75 | 2.58 |
| I need to spend more time studying than I currently do. | 2.94 | 2.67 | 3.09 |
| I have strong problem solving skills. | 3.22 | 3.36 | 3.14 |
| I feel confident in my ability to succeed in engineering. | 2.89 | 2.94 | 2.86 |
| I tend to procrastinate, putting off the things I need to do. | 2.69 | 2.36 | 2.88 |
| I plan to join a student engineering organization. | 2.67 | 2.92 | 2.54 |
| **For the following statements about the DEE program and the teaching assistants (TAs), please indicate your level of agreement.**<br>**Scale: 1 = Strongly disagree to 4 = Strongly agree** | | | |
| | **Overall Mean** | **Two or more Consults** | **0 or 1 Consult** |
| I followed through on advice provided by the teaching assistant(s). | 3.27 | 3.38 | 3.11 |
| The teaching assistants were approachable. | 3.37 | 3.42 | 3.29 |
| The teaching assistants had the necessary content knowledge to answer my questions. | 3.12 | 3.19 | 3 |

| | | | |
|---|---|---|---|
| The teaching assistants encouraged me to ask questions. | 3.36 | 3.36 | 3.35 |
| I would recommend DEE to other students like me. | 3.53 | 3.69 | 3.18 |
| Participating in DEE was valuable. | 3.31 | 3.49 | 3 |
| DEE helped me continue on a path towards an engineering major. | 3.04 | 3.18 | 2.75 |
| When a teaching assistant did not know the answer to a question, they provided other resources to help. | 3.09 | 3.17 | 2.95 |
| DEE sessions were offered at convenient times. | 3.3 | 3.37 | 3.16 |

**Color highlighted significant group different (at $p < 0.05$ level).*