Paper ID #36054

Work-In-Progress: Applying Peer Mentorship in a First Year Engineering Course to Improve Student Learning and Retention Outcomes

Dr. Benjamin D McPheron, Anderson University

Benjamin D. McPheron is Chair of the Department of Physical Sciences & Engineering and Associate Professor of Electrical Engineering at Anderson University. Dr. McPheron received his B.S.E.E. in Electrical Engineering at Ohio Northern University in 2010, and his Ph.D, in Electrical Engineering from the Department of Electrical Engineering at The Pennsylvania State University in 2014. Dr. McPheron teaches Freshman Engineering and various courses in Electrical Engineering including Circuit Theory, Electronics, Controls, and Mechatronics. His research interests include Engineering Education, Control Systems, Mechatronics, and Signal Processing.

Work-In-Progress: Applying Peer Mentorship in a First Year Engineering Course to Improve Student Learning and Retention Outcomes

Benjamin D. McPheron
Anderson University
bdmcpheron@anderson.edu

First-year engineering students may experience challenges in their transition to a university setting, in which they can struggle to feel integrated within the university community. They can find it difficult to connect with their academic program, faculty members, and peers. These challenges often pose barriers to academic success and retention. Mentorship programs for first-year students have been adopted by many universities to help students with this transition. Undergraduate peer mentorship allows first-year students to gain institutional knowledge, connect with the program community, and gain valuable relationships with upper-level students who can serve as resources and mentors. We have begun to develop a similar approach at Anderson University specifically for our first-year engineering students.

In addition to serving as a resource for institutional connection, our peer mentors also serve as technical mentors. Our peer mentorship program is coupled with the engineering design project in the first-semester Intro to Engineering course, and mentors review their group's designs and progress and offer project management support.

There are three specific research questions we wish to address related to peer mentorship in the context of first-year engineering students:

> RQ1: Do students feel that peer mentorship was valuable in connecting to the engineering program and community?
> RQ2: Does peer mentorship lead to better retention outcomes?
> RQ3: Does technical mentorship by upper-level engineering students promote greater academic success?

This paper includes a short review of examples where mentorship has been successful in undergraduate engineering education, a detailed description of the system implemented at Anderson University, and initial results for the specific research questions described. This work is only in its beginning stages, and will be implemented for several more years to assess long term retention outcomes and student academic achievement.

Introduction

Retention and success of first-year engineering students has become a priority for many enrollment driven engineering institutions. In addition, there is a desire to promote equitable opportunities to students who may come from differing levels of academic preparation. First-year students face a difficult transition from high school to university, and may struggle with social integration to their academic program and institution, potentially these areas. This can be magnified when students are engaged in a rigorous academic program while simultaneously placed in a new setting with little social or academic support.

Peer mentorship has been previously used to increase retention outcomes for first year students [1,2] and it has been shown to be effective in promoting academic success of students in STEM fields [3, 4]. A number of recent studies have aimed at assessing the impact of peer mentorship on student success and retention in first-year engineering programs. Through these studies, a number of 'best practices' have been suggested, which were used in designing a peer mentorship program at Anderson University.

In 2017, Coller, et. al. used peer mentors for teams in a first-year engineering design-build-test-communicate course at the University of Michigan, and the authors provide a framework for assessment of their mentorship program [5]. They were able to report several best practices from their experience. Suggestions for successful peer mentorship programs include recruiting excellent former students, assigning mentors at a laboratory (TA) level, gathering regular updates from mentors, and providing clear instructions to peer mentors on their interactions and facilitation efforts. Although the study provided evidence based suggestions, the surveys used had relatively low response rate, and there was no comparison between cohorts receiving peer mentorship and those without.

Corbett, et. al. (2018) developed a peer mentorship model at Louisiana Tech, in which student organizations (American Society of Mechanical Engineers, Society of Women Engineers, etc.) supplied peer mentorship resources [6]. The structure of the mentorship programs was left at the discretion of each student organization.

In 2019, Tahmina explored the impact of peer mentorship on student success in an introductory engineering course at The Ohio State University at Marion [7]. In their work, they explore two peer mentorship options (a) scheduled peer mentoring, where peer mentors essentially hold open office hours and (b) a mentor-mentee pairing. Results suggested that students participating in peer mentorship performed better, and in this cohort there was a preference for the scheduled peer mentoring option.

Someh, et. al. (2020) described the application of undergraduate peer mentors to support first-year students in a first-year cornerstone project [8]. The mentors were intended to help first-year students in the project achieve the required tasks, and to provide a source of institutional and program knowledge to the students they mentored. In this study, two models were tested. The first model, which is closest to a 'teaching assistant' formulation, had mentors who were not assigned to specific groups, but rather attended class meetings and provided support in class by request. The second model involved peer mentors assigned to specific teams, in which support is offered outside of class but meetings are mandatory. They found that the assigned peer mentorship model led to better relationship formation, but both techniques were beneficial to student success.

Also in 2020, Kiassat and Elkharboutly reported on a mentorship program at Quinnipiac University, which was paired with a metacognition course and an online mathematics help module, intended to help underprepared first-year engineering students transition to college [9]. They allowed students to voluntarily sign up to be paired with a senior engineering student mentor, but only 25.7% of the first-year engineering students participated even though 69.4% expressed interest during summer orientations.

From the literature review, several common design principles were applied in developing our peer mentorship program:

- Make peer mentorship participation mandatory and uniform across the first-year engineering student population
- Assign peer mentors to specific teams working on the design project, rather than serving as teaching assistants
- Encourage participants to complete surveys used for continuous improvement of the peer mentorship program

This paper will describe the peer mentorship program at Anderson University, provide a framework for assessing the impact of mentorship on the areas of community connection, retention, and student academic success. This framework aims to measure results pertaining to the specific research questions described in the abstract but restated here:

RQ1: Do students feel that peer mentorship was valuable in connecting to the engineering program and community?

RQ2: Does peer mentorship lead to better retention outcomes?

RQ3: Does technical mentorship by upper-level engineering students promote greater academic success?

Peer Mentorship Implementation

In this study, peer mentorship was added to the first semester Intro to Engineering course at Anderson University. In this course, students learn the basics of the engineering design process, engineering problem solving, and project management. As a part of this course, students work in teams to complete an engineering design project. In the 2021 offering of the course, students were required to design and build mini-golf holes [10] subject to material, budget, and space constraints. In 2020, students were required to design and build a child's toy, and in 2018 and 2019 students designed and built marble roller coasters [11]. The project is split into 4-5 milestones aimed at encouraging each group to iterate through the engineering design process and move towards a final product.

To implement the peer mentorship model applied in this study, junior and senior level engineering students were hired to serve as peer mentors. They were each assigned 1-2 freshman design groups, and expected to meet with these students 3-4 times throughout the semester. Each peer mentor met in-person with their groups, but this could likely be conducted over video conferencing. For convenience, they were encouraged to meet with their groups before each milestone was due to serve as technical and project management mentors. Peer mentors were expected to review project documentation, design process progress, and be a resource for the completion of the project. At the beginning of the semester, a short, 1 hour meeting was held between peer mentors and the course instructor to discuss expectations, requirements, and other relevant training information. In addition, peer mentors were expected to offer a connection to the engineering program community, culture, and university community as a whole.

Assessment Methods

In order to assess the effectiveness of this peer mentorship model and attempt to answer the three research questions, both indirect and direct assessment techniques were used. This framework will be repeated over the next few years as we attempt to collect more data on the long-term efficacy of this approach.

To assess the research questions indirectly, a Likert scale survey was administered to the students in the course. The survey consisted of 4 questions, with 5 being 'Strongly Agree', and 1 being 'Strongly Disagree'. The statements assessed were:

1. I found my peer mentor to be a useful resource for completing my design project
2. I had an easier time adjusting to college life thanks to my peer mentor (RQ1)
3. My peer mentor helped me better connect with the engineering program community (RQ1)
4. I plan to continue studying engineering at this institution next semester (RQ2)

To directly measure the impact of the peer mentorship program on RQ2, retention data were used. For this work-in-progress study, the short term retention rate (persisting to semester 2) was used, but historical data for medium term retention (persisting to 3rd semester) and long term retention (5 year graduation rate) are reported, as these measures will be key in assessing the effectiveness of the peer mentorship program.

For RQ3, we directly measured the GPA of the cohort after semester 1, as well as the average Calculus 1 grade, which can be used to compare the peer mentorship cohort with past cohorts. First-year engineering students have a consistent and uniform schedule for their first semester following our advising guides, which have not changed over the period of this study. In addition, the material covered in Calculus 1 is consistent from year to year.

Initial Results and Discussion

Indirect Assessment: Survey Results

Table 1 displays the average results of the Likert scale survey distributed to students in the course, as described in the previous section, with 1 corresponding to 'strongly disagree' and 5 corresponding to 'strongly agree'. Of the students enrolled in the course, 30 of 32 responded to the survey.

While each of these questions yielded an average on the 'agree' side of the scale, it is perhaps more useful to view the results as the percentage of respondents answering in each category, as shown in Figure 1. For question 1, 80% of respondents indicated agreement with the prompt, while 20% were neutral, suggesting that students did in fact believe that their peer mentor was a useful resource. For question 2, 13% of the respondents disagreed with the prompt, 27% were neutral, and 60% indicated agreement. This indicates a mixed feeling that peer mentors helped with the adjustment to college life, but the results are still weighted toward agreement. The results of question 3 were that 10% of respondents disagreed, 27% were neutral, and the remaining 63% agreed, which suggests that feelings were mixed on the connection to the program community facilitated by the mentors, but the majority agreed. Finally, for question 4, 93% of respondents agreed that they would be continuing in engineering into semester 2, while 7% disagreed. This measure can be tested against actual retention data, as discussed later in this section.

Table 1: Average responses to the Likert scale survey with 1 being 'strongly disagree', and 5 being 'strongly agree'.

Survey Question	Average	Std. Dev.
1	4.33	0.80
2 (RQ1)	3.63	1.22
3 (RQ1)	3.77	1.04
4 (RQ2)	4.73	0.78

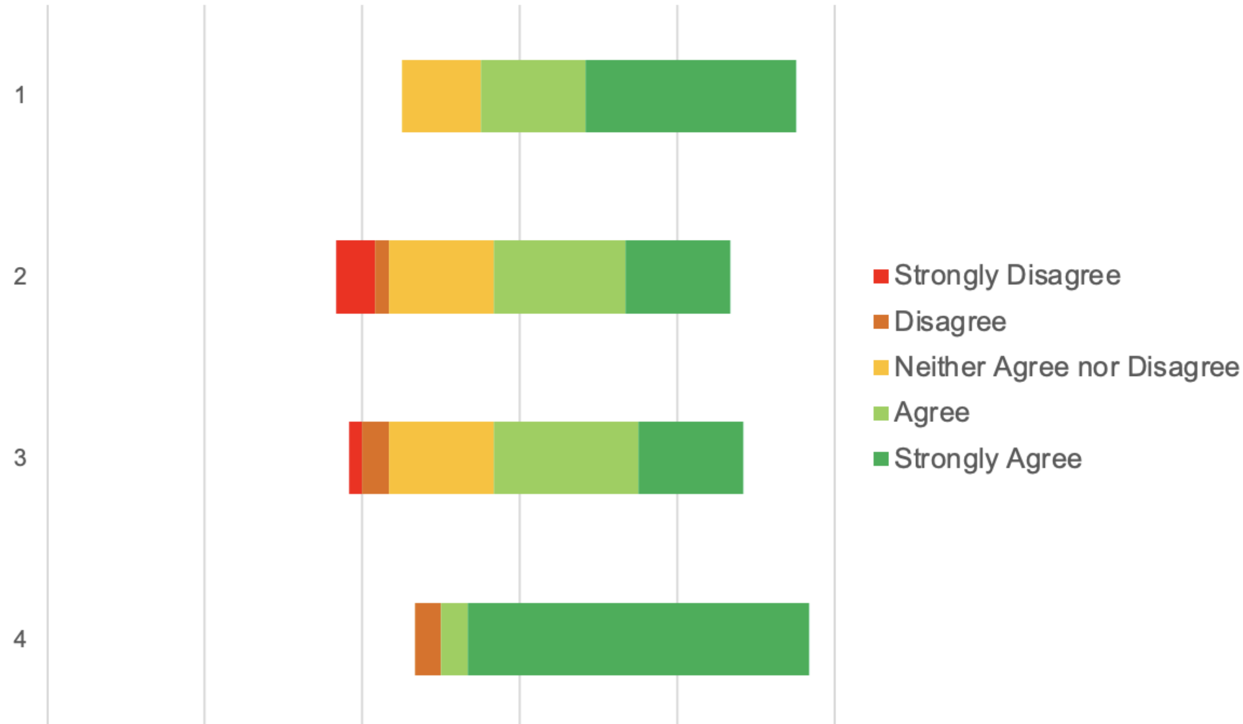

Figure 1: Responses to the Likert scale survey, shown in diverging bar chart

Direct Assessment: Retention Results (RQ2)
Figure 2 displays short and medium term retention rates for cohorts from 2018-2021. Short term retention is defined as retention in the engineering program to semester 2, while medium term retention is defined as retention in the engineering program to semester 3. In future work, 5 year graduation rates will be provided to assess long term retention, but as this study is still a work in progress and data collection only extends back to 2018, 5 year graduation results are not yet available. If the answer to RQ2 is yes, then the retention rate should increase for the 2021 cohort, when peer mentorship was introduced.

Compared to other years, the 2021 cohort (with peer mentorship) saw an increase in short term retention rate. These results are consistent with the answer to question 4 on the survey discussed above (90.63% actual rate vs. 93% survey result). While results are higher with peer mentoring, further data collection is required to assess medium and long term retention with peer mentorship. As discussed later in this paper, other factors may have impacted this retention number, so the study should be repeated several more years before strong conclusions may be drawn. Comparable short term retention was achieved in 2019 without peer mentorship, but the other two years saw much lower short term retention. It cannot be passed without mentioning that short term retention was significantly lower in the 2020 cohort, likely due to complications related to the COVID-19 pandemic and hybrid teaching methods.

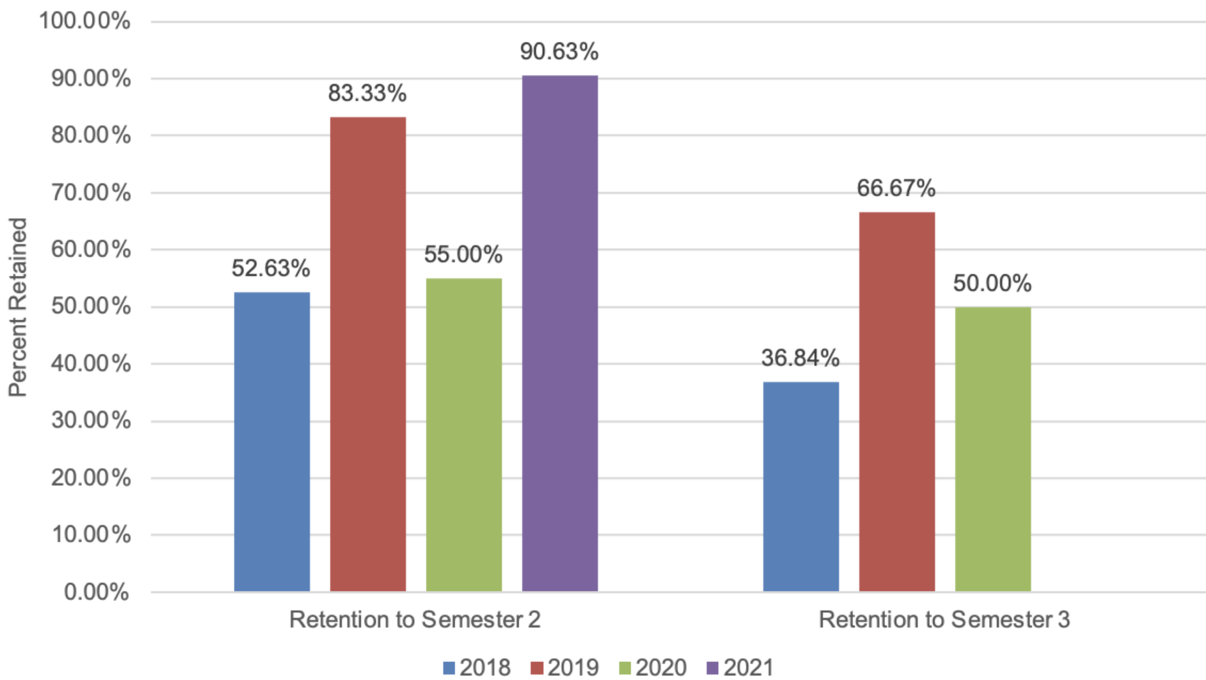

Figure 2: Retention to second 2 (short term retention) and retention to semester 3 (medium term retention) for the 4 years considered in this study. Five-year graduation rate is not yet available for any cohort, and retention to semester 3 is not available for the 2021 cohort at this time.

Direct Assessment: Student Academic Achievement (RQ3)

Table 2 shows the GPA that students earned in their first semester in the engineering program, as well as the average grade in Calculus 1 (on a 4 point scale). Here, it can be seen that the average earned GPA was higher for the 2021 cohort, but not significantly so. However, the average grade in Calculus 1 was not the highest of the cohorts (2019). Together, these data points do not clearly indicate whether or not peer mentorship had any measurable impact on student achievement.

Table 2: Average semester 1 GPA and average Calculus 1 GPA for students participating in this study, shown by year of course offering.

Year	n	Semester 1 GPA	Std. Dev.	Calc. 1 Average	Std. Dev.
2018	19	2.70	1.0	1.91	1.28
2019	18	2.76	0.97	2.77	0.99
2020	20	2.52	1.29	1.93	1.65
2021	32	2.84	0.83	2.48	0.98

Controlling for Other Factors: Cohort Comparison

Finally, the average high school GPA, average MATH score on standardized testing, average Calculus grade, and GPA after semester 1 are provided to compare populations of students, allowing us to consider if mentorship is the primary catalyst for changes or if there are confounding factors. Table 3 shows the average high school GPA and average MATH SAT score for each cohort. While the average GPA is higher for the 2021 cohort, the MATH SAT average is within the same range as other years (excluding 2018). These metrics suggest that any observed increase in retention is likely not due to simply 'having better students', and are encouraging for generalization of the approach.

Table 3: Average high school GPA and average MATH SAT score for students participating in this study, shown by year of course offering.

Year	n	High School GPA	Std. Dev.	Math SAT	Std. Dev.
2018	19	3.37	0.51	556	98.2
2019	18	3.47	0.55	580	108.3
2020	20	3.49	0.43	593	81.6
2021	32	3.58	0.46	578	112.9

Conclusions

In this study, a peer mentorship program for first-year engineering students was implemented, with the goal of improving outcomes in student integration to the engineering program and university, retention, and student understanding of engineering design. An assessment framework is presented to measure the efficacy of peer mentorship when related to three specific research questions, specifically:

> RQ1: Do students feel that peer mentorship was valuable in connecting to the engineering program and community?
> RQ2: Does peer mentorship lead to better retention outcomes?
> RQ3: Does technical mentorship by upper-level engineering students promote greater academic success?

In addition, initial results were presented using this assessment framework. For RQ1, the majority of first-year engineering students agreed that peer mentors were useful in connecting them to the engineering program and university, but these results were mixed, with a large percentage feeling neutral to this question and a small percentage disagreeing. Results for RQ2 demonstrate that short term retention was increased with the introduction of peer mentorship, but medium and long term retention results are not yet available. Finally, for RQ3, there was not a significant change in student achievement when peer mentorship was introduced.

In addition to these results, cohort data was provided to add context to the study and to control for differences in the academic preparation of each cohort. These data suggest that there are not significant differences in the cohorts, indicating that changes in retention and other measures likely are not due to 'having better students' in one cohort when compared to others.

While the results for RQ1 and RQ2 (community and retention) are generally positive, significantly more data must be collected to assess the efficacy of peer mentorship for impacting these outcomes. Specifically, long term retention data are needed, and several more years of the study should be conducted. The students participating will be tracked from enrollment until graduation to continue to develop conclusions. The results related to RQ3 saw no significant impact, and further measurements are needed to determine if there is any significant impact on student achievement as a result of peer mentorship. We plan to continue this study for several more years and continue to assess all three research questions. Future papers will provide updates on this continued study.

References

[1] Donaldson, S.I., E.A. Ensher, and E.J. Grant-Vallone, “Longitudinal examination of mentoring relationships on organizational commitment and citizenship behavior.” Journal of Career Development, 26(4): 233-249.
[2] Elora Candace Voyles., Rhonda K. Kowalchuk., John W. Nicklow., Robert Ricks, “Residential Peer Mentoring Benefits Mentees: What about Mentors?,” Proceedings of the 2011 ASEE Annual Conference & Exposition, 2011.
[3] R. D. Robnett, P. A. Nelson, E. L. Zurbriggen, F. J. Crosby, and M. M. Chemers, “Research mentoring and scientist identity: insights from undergraduates and their mentors,” International Journal of STEM Education, vol. 5, no. 1, 2018, doi: 10.1186/s40594-018-0139-y.
[4] A. M. Zaniewski and D. Reinholz, “Increasing STEM success: a near-peer mentoring program in the physical sciences,” International Journal of STEM Education, vol. 3, no. 1, May 2016, doi: 10.1186/s40594-016-0043-2.
[5] J.A. Coller, M. Su, L.K. Alford, S. Sheffield and R. Fowler, “Assessment of Peer Mentoring of Teams in a First-Year Design-Build-Test-Communicate Class,” Proceedings of the 2017 ASEE Annual Conference & Exposition, 2017.
[6] K.S. Corbett, K. Evans, S. McAdams, J. Gaudin, M.A. Walker and T.S. Fontenot, “Work in Progress: Developing a Model for Student-led Peer Mentorship Programs,” Proceedings of the 2018 ASEE Annual Conference & Exposition, 2018.
[7] Q. Tahmina, “Does Peer Mentoring Help Students be Successful in an Introductory Engineering Course?” Proceedings of the 2019 ASEE Annual Conference & Exposition, 2019.
[8] L.K. Someh, B.P. O’Connell, K.S. Grahame and J. Levi, “Friendly mentor or former consultant: peer-mentors in First Year Engineering Courses,” Proceedings of the 2020 ASEE Annual Conference & Exposition, 2020.
[9] C. Kiassat and R. Elkharboutly, “Peer Mentoring, Learning Strategies Course, and Online Math Help Module to Increase Retention in School of Engineering,” Proceedings of the 2020 ASEE Annual Conference & Exposition, 2020.
[10] M.J. Jensen and J.L. Schlegel, “Implementing an Entrepreneurial Mindset Design Project in an Introductory Engineering Course,” Proceedings of the 2017 ASEE Annual Conference & Exposition, 2017.
[11] P. Schlosser, M. Parke and J. Merrill, “Decision-making in the design-build process among first-year engineering students,” Proceedings of the 2008 ASEE Annual Conference & Exposition, 2008.