2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
ASEE
Paper ID #39312

A Near-Peer Mentoring Framework for a Civil and Environmental Engineering Curriculum

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A Near-Peer Mentoring Framework for a Civil and Environmental Engineering Curriculum

Introduction

Background

In engineering education, it is critical for students to develop a strong personal identity and sense of belonging within the engineering community. Mentoring has been shown to be an effective tool for fostering such traits [1]. Throughout recent years, numerous definitions and frameworks for mentoring have been developed [2]. Many formal and informal mentoring methods have further been documented as successful in contributing to the development and future success of students [3, 4, 5].

Near-peer mentoring is a method of mentoring in which a senior student mentors a younger student [6]. Near-peer mentoring has shown to be especially beneficial because of "social and cognitive congruences" [6, 7] between the mentor and mentee. In addition, self-confidence and self-efficacy are also reported outcomes.

The effects of near-peer mentoring are well-documented. For example, studies have shown that near-peer mentoring can result in an increased sense of community in engineering programs. Kunberger [8] studied the impact of near-peer mentoring on self-efficacy in an introductory engineering course at Florida Gulf Coast University. In this study, upper-level students mentors were incorporated into the class through in-person and online engagement. Using pre- and post-course surveys, complemented by focus group discussions, Kunberger determined that near-peer mentoring resulted in "students [gaining] a better sense of place within engineering over the course of the semester" [8].

Many existing mentorship programs are focused on benefitting the mentee and the opportunities for mutual growth for both mentor and mentee are missed. For example, upper-level students can develop critical professional skills such as networking, communication, and coaching skills when taking on the "mentor" role [9, 10]. When carefully planned and thoughtfully implemented, near-peer mentoring can be mutually beneficial for both the mentor and the mentee.

Near-peer mentoring is designed to be mutually beneficial for both the mentor and mentee. For example, in a study conducted at the Walter Reed Army Institute of Research (WRAIR), undergraduate college students instructed a STEM-based near-peer mentoring summer program for middle and high school students. The mentoring benefitted the pre-college students through STEM-based activities, educational and career advice, and supportive relationships. The framework implemented at WRAIR equally emphasized the importance of the undergraduate mentor's personal and professional growth. In written survey responses, mentors reported developing improved communication skills, gaining maturity (i.e. patience and flexibility), and cultivating more-defined career goals throughout the summer [11].

Formal and informal mentorships can be difficult to establish and sustain. Formal mentoring programs require significant planning and management infrastructure. Creating mentor-mentee pairings can be challenging especially when the pair is not working toward a shared goal. Loss of direction or interest is common in these situations which results in the dissolution of the relationship. Common goals help to build meaningful relationships. In her chapter on formal mentoring programs, Belle Rose Ragins discusses the potential failures that can result from unsuccessful mentoring programs, such as mentor-protege mismatch, scheduling difficulties, and lack of interest from either party [9]. Ramirez further discusses the importance of a clearly defined common goal, as well as regularly-scheduled meetings, to provide structure to the mentoring relationship [5].

Many formal mentoring programs are targeted to specific audiences such as individual minority groups or have high barriers to entry such as lengthy application processes. Students hoping to engage in informal mentorship may have difficulty finding a complementary mentor or mentee. Without an established mentoring program, first-year students may feel uncomfortable or lack opportunity to reach out to upper-level students for guidance. Likewise, upper-level students may not consider mentoring or know how to begin mentoring their younger student peers.

Near-peer mentorship programs can be beneficial in the context of large engineering departments. Specifically, mentoring can provide more focused attention to individual students in large classrooms where professors cannot provide such personalized guidance. As a result, students receive more tailored support, enabling them to gain a deeper technical understanding and build confidence as an engineer. However, formal mentorship programs can be difficult to implement in large groups. Even programs that are effective in smaller settings can be difficult to expand. While studies have shown that consistent mentoring is the most effective approach, it is not always practical in the context of large classes or programs with a large number of students. Finally, there is also a growing need for engineers to have stronger communication skills and professional development skills. Mentoring programs can address this need, as mentoring provides opportunities for mentors and mentees to develop non-technical abilities such as technical writing and personal communication skills. However, few higher-education courses integrate mentoring, of any form, into the class curriculum. As such, students who do not make a concerted effort to seek out mentoring may never receive its benefits.

Project Objectives

In the following paper, two near-peer mentoring programs are described and implemented in the context of a large (200+ students) project-based introduction civil and environmental engineering (CEE) course. They were developed to provide sustainable, effective methods for near-peer mentoring that could be implemented on a larger scale. The two near-peer mentoring frameworks, *targeted mentoring* and *general mentoring*, were developed based on the following objectives:

1. Provide first-year mentees with additional project input and technical writing and presentation feedback.
2. Provide first-year mentees additional information about campus life, the curriculum, and professional opportunities based on the experience of current upper-level students.

3. Create networking opportunities for students across the curriculum and strengthen the sense of community within the department.
4. Create opportunities for upper-level students to develop mentoring relationships and skills as they prepare to enter the profession.

The benefits of near-peer mentoring are well-established and align well with the goals and mission of the department [12]. The framework presented herein is the first step in building a curriculum-level framework that establishes mentoring relationships among all first year students and upper-level students. This framework creates a unique networking opportunity for students in a large program where most students are not used to attending courses with hundreds of other students.

Course Descriptions

The research in this paper is an extension of efforts to develop an introductory civil and environmental engineering (CEE) course as described by Henschen [13]. Throughout recent years, the course (referred to as CEE 190) has been overhauled from a one-credit seminar-based course to a four-credit project-based course.

The changes to the course were motivated by department-wide efforts to incorporate curriculum revisions that better prepare engineering students for graduation and professional practice. Five skills were identified to be taught and reinforced at each curriculum level, as demonstrated by Figure 1.

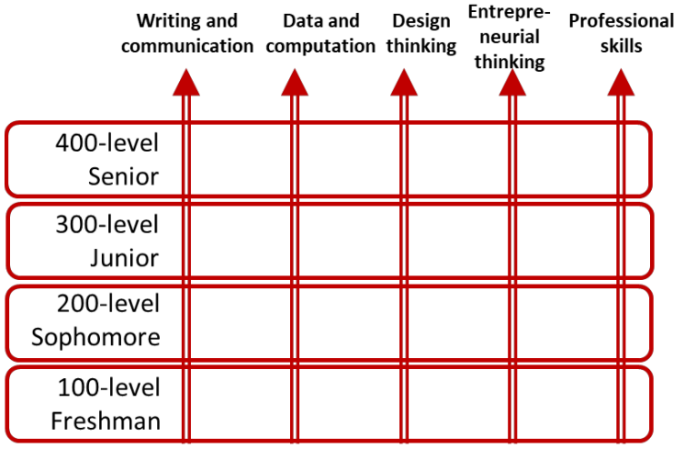

Figure 1. Skills to be taught and reinforced at each curriculum level [13].

The purpose of CEE 190 is not only to introduce students to the civil engineering department, but also to emphasize the importance of the non-technical skills described in Figure 1. In efforts to incorporate such skills into classroom curriculum, an open-ended project was introduced as a critical element of the introductory engineering course.

In this semester-long project, each group of students identifies an “engineering problem” on campus and researches potential solutions. In their reports and presentations, the groups are encouraged to discuss various aspects of the problem, including but not limited to technical,

economical, and environmental considerations. A major goal of the project is to strengthen students' confidence in their technical writing and presentation abilities.

Due to the breadth and number of projects, advising the 60 individual teams is a challenge. Additionally, providing feedback on technical writing and presentations is critical for improvement but time-consuming. To support both technical writing and project advising, a strategy for implementing peer mentoring from upper-level courses was developed.

The nature of the open-ended project in a large first-year class offers the opportunity to implement mentoring programs that benefit not only the first-year student "mentees" in the class, but also upper-level "mentors" from more advanced engineering courses. Additionally, the four credit hours associated with the course affords course instructors the in-class time to directly incorporate near-peer mentoring into the course curriculum. The open-ended project also provides opportunities for both the first-year and upper-level students to build connections within their department, solidifying their identity as engineers. Finally, the large number of students enables two mentoring frameworks to be implemented and compared.

Students from the first-year introductory course were paired with student mentors from three advanced engineering courses. Two of the advanced engineering courses, referred to as CEE 4XX, focus on construction materials. The third senior-level engineering course, referred to as CEE 495, focuses on professional practice and development. The interactions between first-year students from CEE 190 and upper-level students from more advanced engineering courses reinforce the importance of non-technical skills throughout all levels of the engineering curriculum.

Two formats of near-peer mentoring were piloted in the context of this first-year introductory engineering course: *targeted mentoring* and *general mentoring.*

"Targeted" Mentoring Framework

The first framework for near-peer mentoring provides significant benefits to both first-year student "mentees" from CEE 190 and upper-level student "mentors" from CEE 4XX. This framework involves a "targeted" pairing of first-year project-teams with upper-level project-teams that are studying similar topics with slightly different project objectives. The two groups meet periodically throughout the course of the semester to discuss their projects' progress and challenges. The first-year projects provide context to the more-technical upper-level projects, while the upper-level students help provide technical background for the freshmen.

Together, the two teams work together towards a common goal. The partnership and regular meetings between the two groups create opportunities for a deeper impact on both the first-year mentees and the upper-level student mentors. In this framework, students from more advanced engineering classes have the opportunity to gain experience teaching and mentoring younger students. The first-year students not only gain a deeper technical understanding of their project, but are also introduced to a potential role model who has successfully completed much of their engineering curriculum. Ultimately, the groups provide mutual support through shared knowledge and collaboration. Additionally, the repeated meetings between the same groups of

people working together towards a common goal allows for a greater chance of more meaningful connections. The relationships developed in repeated mentoring sessions can result in future contacts in their professional and academic careers.

Although this framework can provide significant benefits for mentors and mentees, it is also more challenging to implement and manage. The mentor-mentee pairs require strategic planning, and the periodic meetings require organization and a willingness to participate from all parties. This framework can be especially difficult to implement with large groups of students, as there may be limited groups of first-year students and upper-level students studying similar topics. Finally, repeated mentoring sessions can be difficult to facilitate, even with the help of a course teaching assistant.

As such, only two pairs of project-teams were formed in this pilot study. The results in this paper provide insight into how this framework can be implemented for the planned expansion to other 4XX courses.

"General" Mentoring Framework

In order to provide project mentorship to the entire first-year course (200+ students), a second framework was developed. In this framework, seniors enrolled in the department's senior-level professional development course, CEE 495, attend at least two lectures of the first-year course to meet with multiple first-year student groups. In this mentorship, senior students are given questions and directions to provide feedback to the first-year students' projects. With this system, each senior meets with multiple teams during their one-hour visits. There are 5 mentorship dates explicitly scheduled (50 minutes each) with CEE495 students throughout the semester for first year student teams.

This framework is simpler to implement and manage, as the mentors and mentees are randomly assigned and follow-up meetings do not need to be coordinated. As such, the nature of the "general" mentoring framework makes it feasible in classrooms with large student to teacher ratios.

Although this mentoring is not expected to provide the same level of benefits as the previous "targeted" mentoring, the aim is that both the mentors and mentees receive some benefit from the exercise. The primary objectives of each meeting are provided (e.g., feedback on team project proposal, 3-minute presentation, interim report, final report, 6 minute presentation), and it is expected that the conversations have a broad impact on all the students involved. The varied nature of the discussion topics and the informal format of the mentoring provides the opportunity for the first-year and upper-level students to create connections and build community as relationships evolve naturally. The recurrent random pairings of mentors and first-year students allows for a greater chance of connection between the upper-level mentors and first-year mentees.

In this "general" mentoring framework, first-year students gain invaluable knowledge through conversations with upper-level students. Mentees are able to ask questions to peers who were recently in their positions, while the mentors gain valuable experience mentoring younger peers

within a structured but feedback flexible framework. Senior students gain professional development skills, while first-year students receive additional project guidance and the opportunity to learn from the experience of their older peers.

The results of this paper, as described below, illustrate the benefits and challenges of both mentoring frameworks.

Methodology

Both mentoring frameworks were organized and implemented within the context of the introductory civil and environmental engineering course described above (CEE 190). Course instructors strategically planned the mentoring groups to coordinate with project milestones and teaching assistants helped moderate the mentoring group activities in each mentorship session.

"Targeted" Mentoring Framework

In the "targeted" mentoring framework, groups of first-year students are strategically paired with groups of upper-level teams. Instructors or teaching assistants pair the two groups together based on similar interests. In the case of the Fall 2022 pilot program, groups of first-year students were paired with upper-level students researching material related to the first-year students' project topic.

The two groups met three times throughout the semester. Dates are strategically planned in advance with specific goals in mind. For example, in the pilot program, the following meetings in Table 1 were scheduled around project due dates.

Each meeting is facilitated by a teaching assistant with specific objectives. As shown in Table 1, the first meeting provided an opportunity for the groups to meet and share about their team's project. In the second meeting, the upper-level students discuss more in-depth technical data related to the first-year students' project. The first-year students share non-technical considerations for the project and, together, the groups discuss the implications. In their final meeting, the two groups develop final conclusions about their work.

Table 1. Meeting Objectives for Targeted Mentoring.

	Date	**Meeting Objectives**
Meeting #1	Week 2 of Project	Mentors and Mentees: - Share your project objectives with the other team - Present background information your team has gathered
Meeting #2	Week 5 of Project	Mentors: - Share early test results Mentees: - Collect data for your report Mentors and Mentees - Discuss implications of the data
Meeting #3	Week 7 of Project	Mentors and Mentees: - Share final results and conclusions

"General" Mentoring Framework

In the "general" mentoring framework, upper-level mentors visited a first-year course during class time. The first-year students are arranged by their project teams into approximately sixty teams. The upper-level mentors rotate between tables, meeting with each of the mentee groups for up to 50 minutes. As such, each team of first-year students is able to engage with at least two upper-level students throughout the one-hour period.

At the start of each mentoring session, the upper-level students are given a list of discussion topics. The listed topics included project input, including presentation practice and technical writing review, as well as topics involving student life, such as class schedules, internships, and extracurricular organizations.

Throughout the semester, five mentoring sessions were organized. First-year CEE 190 students attended all five sessions, while CEE 495 student mentors were only required to attend two sessions. This is because there were more CEE 495 students than CEE 190 project teams.

Assessment

To understand the effectiveness of both near-peer mentoring frameworks, both the first-year "mentees" and upper-level "mentors" were invited to participate in anonymous surveys about the success of the mentoring programs. The survey questions were designed to identify the key benefits and negative effects of the mentoring programs.

The survey questions are outlined in Table 2 below and were administered to the students via IRB-approved surveys.

Table 2. General Mentoring Survey Questions.

Framework	Target Audience	Survey Question	Response Format
General Mentoring	Mentees	How many times did you interact with the students from CEE 495?	#
		How beneficial were the meetings with the CEE 495 students to you as a student?	Range: 1 - 5 5: Very Beneficial 4: Somewhat Beneficial 3: Neither Beneficial nor Negative 2: Somewhat Negative Effect 1: Negative Effect
		How beneficial were the meetings with the CEE 495 students to your group's project?	
		How did the meetings with the CEE 495 increase your sense of belonging in the major or department?	Range: 1 - 5 5: Positive Effect 4: Somewhat Positive Effect 3: Neither Positive nor Negative Effect 2: Somewhat Negative Effect 1: Negative Effect
		How did your attitude about the importance of writing change through the semester?	Range: 1 - 5 5: More Important 4: Somewhat More Important 3: No Effect 2: Somewhat Less Important 1: Less Important
		How did your confidence in writing change through the semester?	Range: 1 - 5 5: More Confident 4: Somewhat More Confident 3: No Effect 2: Somewhat Less Confident 1: Less Confident
	Mentors	How many times did you meet with the CEE 190 class teams?	#
		What topics were discussed with the 190 students?	Range: 1 - 5 1: CEE 190 topics 2: Mostly CEE 190 topics 3: Mix of topics 4: Mostly student life topics 5: Student life topics
		How much do you feel you helped the students in 190?	Range: 1 - 5 5: Positive Effect 4: Somewhat Positive Effect 3: Neither Positive nor Negative Effect 2: Somewhat Negative Effect 1: Negative Effect

Table 3. Targeted Mentoring Survey Questions

Framework	Target Audience	Survey Question	Response Format
Targeted Mentoring	Mentees	How beneficial were the meetings with the CEE 4XX students to you as a student?	Range: 1 - 5 5: Very Beneficial 4: Somewhat Beneficial 3: Neither Beneficial nor Negative 2: Somewhat Negative Effect 1: Negative Effect
		How beneficial were the meetings with the CEE 4XX students to your group's project?	
	Mentors	How many times did you meet with the CEE 190 class teams?	#
		What topics were discussed with the 190 students?	Range: 1 - 5 1: CEE 190 topics 2: Mostly CEE 190 topics 3: Mix of topics 4: Mostly student life topics 5: Student life topics
		How much do you feel you helped the students in 190?	Range: 1 - 5 5: Positive Effect 4: Somewhat Positive Effect 3: Neither Positive nor Negative Effect 2: Somewhat Negative Effect 1: Negative Effect
		Was the mentoring experience beneficial to you?	
		Was the mentoring experience beneficial to you?	

Results

The results from this study were produced from surveys where students are asked to reflect on their experiences with the mentoring framework. Table 4 contains the results from the mentee surveys and Table 5 contains the results from the mentors. For both the mentors and the mentees, the response rate was as high as 10% of the enrolled students.

Table 4. Results from Mentee Assessment.

Survey Questions	Survey Responses	
	Mean	Mode
General Mentoring: Mentees (n = 25)		
How many times did you interact with the students from CEE 495?	3.60	3.00
How beneficial were the meetings with the CEE 495 students to you as a student?	3.73	4.00
How beneficial were the meetings with the CEE 495 students to your group's project?	3.54	3.00
How did the meetings with the CEE 495 increase your sense of belonging in the major or department?	3.69	3.00
How did your attitude about the importance of writing change through the semester?	4.31	5.00
How did your confidence in writing change through the semester?	4.00	4.00
Targeted Mentoring: Mentees (n = 1)		
How beneficial were the meetings with the CEE 4XX students to you as a student?	3.00	3.00
How beneficial were the meetings with the CEE 4XX students to your group's project?	5.00	5.00
Were your meetings with the 4XX students or 495 students more beneficial?	5.00	5.00

Table 5. Results from Mentor Assessment.

Survey Questions	Survey Responses	
	Mean	**Mode**
Targeted Mentoring: CEE 4XX Mentors (n = 3)		
How many times did you meet with the CEE 190 class teams?	2.00	—
What topics were discussed with the 190 students? 1 - CEE 190 topics 3 - Mix of topics 5 - Student life topics	2.67	3.00
How much do you feel you helped the students in 190?	3.67	4.00
Was the mentoring experience beneficial to you?	3.33	3.00
General Mentoring: CEE 495 Mentors (n = 4)		
How many times did you meet with the CEE 190 class teams?	2.00	2.00
What topics were discussed with the 190 students? 1 - CEE 190 topics 3 - Mix of topics 5 - Student life topicsWhat	3.00	4.00
How much do you feel you helped the students in 190?	3.50	4.00
Was the mentoring experience beneficial to you?	2.50	2.00

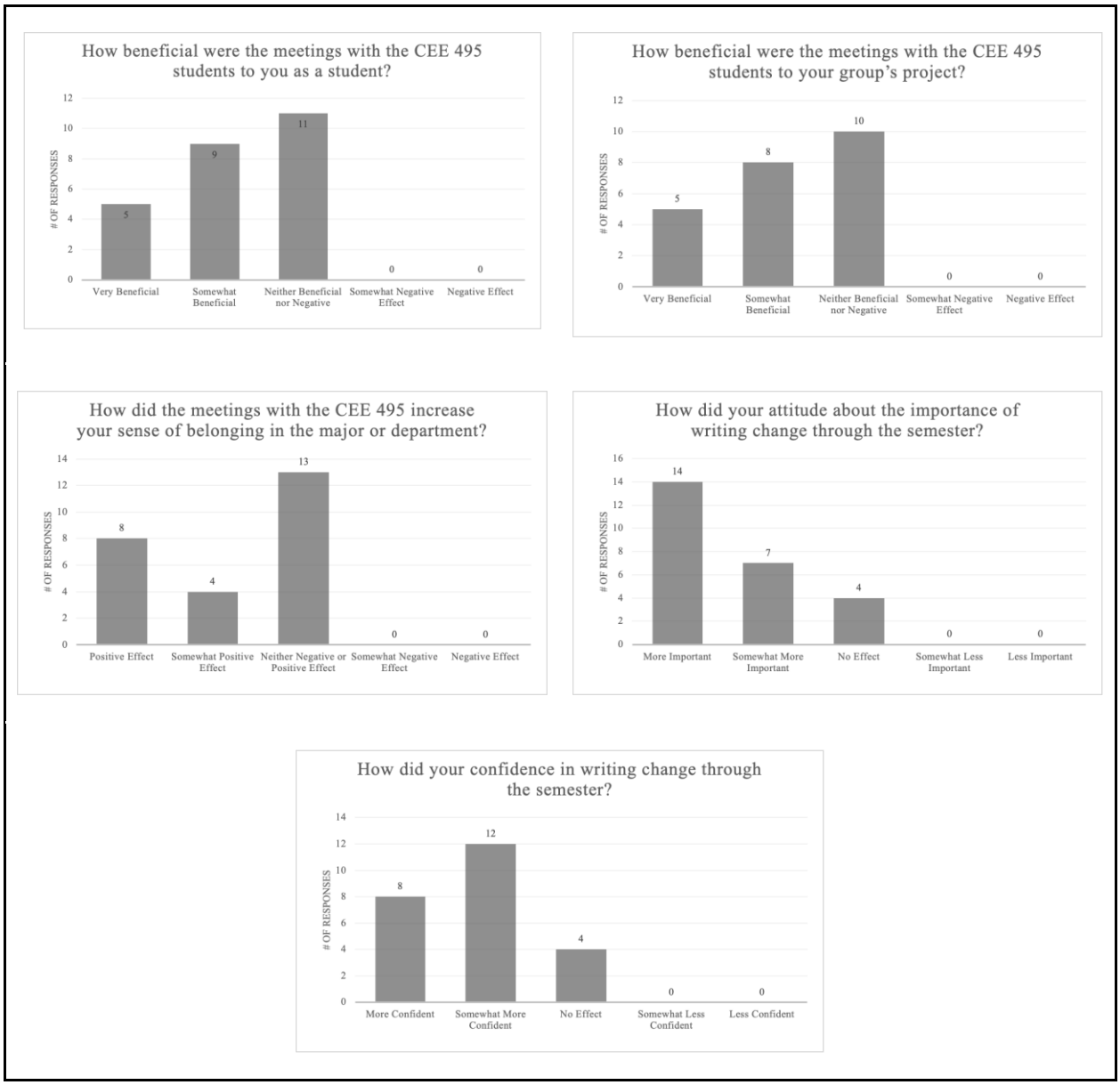

Figure 2. Results from CEE 190 General Targeted Mentoring Survey.

Discussion

Out of the hundreds of pilot participants, only 33 participants responded (26 mentees and 7 mentors). The majority of first-year students who participated in the general mentoring program found the interactions to be "very beneficial" or "somewhat beneficial." As shown in Figure 2, the most significant benefit provided by the general mentoring sessions was insight into student life. Fewer benefits were reported for the students' group project and sense of belonging within the CEE department.

First-year students reported, however, a significant improvement in their confidence in technical writing abilities. The reported improvement in confidence could be the result of successful mentoring (and instructor messaging from day 1 of course), as several of the listed discussion

topics suggested for general mentoring involved technical writing skills. In fact, preliminary open response data reveals that the first-year students found the CEE 495 mentors especially helpful in improving their phrasing, concision, and organization of the technical writing reports.

Due to the limited number of responses, conclusions drawn from the surveys are preliminary. The results indicate that the mentoring programs did not result in notable benefits for the mentors. As shown in Table 4, the majority of CEE 4XX students who participated in the targeted mentoring program did not recognize any effect for their efforts. For the CEE 495 students, their reflections indicated a negative effects. Preliminary open response data indicates that the mentoring sessions "took up time in ways that [they] would have preferred it not" despite being "a cool way to mentor and meet people younger than [them]". Feedback from the CEE 4XX student mentors who participated in the "targeted" mentoring framework is limited; preliminary open response data indicates that mentors were unsure if they benefited their mentees in any way.

Some common themes apparent in a review of the general mentoring feedback include receiving feedback on project and writing, gaining insight into class scheduling, and hearing advice regarding engineering curriculum and extracurriculars.

The most significant assessment data came from the CEE 190 students who articulated there were benefits achieved as a result of the near-peer mentoring pilot. Benefits were achieved without a significant investment in time from the faculty, mentors, and mentees, or teaching assistants. Initial results indicate that, with some improvements, these frameworks for mentoring can be sustainable, efficient methods to achieve the benefits of near-peer mentoring within the context of a large classroom.

Conclusions and Future Work

Near-peer mentoring has been shown to result in numerous benefits for participating mentors and mentees but can be difficult to implement and sustain. In this paper, the results of pilot testing of two frameworks for near-peer mentoring are discussed:" (1) "targeted" mentoring involving a strategic pairing of first-year project-teams with upper-level student project-teams researching similar topics and (2) "general" mentoring involving grouping of first-year students with senior-level mentors to informally discuss project level details, academic planning, and professional development. In both frameworks, the mentoring is directly integrated into the classroom curriculum and meant to benefit both the mentors and mentees. Survey results indicate that general mentoring benefits were achieved without significant investments of time from the faculty, mentors, or mentees.

In the next implementation phase of this research, we plan to improve mentors and mentees experiences by formal lecture training to both courses on keys to successful mentoring. Additionally, we want to increase engagement in the generalized mentoring framework by informally grouping students by topics of interest and expertise of senior mentors. We will broaden the pool of mentors by incorporating students from additional advanced engineering courses.

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