

WIP: Student Mentors and the Engineering Design Process Experience for First Year Students

Prof. Megann P Hedgecock, Pennsylvania State University

Megann P. Hedgecock is a lecturer in Engineering at Penn State Brandywine in Media, Pennsylvania. She has a B.S. in Civil and Environmental Engineering from Lehigh University and an M.S. in Structural Engineering from Cornell University. She has more than twenty years of experience in the engineering and education industries. She teaches courses in engineering fundamentals, engineering mechanics, and computer science. Megann has research interests in mentoring, sustainability, and diversity, equity and inclusion.

Mrs. Sally Sue Richmond, Penn State Great Valley

Sally Sue Richmond is a Lecturer in Information Science at the School of Graduate Professional Studies, Penn State Great Valley. Richmond has a B.A. in Art and an M.S. in Information Science from The Pennsylvania State University. She has 20+ years industry experience in IT. Her research interests are problem-solving, team processes, and mentoring.

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Introduction

In this Work in Progress, we describe the mentoring program between first- and fourth-year engineering students that has positive implications for both the mentors and mentees. There is substantial evidence that near-peer mentoring of and by engineering students helps both mentees and mentors. Students must gain many skills beyond technical knowledge to become competent practicing engineers. ABET names seven outcomes defining the skills, knowledge, and behaviors that engineering students must acquire to be ready to enter the workforce. Among these are an ability to “communicate effectively with a range of audiences” and “function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.” [1].

Employers also value these skills. In a 2023 survey [2], employers rated the importance of each of eight career readiness competencies. The percentage of employers who rated a competency as being either “important” or “very important” was highest for *communication* (99.1%), followed by *teamwork* (96.5%), *critical thinking* (94.9%), and *professionalism* (91.0%). Interestingly, they ranked the importance of *technology* competency lower (74.9%). The employers also rated the proficiency level of recent graduates for each competency. While 81.7% of the employers rated recent graduates’ *technology* skills as “very proficient” or “extremely proficient” and 78.1% gave a similar high rating for *teamwork*, the percentage was much lower for *communication skills* (55.2%) and *professionalism* (50%).

This disconnect between the importance employers place on a competency and recent graduates’ proficiency is greatest for *communications* and *professionalism*. This is not surprising, since most courses in any engineering program are technical courses, and few communications courses are required. If professional skills are taught at all, it is usually done on an ad-hoc basis within other courses or as a single course that may be an elective. This contrasts with employers’ needs since they expect graduates to communicate effectively and demonstrate professionalism both upon hire and on an ongoing basis. Students in the role of mentor and mentee are actively engaging in these skills in a manner that closely simulates what they will experience in the workplace.

There are several ways to mentor students. One is near-peer mentoring, where a student is mentored by someone close in age [3]. Near-peer mentoring offers several advantages over other types of mentoring. Mentees are less self-conscious about asking questions or performing tasks in front of their near-peer mentors, since they are more socially and cognitively like their mentees [4]. Near-peer mentors have recently experienced what the mentees are currently going through and, thus, the mentors have gained some perspective but still recall the nuances of the experience.

Near-peer mentoring frameworks have been studied in various engineering curricula. The framework in a Civil and Environmental Engineering curriculum was shown to improve the mentee’s technical writing skills and gain general guidance about college life [5]. A near-peer framework in a mechatronics camp highlighted the importance of underrepresented minority students being able to identify with a mentor [4]. A study of the impact of near-peer mentoring in

an introductory engineering course found that “some students gained a better sense of place within engineering over the course of the semester” [6].

Project Approach

The authors did not plan this project as a research study. It was a response to a perceived need to help students acquire skills that employers expect them to have but report that recent graduates often lack. These non-technical, yet vitally important, skills are not formally taught in their courses. In this project, two instructors teaching different engineering courses at different campuses within the same University collaborated to provide near-peer mentoring to first-year engineering students while also giving fourth-year engineering students the opportunity to practice their leadership and mentoring skills. The project has been implemented in three previous semesters and is ongoing. Each semester the instructors use feedback from both mentors and mentees to improve the near-peer mentoring framework.

Background

The engineering students participating in this near-peer mentoring experience are enrolled at a large public research University consisting of 23 campuses situated throughout the state. The first-year students attend classes at one campus and the fourth-year students attend classes at another campus. The campuses are approximately 15 miles apart. The first-year engineering students may go on to earn an engineering degree in any of the more than 25 engineering disciplines offered by the University. The fourth-year students are all enrolled in the B. S. in Multidisciplinary Engineering Design (MDE) program, a four-year degree that incorporates coursework and practical experience in mechanical, electrical, and computer engineering with an overarching emphasis on engineering design.

The first-year students are taking a Cornerstone Engineering Design course, EDSGN 100. This is a required course for most engineering majors that introduces students to engineering fundamentals. The course includes a design project that is a significant part of the curriculum. The first-year students work in teams to complete the project and present their work in a poster session at the end of the semester, attended by industry partners, engineering alumni, graduate engineering students, faculty, and students' friends and family.

The fourth-year MDE students are taking a year-long capstone course where they complete a more complex design project. As part of this capstone course, the instructor assigns MDE students to mentor one or two EDSGN 100 teams. The fourth-year students have not received any formal mentor training. In both courses, students follow a general engineering design process where they identify the problem and customer needs, specify system requirements, develop alternative concept designs, evaluate and then select one concept design that they develop into a full detailed design and prototype. Whereas the MDE students have completed multiple team design projects in several courses by the time they start their senior capstone project, this is a new experience for the EDSGN 100 students. The EDSGN 100 students document their progress in a set of assignments as they work through the engineering design process. Each assignment is called a *milestone*, and each milestone adds to the previous milestone document. The assignments are intended to ensure the students work on their project consistently throughout the semester.

The motivation to start near-peer mentoring came from third-year MDE students who attended the EDSGN 100 poster session in spring 2023. They were taking a course taught by the same instructor who would be their capstone instructor during their fourth year. During discussion after the poster session, these third-year students said they would like to meet with the EDSGN 100 students in the following year (fall 2023) before the poster session to offer suggestions for improvement.

The same EDSGN 100 instructor and capstone instructor teach these two courses each semester. While the near-peer mentoring framework has evolved over these semesters based on feedback from mentors and mentees, the goal remains the same, to improve students' communication and professionalism skills. The changes related to the number of mentors assigned to mentee teams, the activities assigned, whether the activities were voluntary or graded assignments, and deliverables expected from both the mentors and mentees.

First Iteration

We implemented the first iteration of this framework in fall 2023. The capstone instructor assigned each capstone team, consisting of 4-5 students, to mentor two or three EDSGN 100 teams. Mentors met with their mentees three times throughout the semester, an introductory meeting, a meeting to review design concepts, and a meeting to practice their elevator pitch for the poster session. The EDSGN 100 instructor tasked the mentees with contacting their mentors and scheduling the three meetings. All meetings were virtual. The capstone students volunteered their time and had no graded assignments. At the end of the semester the capstone instructor received feedback through an informal classroom discussion. The EDSGN 100 mentees had a graded assignment where they responded to a set of open-ended questions about their experience.

EDSGN 100 mentees expressed appreciation for the support they received from the mentors but also some frustration about the difficulty of scheduling meetings. The mentors all said the experience both helped them improve their ability to give substantive feedback and increased their confidence in their ability to be engineers. Both the EDSGN 100 teams and MDE mentors expressed a desire to meet four times instead of three and unanimously agreed the instructors should continue implementing near-peer mentoring.

Second iteration

Based on this feedback, we modified the near-peer framework and implemented it again in spring 2024. We increased the number of meetings to four, adding a meeting where the mentors gave feedback on their mentees' poster before they were sent for printing. Table 1 shows the timing of each meeting. We reduced the number of mentors assigned to each EDSGN 100 team to two. The mentees were a new group of EDSGN 100 students, and the mentors were the same MDE capstone students as in the previous semester (fall 2023). The mentors had an additional graded assignment to provide feedback at the end of the semester about their experience. As in the previous iteration, the mentees were tasked with contacting their mentors and scheduling meetings, with the added task of producing and distributing meeting minutes.

Table 1. EDSGN 100 team design project schedule showing assignment due dates and schedule for meeting with mentors

Activity	Week
Assign project and teams	4
Problem identification research, customer interviews, meeting #1 with MDE mentors	5
Develop alternative concept designs	6-7
Concept design evaluation, meeting # 2 with MDE mentors to review selected concept	8
Milestone – submission of progress report through concept selection	9
Creation of models and detailed design	10
Milestone – draft of final report and poster, meeting #3 with MDE mentors	11
Submit revised poster	12
Meeting # 4 with MDE mentors to prepare for poster session	14
Poster session, submit final report	15

Much of the feedback from the mentees was similar and included the following:

- “The MDE Capstone team provided valuable insights into the technical aspects of our design, helping us streamline the processes. Their guidance on project management and timeliness was particularly useful, ensuring we stayed on track.”
- “The MDE Capstone team was useful because it was nice having someone else check on our team's progress outside of just the team members and the professor. We had four zoom meetings so they were never in person with us but that was fine because our meetings were short anyway.”
- “They were not terribly responsive and took long to respond to requests to meet.”
- “They could have been more useful if we saw them in person instead of zoom calls.”

The MDE mentors also responded mostly favorably and unanimously agreed we should continue with the near-peer mentoring. Like their mentees, the mentors thought that in-person meetings would be better than virtual. About a third of the mentors expressed frustration about the lack of communication and follow-through from their mentees, although they also noted a distinct variance between the mentee teams.

In fall 2024, the EDSGN 100 students from the first year of the project completed a survey about their experience with the MDE mentors during the EDSGN 100 course they had taken the previous year. Responses were mixed but there was positive feedback about improved confidence in the ability to complete STEM course assignments, which may contribute to both the engineering and coping self-efficacies (see Figure 1).

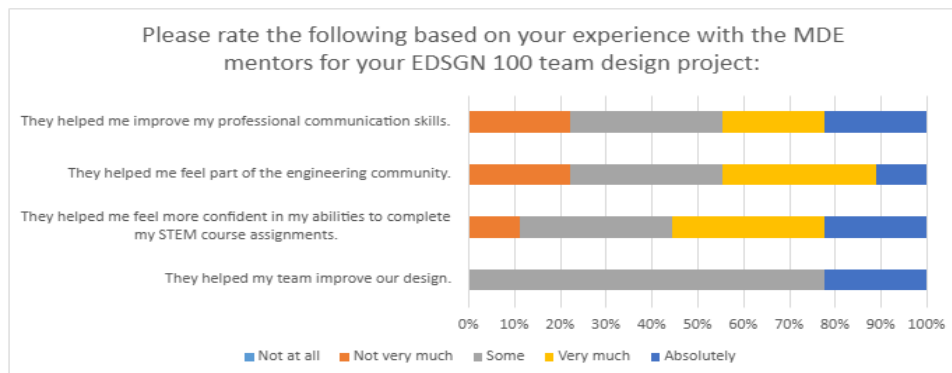


Figure 1. Survey responses from second-year engineering students about the effect of mentoring received the prior year from their EDSGN 100 mentoring experience

Third iteration

We adjusted the near-peer mentoring framework and implemented a third iteration in fall 2024. The structure was the same as for the second iteration, with several additions. At the beginning of the semester the capstone instructor emphasized the importance of mentors responding promptly to their mentees' communications. The mentees were asked to copy both their EDSGN 100 instructor and the capstone instructor on all emails. The instructors intended to track these emails to ensure mentees were reaching out to their mentors on schedule, but due to time constraints they were unable to follow through on their intent. The EDSGN 100 instructor also asked the mentees to list words they associated with the term *mentor* at the beginning of the semester and again at the end of the semester. Words such as *guide*, *teacher*, and *leader* dominated the responses at both times, suggesting that the MDE mentors lived up to these roles in this semester.

EDSGN 100 students were asked for feedback about the MDE mentoring mid-semester and the results were largely positive about the benefits in terms of technical feedback on design concepts, communication and professional skills, and guidance on class assignments, suggesting that the objectives of the near-peer framework were being achieved. The EDSGN 100 mentees also felt they benefitted by getting more information related to engineering in general. Feedback was less positive about MDE mentoring related to campus life, but this was not a direct objective of the project. After three iterations of the near-peer mentoring framework the results are consistently positive in terms of improved communication skills and professionalism as well as improved self-efficacies. Figure 2 summarizes this feedback. The EDSGN 100 students completed the same survey at the end of the semester. Results are shown in Figure 3. The end of the semester responses are even more positive than the responses from mid-semester.

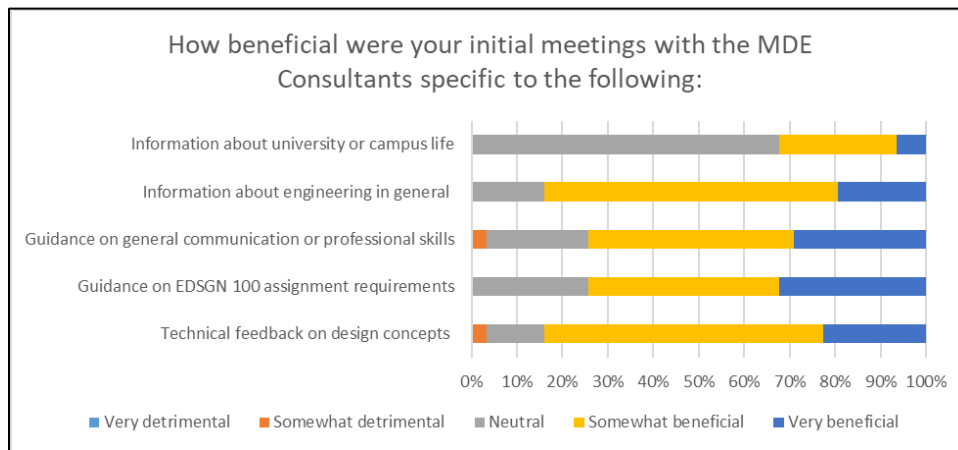


Figure 2. Mid-semester responses, fall 2024

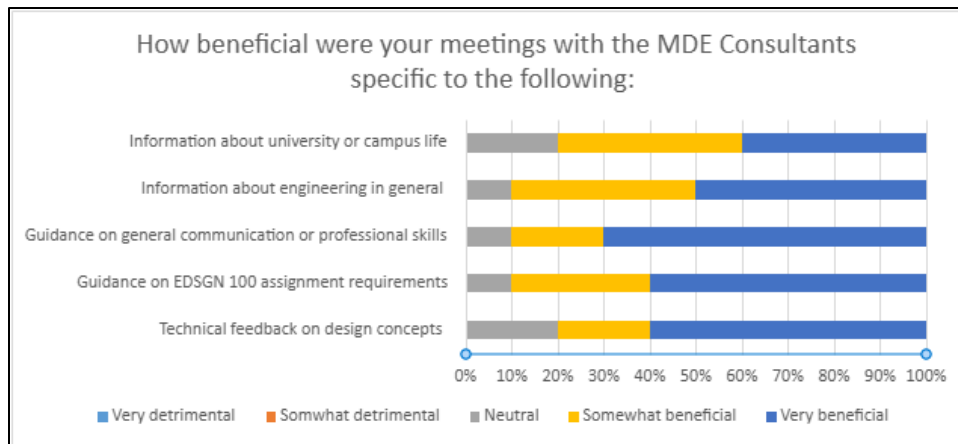


Figure 3. End-semester responses, fall 2024

At the conclusion of the fall 2024 semester, EDSGN 100 students answered several open-ended questions and completed a survey about their experience. Samples of their open-ended feedback are organized in the Feedback Capture Matrix shown in Figure 4. There is considerable positive feedback (top left quadrant of the matrix) about constructive criticism and insights related to the project and otherwise. Not all teams' interactions with the MDE mentors were positive, though. In some instances, planning, scheduling, and attendance went smoothly but this was not true across the board. There were some negative responses (bottom left quadrant) about the attitudes of the MDE mentors and their subject matter knowledge. One consistent suggestion for improvement (top right quadrant) across semesters is trying to meet face-to-face instead of virtually. Other ideas (bottom right quadrant) included having the MDE team share examples of deliverables and asking the MDE mentors to align their ideas with the project constraints.

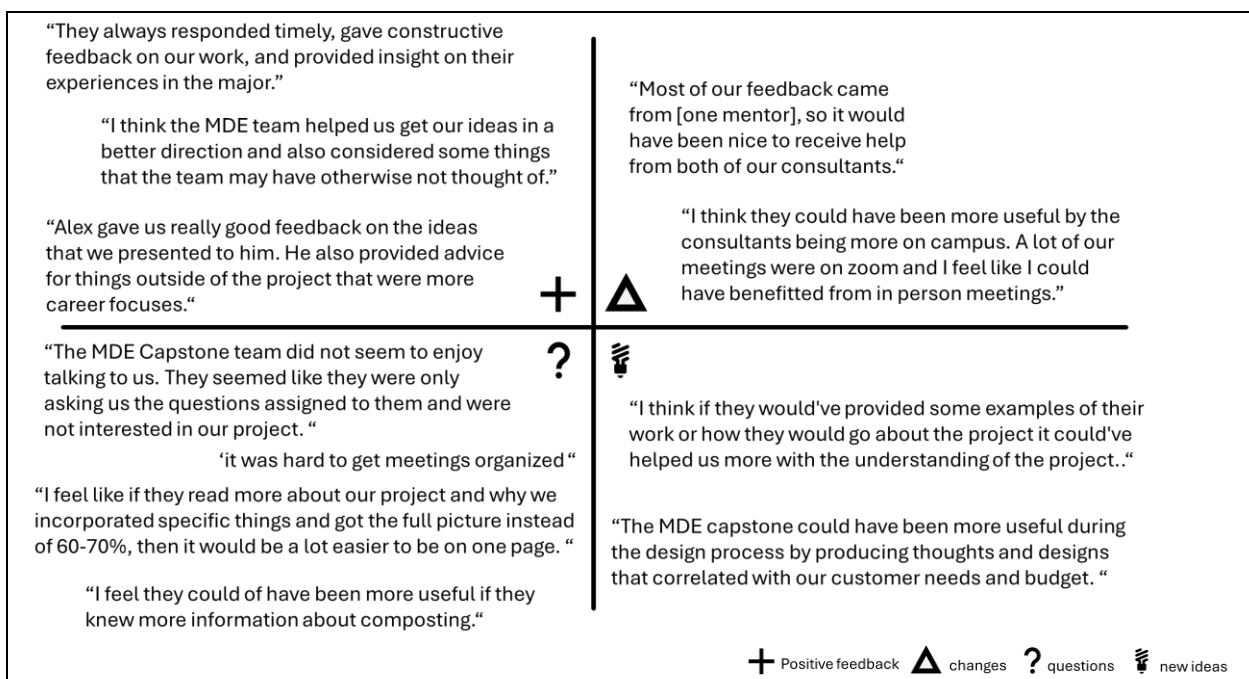


Figure 4. Feedback Capture Matrix from EDSGN 100 fall 2024 Students on MDE Consultants

Results and Discussion

The feedback over three semesters gives sufficient evidence to support continuing this near-peer framework. Mentees found the experience was positive and helped them improve their communication skills and professionalism. Mentors reported that mentoring the first-year students improved their ability to provide balanced feedback that included both positive comments and constructive criticism, practice leadership, and increased their confidence in their ability to become successful engineers. However, our conclusion is based primarily on students' subjective perceptions. Additionally, the class sizes are small, each EDSGN 100 section had 40 students, and the capstone class size ranged from 16-18 mentors.

It is currently the middle of the spring 2025 semester, and we are in the fourth iteration of the near-peer mentoring experience. As in previous semesters, we have made several changes based on feedback from mentees and mentors. The most common negative feedback from both mentors and mentees was frustration at being unable to meet in person. Most fortuitously, the instructors were able to arrange for the MDE mentors to travel to the EDSGN 100 students' campus and meet in person for their first meeting. However, since this required gaining approval from another instructor to allow the MDE mentors to miss that instructor's class on that day, the remaining meetings are likely to be virtual. An obvious solution would be to schedule both EDSGN 100 and the capstone class at the same time. However, due to course demand and faculty availability, this is unlikely to happen.

Another common negative theme is that some mentees and some mentors did not follow through on required tasks. While always a minority, some mentees rightfully complained that their mentors did not respond to emails or did not provide useful feedback and a minority of mentors reported that some mentees did not schedule the required meetings, were unprepared for meetings, and did not distribute meeting minutes. The instructors intended to monitor this using the emails they are copied on but admittedly did not achieve this goal last semester. This semester the capstone instructor assigned one capstone student to act in a "mentor the mentors" role. This student is an adult learner with leadership and mentoring experience. This student will track both mentee and mentor activity, reach out to any mentees or mentors who are not completing their assigned tasks, and coach mentors to improve their mentoring skills.

For the upcoming fall semester, the capstone instructor plans to introduce some type of support to help seniors understand and practice more effective mentoring, based on feedback from this year's seniors about what they think would be effective and research into best practices. Both instructors also plan to formalize the mentor the mentor role and assign a senior to this role.

We believe this near-peer mentoring framework provides a valuable opportunity for both mentors and mentees to improve their communication skills and professionalism, and to increase first-year students' sense of belonging to the engineering community. Based on the evidence gathered so far, we feel that near-peer mentoring helps foster a richer undergraduate experience for our students and better prepares them to be effective practicing engineers. We intend to continue the project, improving it over time based on student feedback.

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