A Novel Near-peer Mentoring Model Involving Doctoral Students in an Interdisciplinary Client-facing Project-based Learning Course

Arko Barman
Data to Knowledge Lab
Rice University
Houston TX, USA
arko.barman@rice.edu

***Abstract*—In our Innovative-Practice Full Paper, we introduce a novel near-peer mentoring model that involves doctoral students for mentoring in a client-facing project-based learning (PBL) course involving teams of students working on interdisciplinary projects. Mentoring forms the backbone for any PBL framework and an increase in enrollment necessitates the mentoring of a growing number of teams for instructors. We introduced a competitive mentoring fellowship program that seeks applications from doctoral students for mentoring project teams and awards fellowships to the selected applicants. Every team in the course is assigned a dedicated fellow from the program as a mentor who provides mentoring to the team in addition to the instructors throughout an entire semester. The program is also designed to help doctoral students gain valuable experience mentoring a project end-to-end. Being an interdisciplinary course, we seek applications for mentoring from several departments across the university and evaluate the applications based on the expertise and knowledge of the applying doctoral students in a variety of relevant fields. To date, we have had 32 mentors in the program from five departments across the university. The selected fellows are tasked not only with mentoring their respective teams but also with attending meetings with the clients sponsoring the projects and understanding the needs of the clients for successfully completing the project. These responsibilities additionally provide the near-peer mentors with the experience of interacting with a client for the best possible outcome from the project. Evaluation of the program is done through separate surveys for enrolled students in the course (mentees) and the fellows (near-peer mentors) in the program. Results from our evaluation indicate that enrolled students appreciate the additional mentoring provided by the fellows while the fellows rate the program highly because of the experience they gain and the professional skills, such as team management, project management, and leadership skills, that they develop. We discuss strategies for improving the program in the future based on the recommendations of both the mentors and the mentees. Additionally, we discuss the instructor's perspective on designing and offering the program, which has benefits for instructors and departments as well.**

***Index Terms*—mentoring, project based learning, interdisciplinary, experiential learning, academic support**

I. Introduction

Project-based learning (PBL) is an effective means of experiential learning inspired by the principles of constructivism. This methodology of active learning encourages students to understand and apply concepts, effectively resulting in context-specific learning and the benefits of knowledge sharing, social interactions, and achieving a goal or target [1]. The effectiveness of PBL is especially enhanced when working in interdisciplinary teams through the benefits of collaborative learning, such as in a capstone course [2], [3]. Working on client-facing projects has been shown to be beneficial since the students gain the invaluable experience of working on a real-world project and interacting with a client to understand and deliver a product while still within an academic environment. Several science, technology, engineering, and mathematics (STEM) degree programs in various universities have been steadily incorporating interdisciplinary client-facing PBL courses in their curriculum in recent years [2], [4]. With the growing popularity of these courses, there has been a sharp increase in enrollment, resulting in an increasing burden of mentoring more and more projects by the instructors. While, traditionally, teams in these courses have been successfully mentored by the faculty [5], the increasing enrollment necessitates the introduction of innovative ideas to utilize available resources within the university for a manageable workload for the instructors.

A. Literature Review

The benefits of collaborative mentoring [6], peer mentoring [7], and especially near-peer mentoring [8]–[13] for both mentees and mentors has been widely studied and reported in recent years, especially in medicine [14], [15] and nursing [16]. Near-peer mentoring results in mentors developing their teaching skills and a sense of belonging in STEM, and mentees having greater motivation and confidence as well as improving learning outcomes and strengthening self-efficacy [17], [18]. In addition, near-peer mentoring improves retention and a sense of belonging in STEM for mentees, especially women and students from underrepresented minorities [19]–[21]. Further, both qualitative and quantitative studies indicate that near-peer mentors experience a sense of being guided by an instructor while guiding, resulting in the development of their professional identities as researchers [22], [23]. Near-peer mentoring has also been applied in the PBL

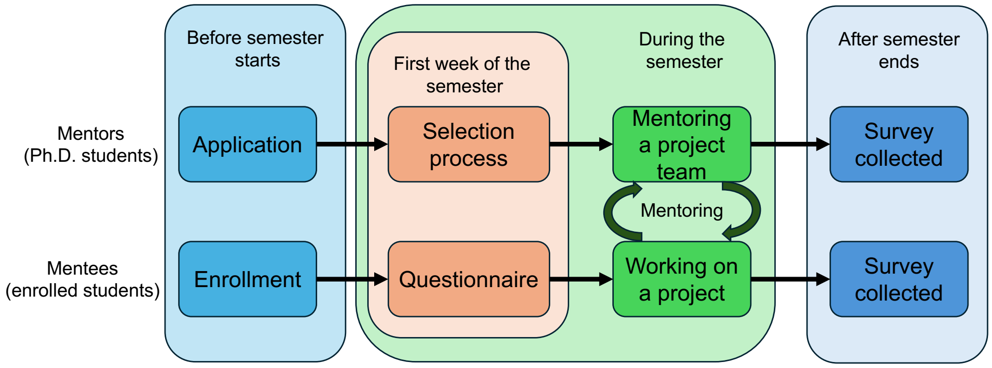


Fig. 1: Overview, structure, and timeline of the mentoring program

scenario for first-year and second-year undergraduate students in recent years [24]–[26].

B. Our Near-peer Mentoring Program

Thus, the implementation of near-peer mentoring in an interdisciplinary client-facing PBL course has the promise of unprecedented three-way benefits for all the involved parties – the instructor, the mentors, and the enrolled students, i.e., the mentees. The instructors can now focus more on high-level technical details while the near-peer mentors can provide low- to medium-level mentoring support. On the other hand, the mentee students benefit from an additional layer of mentoring support besides the observed benefits of having near-peer mentors as stated before.

In designing and implementing this program, we noted a gap in the literature on the roles and benefits of having doctoral students as near-peer mentors for undergraduate, master's, and doctoral students, especially in a PBL framework. Therefore, we report our novel study design of employing doctoral students as near-peer mentors. Having an immersive research experience, doctoral students are well-equipped to mentor applied research projects but often lack the necessary skills for the project management of a large-scale end-to-end project and its workflow, effectively communicating with clients, and mentoring a team of students. Our study design not only aims to provide additional mentoring support for student mentees but also to develop mentoring skills, communication skills, and project management skills in the doctoral student mentors. We envisage that our program will also enable mentors to hone their leadership skills as they are tasked with leading a research project, perhaps for the first time in their research careers.

C. Our Contributions

The contributions of our study are summarized below:

- the design, development, and implementation of a novel near-peer mentoring program with doctoral students as mentors of teams in an interdisciplinary client-facing PBL course
- collection and analysis of feedback on the program from both mentors and mentees
- reporting the benefits of the program to instructors and academic departments

II. The Course & The Mentoring Program

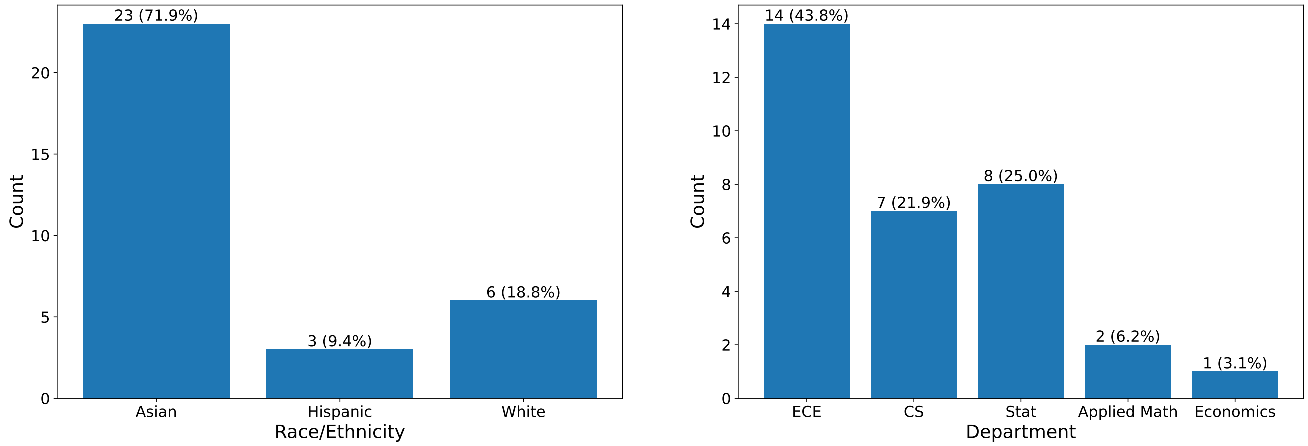
Here, we discuss the course structure and the fellowship program in detail. The overview, structure, and timeline of the fellowship program vis-à-vis the course is shown in Fig. 1.

A. The Course

The mentoring program was implemented for a client-facing interdisciplinary machine learning and data science capstone course that was designed to impart the benefits of experiential learning, collaborative learning, and PBL to both undergraduate and graduate students [2]. Occasionally, there are a few doctoral students enrolled in the course as well. Students from different majors and minors, such as computer science, data science, statistics, electrical & computer engineering, applied mathematics, and biosciences & bioengineering, enroll in this course. The course has a prerequisite of a machine learning course, or in lieu of it, an extensive background in statistics, as determined by the instructors on a case-by-case basis.

The projects offered in the course include real-world problems from industry, non-profit organizations, government and civic bodies, hospitals and medical centers, and research labs. The projects and the associated data are thoroughly evaluated and vetted by one of the instructors before being offered to students. At the beginning of the semester, the enrolled students are asked to fill in a questionnaire that evaluates their background in different domains of application of data science, e.g., computer vision, natural language processing, statistical analysis, genetics, time series analysis, and signal processing, as well as their preference for the available projects in that semester. The instructors then form teams by assigning students to appropriate projects based on their backgrounds and preferences.

The course deliverables include a presentation, a report, and a collaboratively developed software created using version control systems. Besides being assessed at the end of the semester (i.e., project completion), there are two interim checkpoints for assessment and feedback based on the project progress. Throughout the semester, the student teams are mentored by one of the instructors as well as the near-pear doctoral student mentor. They are expected to have weekly interactions not only among themselves but also with their



(a) (b)

Fig. 2: Distribution of the mentor group across (a) race/ethnicity, and (b) departments. (CS: Computer Science, ECE: Electrical & Computer Engineering)

client. At project completion at the end of the semester, student teams present their project at an open showcase and submit their report to the instructors and the client.

The grading scheme includes both a team (presentation, report, and software) component amounting to 70% and an individual component (class participation, instructor's assessment of individual contribution, and self and peer evaluation) amounting to 30% of an individual student's grade.

B. The Mentoring Program

Two weeks before the semester starts, applications are sought from the doctoral student community of the university for the mentorship program. The application form consists of a questionnaire designed to gauge the background of the applicants in machine learning, statistics, programming, database systems, and the different domains of application of data science, e.g., time series analysis, signal processing, computer vision, medical imaging, genetics, natural language processing, and causal inference. The questionnaire also asks applicants some behavioral questions as well as a personal statement outlining their motivation for the program and what they want to achieve through it.

Based on the applications received, at least two instructors evaluate and shortlist the applications based on their research and technical background, responses to behavioral questions, and personal statements. Preference is given to doctoral students in their third year or above, or those with prior work and/or research experience. From the pool of shortlisted candidates, appropriate mentors are assigned to particular projects based on how their background aligns with the technical skills required for a project, each mentor being assigned a single project. Mentoring of student teams begins in the second week of class.

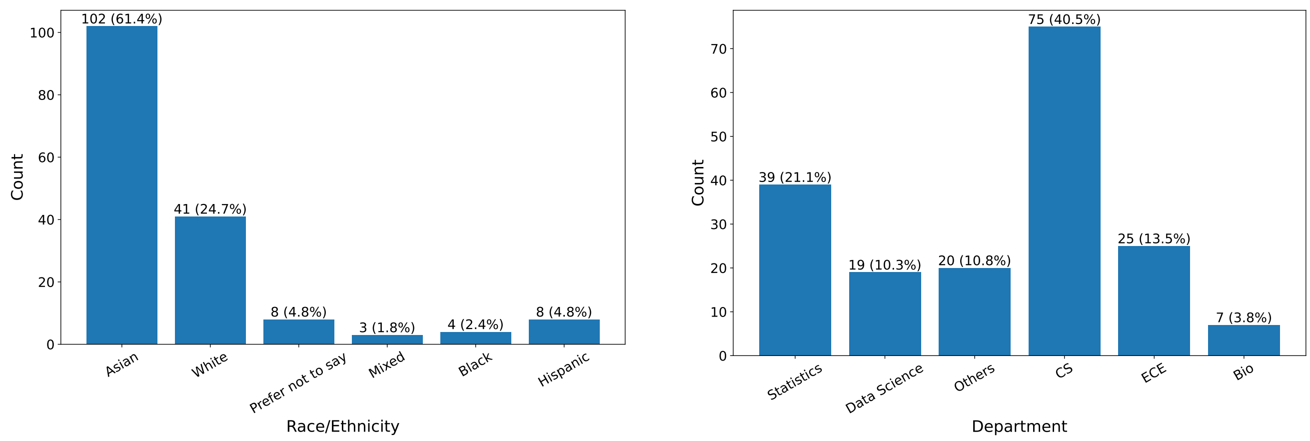
The doctoral student mentors have clearly defined responsibilities and time commitments in the program. The primary responsibilities of the mentor include attending two weekly meetings, one with the students for mentoring where the mentor plays an active role, and the other one being a student-led meeting between the student team and the client. Besides these meetings, the mentors have the responsibility of meeting the team or the instructor as needed, responding to emails or other messages on professional messaging platforms, and reviewing the report and the software of their team to provide feedback from time to time. The expected time commitment of every mentor is approximately 2 hours every week for a total of about 30 hours over the course of the semester.

Overall, the near-peer mentor helps the team with literature review; developing the student team's skills of how to search, read, and understand relevant publications; understanding technical concepts; preparing and providing technical resources (e.g., software packages, libraries, code repositories, and tutorials) to the team with the instructor's guidance; how to use reference management software; how to structure reports; and providing code review and feedback. In addition, they are also tasked with helping the instructor evaluate and assess the individual contribution of the students towards the project.

It is to be noted that the mentoring program is set up and referred to as a "research mentoring fellowship program" and the mentors are officially termed as fellow mentors. A fellowship amount is awarded to the mentors in recognition of their efforts, time, and contribution to student learning and service to the student community.

III. Collection of Feedback

To evaluate the usefulness of the program, we collected feedback from both the mentors and the mentees through separate questionnaires. The questionnaires had questions requiring responses on a Likert scale as well as free-text responses. We describe the questionnaires in detail below. All collection of



(a) (b)

Fig. 3: Distribution of the student mentee group across (a) race/ethnicity, and (b) departments (academic units, majors, and minors). (CS: Computer Science, ECE: Electrical & Computer Engineering, Bio: Biosciences & Bioengineering)

feedback was anonymous and categorized by the university's Institutional Review Board (IRB) as exempt.

A. Feedback from Mentees

The students enrolled in the course were asked to submit their responses to an anonymous exit survey that contained various questions about the course itself. Embedded in this survey were 6 questions related to the mentoring program, out of which 1 question was a free-text response asking for comments and the remaining 5 questions were on a 5-point Likert scale: strongly disagree (1), disagree (2), neutral (3), agree (4), and strongly agree (5). These questions were designed to understand the efficacy of the mentoring program, the type of help they received, and the commitment of the mentor.

The questions were as follows:

- Your fellow mentor helped you with technical aspects. (5-point Likert scale)
- Your fellow mentor provided you feedback on presentation, report, and software. (5-point Likert scale)
- Your performance in the course benefited from having a fellow mentor in addition to your faculty/instructor mentor. (5-point Likert scale)
- Your fellow mentor spent sufficient time with the team to provide advice and mentorship. (5-point Likert scale)
- You would have preferred more engagement from your fellow mentor. (5-point Likert scale)
- Any comments on your fellow mentor. (free text)

B. Feedback from Mentors

At the end of the project, the mentors were asked to submit their responses to an anonymous survey questionnaire. The questionnaire had 8 questions on a 5-point Likert scale: strongly disagree (1), disagree (2), neutral (3), agree (4), and strongly agree (5). The questionnaire was designed to understand if the mentors benefited from the program and in what ways. In addition, there was also an option for free-text response.

The questions were as follows:

- The program helped me in my professional growth (5-point Likert scale)
- I developed/gained mentoring skills (5-point Likert scale)
- The program increased my sense of belonging in STEM (5-point Likert scale)
- I gained project management skills (5-point Likert scale)
- I gained skills for managing a team (5-point Likert scale)
- I am more confident now in managing a research project end-to-end (5-point Likert scale)
- I developed leadership skills (5-point Likert scale)
- The program was helpful for my research career (5-point Likert scale)
- Comments (free text)

IV. Results & Analysis

We report survey results collected over three past semesters of the fellowship program. To understand the context of the results of the survey questionnaires, we first present general demographic information about the students enrolled in the course as well as those of the mentors. The demographic information of these two groups shows us the diversity of both the mentors and the mentees in terms of gender, race, and academic department.

A. Demographic information

1) Mentees: The total number of enrolled students in this course over 3 semesters of reported data was $n = 166$. Out of these, there were 51.2% undergraduate ($n = 85$), 43.4% master's ($n = 72$), and 5.4% doctoral students ($n = 9$). In terms of gender distribution, the student group was 62% male ($n = 104$), 35.5% female ($n = 59$), 1.2% non-binary ($n = 2$), and 0.6% ($n = 1$) students preferred not to answer. We show the race/ethnicity distribution in Figure 3a. Note that

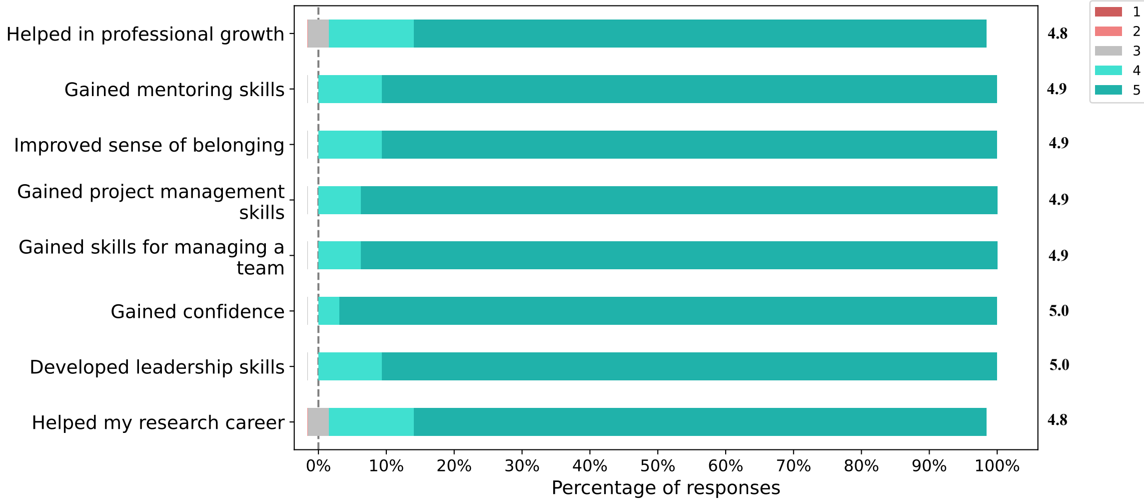


Fig. 4: Results from the mentor feedback data for questions requiring responses on a Likert scale. The averages of the responses are seen on the right. (5: strongly agree / highest rating; 4: agree; 3: neutral; 2: disagree; 1: strongly disagree / lowest rating)

Fig. 5: Word cloud of the comments (free-text responses) in the feedback from the mentors.

we have considered all Asians under one category although the students might identify themselves with different smaller ethnic or geographic groups.

Given the interdisciplinary nature of the course, students from different departments, majors, and minors were enrolled in the course, such as Computer Science, Electrical & Computer Engineering, Statistics, Data Science, and Biosciences & Bioengineering. In addition, there were a few students from Physics, Mathematics, Applied Mathematics, Social Policy Analysis, Political Science, Linguistics, Economics, and other departments across the university: these have been categorized into a single group called "Others". The distribution of students by academic disciplines is shown in Figure 3b.

2) Mentors: In total, we had $n = 32$ near-peer doctoral student mentors in the program over 3 semesters, each mentor dedicated to mentoring a single group project. In this group, 75% were male ($n = 24$) and 25% were female ($n = 8$). The distribution of the mentor group in terms of race/ethnicity is shown in Fig. 2a. It was observed that there were no mentors who identified themselves as black. In fact, we observed that there were no applicants in the program who identified themselves as black. Once again, we note that all Asians were grouped into one category even though they might identify themselves with different smaller racial or ethnic groups.

Similar to the student mentee group, the distribution of the mentors across departments shows a remarkable diversity due to the interdisciplinary nature of the course. This distribution is shown in Fig. 2b.

B. Survey Feedback Data

As described in Section III, feedback was collected from both the mentees and the mentors to evaluate the effectiveness and other aspects of the program for both groups. Here, we present the results from the collected feedback.

1) Mentees: Out of the 166 students, the feedback was completed by 121 students (72.89%). Results from the Likert scale responses in the survey collected from the mentees are shown in Fig. 6, with the average of the responses indicated on the right. The scale indicates 1 for the lowest rating or "strongly disagree" to 5 for the highest rating or "strongly agree". The questions have been suitably and meaningfully abridged in the figure for practical purposes.

The results are summarized below:

- The average rating for a mentor was 4.4 with 83.5% indicating a rating of 4 or above for their mentor; 12.4% rated their mentor 3 (neutral); the remaining 4.1% of the students indicated a low rating of 2 or below.
- 81.8% of the respondents agreed or strongly agreed with receiving technical help from their mentor; 12.4% were

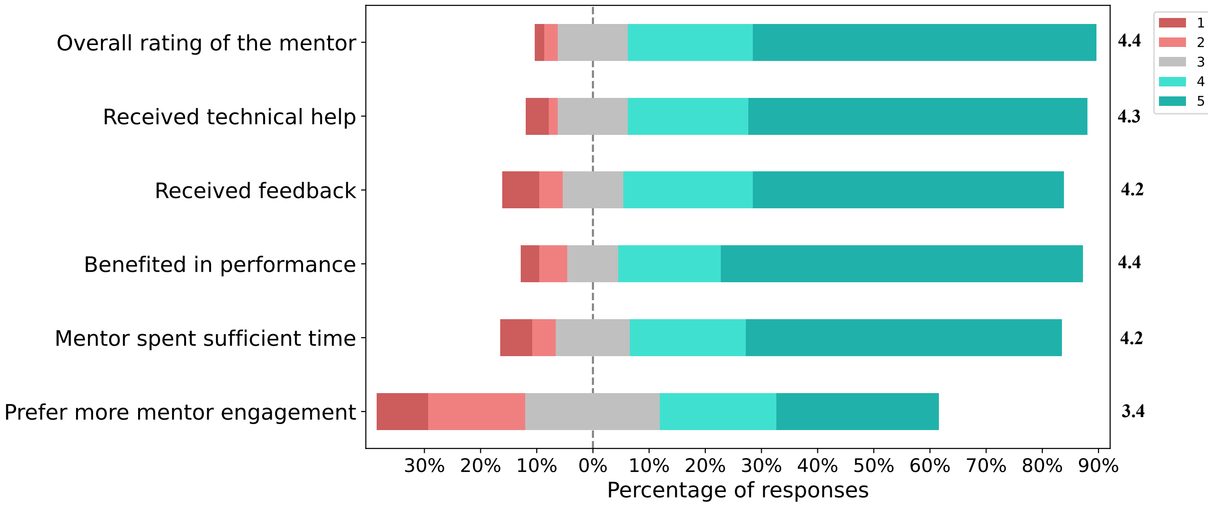


Fig. 6: Results from the mentee feedback data for questions requiring responses on a Likert scale. The averages of the responses are seen on the right. (5: strongly agree / highest rating; 4: agree; 3: neutral; 2: disagree; 1: strongly disagree / lowest rating)

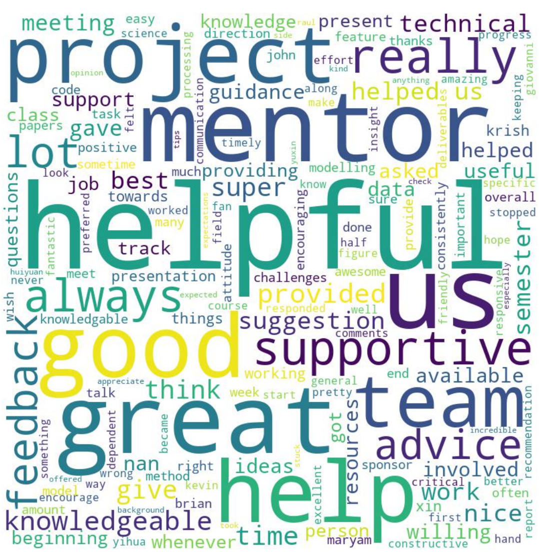


Fig. 7: Word cloud of the free-text responses in the feedback from the mentees.

neutral; 5.8% disagreed or strongly disagreed (average rating of 4.3)

- 78.5% of the respondents agreed or strongly agreed with having received feedback on their course deliverables, i.e., report, presentation, and software; 10.7% were neutral; 10.8% disagreed or strongly disagreed (average of 4.2)
- 82.7% of the respondents agreed or strongly agreed that their performance in the course benefited from having a near-peer mentor; 9.1% were neutral; 8.2% disagreed or strongly disagreed (average of 4.4)
- 76.9% of the respondents agreed or strongly agreed that the mentor spent sufficient time with the team; 13.2% were neutral; 9.9% disagreed or strongly disagreed (average of 4.2)
- 49.6% of the respondents agreed or strongly agreed that they would prefer more engagement from the mentors; 24% were neutral; 26.4% disagreed or strongly disagreed (average of 3.4)

A word cloud generated from the free-text responses is shown in Fig. 7. Words indicating positive responses, such as “good”, “great”, “helpful”, “help”, “supportive”, “advice”, “knowledgeable”, “supportive”, “lot”, and “provided”, can be clearly seen in the word cloud. Based on the responses, this indicates a generally positive attitude toward the mentoring program.

However, to identify the areas of improvement in the program and to ensure that the benefits to the mentees are maximized, we evaluated the free-text responses from the respondents who rated their mentor 2 or below in any of the questions. In particular, we would like to highlight the following excerpts from the comments of these respondents:

> “He had minimal contribution to our project.”

> “He did not give our team enough support...”

> “She helped us with some stuff but not as helpful as we hope for her to be...”

> “We have seen him 2 or 3 times and did not have basically any discussions”

> “I do not think [*name redacted*] was very effective in giving us advice/I felt like his advice was not good. He was involved a good amount but it did not positively impact the team, in my opinion.”

> “They were not involved”

> “She was a nice person, but she wasn’t there for a good amount of the time. I think if she was more present and if she took the class before, she can provide us more tips on how to succeed in the class.”

These comments indicate that mentors were rated poorly when they were not present, not involved, or did not provide enough support to the team as needed. In one instance, we noted that the assignment of a mentor to the team might not have been a good match with their background and skill set.

2) Mentors: Over 3 semesters, the program had a total of 32 mentors. All of them provided feedback on the program. Results from the questions requiring responses on a Likert scale are shown in Fig. 4. The average values for the responses are shown on the right. Similar to the mentee feedback, the scale indicates 5 for the highest rating or "strongly agree" to 1 for the lowest rating or "strongly disagree". The questions have been suitably abridged in the figure.

In general, we noted an overwhelmingly positive response from the mentors for the program. The results are summarized below:

- 96.9% of the mentors agreed or strongly agreed that the program helped in their professional growth; 3.1% (only 1 mentor) were neutral (average of 4.8)
- All the mentors agreed or strongly agreed that they gained mentoring skills from the program (average of 4.9)
- All the mentors agreed or strongly agreed that the program improved their sense of belonging in STEM (average of 4.9)
- All the mentors agreed or strongly agreed that they gained project management skills (average of 4.9)
- All the mentors agreed or strongly agreed that they gained skills for managing a team (average of 4.9)
- All the mentors agreed or strongly agreed that they now felt more confident in managing a research project end-to-end (average of 5.0)
- All the mentors agreed or strongly agreed that they developed leadership skills (average of 5.0)
- 96.9% of the mentors agreed or strongly agreed that the program helped their research career; 3.1% (only 1 mentor) were neutral (average of 4.8)

A word cloud was created using the comments from the mentors submitted as free-text responses, as shown in Fig. 5. Clearly visible words in the word cloud include "experience", "skills", "learned", "career", "great", "loved", "useful", and "gained". This further indicates a very positive response towards the program.

To find avenues for improvement, we evaluated all the responses to identify any suggestions for improvement. We noted the following comment indicating the usefulness of a training session for the mentors at the beginning of the semester:

> "The program was great. It can benefit from having a training session at the beginning."

V. Discussion

Near-peer mentoring is a proven mentoring paradigm that benefits both mentors and mentees learn new skills and advance in their professional careers in the long run. While improvement in self-efficacy and a feeling of belonging in STEM are widely reported outcomes, we would also like to stress the development of crucial professional skills and transferable skills, such as team management, project management, and leadership skills, for both mentors and mentees. In particular, we would like to emphasize the importance of developing communication skills for both groups in the process.

A widely acknowledged benefit of the near-peer mentoring model is how the mentees learn better through the process by feeling more connected to and developing a rapport with their near-peer mentors than with instructors [15], [27], [28] and often develop meaningful lasting professional relationships beyond the program [29]. Near-peer mentors and mentees often engage as partners as opposed to the inherent hierarchical power structure between instructors and students. This behavior benefits both groups in terms of professional development and growth [19].

Mentees benefit from near-peer mentoring not only through the cultivation of lasting relationships but also through an increase in self-efficacy that particularly helps in the retention of women and underrepresented minorities in STEM disciplines [9], [20], [30].

We observed gender and racial disparities in the mentor applications. While we understand that this reflects the existing disparities in the doctoral student population at the university, we will actively seek to encourage more women and underrepresented minorities to apply to the mentoring program in the future.

Besides mentoring support, our program was also designed to help student mentees receive feedback from mentors if needed. This process was envisaged as a useful loop for continuous improvement on the part of the mentees by interacting more with their near-peer mentors instead of the instructor, keeping in mind that near-peer mentors share a possibly closer relationship [15] as well as the useful role of frequent constructive feedback [31].

A unique perspective in which near-peer mentoring can be viewed is as a "learning-centered mentorship" where the mentor also goes through a learning process [32]. This is evident from the responses of the mentors as seen in Fig. 5. In this mentoring model, authority and autonomy in the learning process flow in multiple directions, as opposed to only having an instructor as a mentor for a team. For example, there is a lateral flow in the form of collaboration, a three-fold top-down flow (instructor – near-peer mentor; instructor – students; near-peer mentor – students, i.e., mentees) in the form of supervising, as well as bottom-up in the form of continuous learning for the instructor and gaining different sets of skills for the near-peer mentor. This sets up the entire classroom as a backdrop for interactive learners at all levels.

Besides gaining mentoring skills, we also note how the mentors felt that the program was helpful in advancing their career and the development or gaining of professional skills (such as project management, managing teams, and leadership skills) useful for their future, research or otherwise. This aligns with similar observations in prior studies, which indicate "learning while mentoring" as an important outcome of near-peer mentoring programs [33]. This is also observed in Fig. 5, where both "learned" and "mentoring" are prominent words. The findings in our study also reaffirm the enhancement in self-competency beliefs and gaining of confidence for mentors through near-peer mentoring that has been reported in prior studies [34].

Due to the client-facing aspect of the course, the mentors also gain valuable experience in meeting with clients and sponsors, understanding what the desired outcomes for the project are, and helping the student team achieve those objectives. This added benefit of the program for the mentors would not otherwise have been available to doctoral students at the university.

In our study, we observed and wish to strongly emphasize a benefit of the near-peer mentoring program that has not been widely reported in literature – the benefit to the instructors and the departments in managing large PBL classes. With growing enrollment, instructors are often forced to cap the enrollment in courses and turn away students, resulting in "forced gatekeeping" due to a lack of personnel and resources. Our model provides the means to scale up PBL courses with the mentoring responsibilities now being shared between the instructors and the near-peer mentors.

For universities with a sizeable community of doctoral students, this untapped resource can be effectively utilized for this purpose. Besides a monetary incentive, doctoral students in the program have the opportunity to gain experience in a variety of professional skills that might otherwise not be available to them in the university. In particular, it is easier to find and recruit an adequate number of mentors for interdisciplinary courses as doctoral students from various departments and backgrounds might be eligible to mentor in the program.

While near-peer mentors can impart certain skills such as how to search for appropriate publications, how to read and glean information from publications, how to use reference management software, how to structure reports, how to structure software repositories, and choosing appropriate libraries and packages, the instructor can now focus more on advising related to high-level tasks such as technical details of methods and algorithms, how to choose appropriate methods for particular problems, the tuning of model parameters and hyperparameters, and other technical details. However, this does not preclude the near-peer advisors from advising the team on high-level technical details – they would be welcome to collaborate with the instructor on these tasks based on their expertise and depth of knowledge in the subject area. Some tasks, such as sharing appropriate resources for learning, e.g., papers, tutorials, and technical reports, with the students, are shared between the near-peer mentors and instructors.

The near-peer mentors also provide advice and feedback on the presentations, reports, and software to the team if they request it. In the absence of these mentors, the instructors would have to perform this task, which might become a large workload for larger PBL classes with more enrollment. This is another aspect of this model that eases the workload of the instructor by the sharing of responsibilities with the near-peer mentors.

For further improvement of the program in the future, we wish to implement the suggestion of one of the mentors by having a training session for the mentors at the beginning of the semester. In this training session, we plan to incorporate relevant topics and discussions, including best practices for mentoring, how to be a successful mentor, what the student mentees expect from a good mentor, and the best practices for communicating with mentees and clients. Since a large population of doctoral students are not familiar with the best practices in mentoring and have no prior experience in mentoring, we anticipate this training to be invaluable in helping them understand their roles, responsibilities, and other nuances associated with mentoring.

Taking into consideration the responses from the mentees, we also plan to incorporate mechanisms for obtaining feedback from the mentees at multiple checkpoints during the semester to gauge the involvement of their mentor and intervene if we note that the mentees would prefer more involvement and engagement from the mentor. Based on the feedback, the intervention could include discussing the responsibilities and time commitment with the respective mentor, and reiterating the discussions during the training session as needed. We believe that these steps in the future will try to improve on the perceived shortcomings of the program both from the perspective of the mentors and the mentees.

VI. Conclusion

In this study, we report the design and implementation of a novel near-peer mentoring program where doctoral students act as mentors for teams in an interdisciplinary client-facing project-based learning (PBL) course. Our model benefits all three groups involved in the course – instructor, mentor, and students, i.e., mentees. We collect and analyze feedback from the mentors and the mentees and show how the program is perceived to be effective by both these groups. Our observations emphasize the benefits of introducing this mentoring model in PBL classrooms. We also offer the perspectives of the instructor regarding the benefits of the program to the instructor and the department in trying to scale up PBL courses with the help of near-peer mentors.

References

[1] D. Kokotsaki, V. Menzies, and A. Wiggins, "Project-based learning: A review of the literature," *Improving Schools*, vol. 19, no. 3, pp. 267–277, Nov. 2016.

[2] G. I. Allen, "Experiential Learning in Data Science: Developing an Interdisciplinary, Client-Sponsored Capstone Program," in *Proceedings of the 52nd ACM Technical Symposium on Computer Science Education*, ser. SIGCSE '21. New York, NY, USA: Association for Computing Machinery, Mar. 2021, pp. 516–522.

[3] A. Qattawi, A. Alafaghani, M. A. Ablat, and M. S. Jaman, "A multidisciplinary engineering capstone design course: A case study for design-based approach," *International Journal of Mechanical Engineering Education*, vol. 49, no. 3, pp. 223–241, Jul. 2021, publisher: SAGE Publications Ltd STM.

[4] J. Foster and G. Yaoyuneyong, "Collaborative cross-disciplinary client-based projects: a case study," *International Journal of Fashion Design, Technology and Education*, vol. 7, no. 3, pp. 154–162, Sep. 2014.

[5] M. Raber, S. Amato-Henderson, and V. Troesch, "Assessing the impact of faculty advising and mentoring in a project-based learning environment on student learning outcomes, persistence in engineering and post-graduation plans," in *2011 Frontiers in Education Conference (FIE)*, Oct. 2011, pp. S3F–1–S3F–6, iSSN: 2377-634X.

[6] L. Lei, C. Uslay, and J. Vaidya, "Empowering Business Students: The Rise of Experiential Learning, Collaborative Mentoring, and Data Science," *Rutgers Business Review*, vol. 8, no. 1, pp. 1–15, Mar. 2023.

[7] M. M. Yang, B. P. Golden, K. A. Cameron, L. Gard, J. A. Bierman, D. B. Evans, and B. L. Henschen, "Learning through Teaching: Peer Teaching and Mentoring Experiences among Third-Year Medical Students," *Teaching and Learning in Medicine*, vol. 34, no. 4, pp. 360–367, Aug. 2022.

[8] 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, p. 14, Aug. 2016.

[9] T. Kunberger and C. Geiger, "The impact of near-peer mentoring on self-efficacy in an introductory engineering course," in *2016 IEEE Frontiers in Education Conference (FIE)*, Oct. 2016, pp. 1–4.

[10] R. Pereira, C. Borges, and C. Teixeira, "Near-peer mentoring program implementation in STEM higher education," in *2023 5th International Conference of the Portuguese Society for Engineering Education (CISPEE)*, Jul. 2023, pp. 1–8.

[11] C. Sabatti and Q. Zhao, "Near-peer mentoring in data science: Two experiences at Stanford University," Nov. 2022, arXiv:2211.08637 [stat].

[12] J. Dones, F. Martin, J. Lu, and F. Mir, "Design and Impact of a Near Peer-Led Computer Science Summer Bridge Program," in *2022 IEEE Frontiers in Education Conference (FIE)*, Oct. 2022, pp. 1–9, iSSN: 2377-634X.

[13] P. Dart, L. Johnston, and C. Schmidt, "Enhancing project-based learning: variations on mentoring," in *Proceedings of 1996 Australian Software Engineering Conference*, Jul. 1996, pp. 112–117.

[14] B. Aba Alkhail, "Near-peer-assisted learning (NPAL) in undergraduate medical students and their perception of having medical interns as their near peer teacher," *Medical Teacher*, vol. 37, no. sup1, pp. S33–S39, Mar. 2015.

[15] S. Singh, N. Singh, and U. Dhaliwal, "Near-peer mentoring to complement faculty mentoring of first-year medical students in India," *Journal of Educational Evaluation for Health Professions*, vol. 11, p. 12, Jun. 2014.

[16] E. Flott, S. Ball, J. Hanks, M. Minnich, A. Kirkpatrick, L. Rusch, D. Koziol, A. Laughlin, and J. Williams, "Fostering collaborative learning and leadership through near-peer mentorship among undergraduate nursing students," *Nursing Forum*, vol. 57, no. 5, pp. 750–755, 2022.

[17] T. Rayford, N. Ruedas-Gracia, M. H. Goldstein, C. Schimpf, L. Hebert, L. Escamilla, and J. J. Zavala, "Educational Enrichment: The Benefits of Near-Peer Mentoring for Undergraduate Engineering Students," *ASEE Annual Conference and Exposition, Conference Proceedings*, Aug. 2022.

[18] H. Pon-Barry, B. W.-L. Packard, and A. St. John, "Expanding capacity and promoting inclusion in introductory computer science: a focus on near-peer mentor preparation and code review," *Computer Science Education*, vol. 27, no. 1, pp. 54–77, Jan. 2017.

[19] G. Trujillo, P. G. Aguinaldo, C. Anderson, J. Bustamante, D. R. Gelsinger, M. J. Pastor, J. Wright, L. Márquez-Magaña, and B. Riggs, "Near-peer STEM Mentoring Offers Unexpected Benefits for Mentors from Traditionally Underrepresented Backgrounds," *Perspectives on undergraduate research and mentoring : PURM*, vol. 4, no. 1, 2015.

[20] M. J. Lee, "Increasing Minority Youths' Participation in Computing through Near-Peer Mentorship," *Journal of computing sciences in colleges*, vol. 35, no. 3, Oct. 2019.

[21] C. Sun, "Power of Near-Peers: Conceptualizing and Testing a Near-Peer Mentoring Model in Raising Youths' Self-Efficacy in Computer Programming," All Graduate Theses and Dissertations, Spring 1920 to Summer 2023, Utah State University, May 2021.

[22] C. Wagner and J. du Toit, "A qualitative study of interdisciplinary near-peer research mentoring in professional training," *Training and Education in Professional Psychology*, vol. 13, no. 1, pp. 29–36, 2019.

[23] L. S. Tenenbaum, M. K. Anderson, M. Jett, and D. L. Yourick, "An Innovative Near-Peer Mentoring Model for Undergraduate and Secondary Students: STEM Focus," *Innovative Higher Education*, vol. 39, no. 5, pp. 375–385, Nov. 2014.

[24] A. T. Cianciolo, B. Kidd, and S. Murray, "Observational analysis of near-peer and faculty tutoring in problem-based learning groups," *Medical Education*, vol. 50, no. 7, pp. 757–767, 2016.

[25] J. Gadad, V. Talageri, P. Baligar, and G. Joshi, "Peer-Mentoring in Design Projects in Project-Based Learning (PBL) at First-Year Engineering Course," in *2021 IEEE Frontiers in Education Conference (FIE)*, Oct. 2021, pp. 1–5.

[26] Z. Pilot, M. Suprise, C. Dinius, A. Olechowski, and R. Habib, "Structured peer mentoring improves academic outcomes and complements project-based learning in an introductory research methods and statistics course," *Scholarship of Teaching and Learning in Psychology*, vol. 9, no. 2, pp. 185–195, 2023, place: US Publisher: Educational Publishing Foundation.

[27] M. C. Paretti and B. D. Lutz, "Student Perceptions of Project Mentoring: What Practices and Behaviors Matter?" in *2014 ASEE Annual Conference & Exposition*, Jun. 2014, pp. 24.1122.1–24.1122.11, iSSN: 2153-5965.

[28] L. Jackson and H. A. Maestre, "The Data Science Mentoring Fire Next Time: Innovative Strategies for Mentoring in Data Science," in *Proceedings of the 26th ACM SIGKDD International Conference on Knowledge Discovery & Data Mining*, ser. KDD '20. New York, NY, USA: Association for Computing Machinery, Aug. 2020, pp. 3597–3600.

[29] A. Garcia-Melgar and N. Meyers, "STEM Near Peer Mentoring for Secondary School Students: a Case Study of University Mentors' Experiences with Online Mentoring," *Journal for STEM Education Research*, vol. 3, no. 1, pp. 19–42, Apr. 2020.

[30] J. Rosales, E. Melville, M. A. Wright, S. Akhtar, and R. N. Wright, "The Experience of Near-Peer Computing Mentors: Strengthening and Expanding Women's Computing Identities in Undergraduate Interdisciplinary Contexts," in *Proceedings of the 55th ACM Technical Symposium on Computer Science Education V. 1*, ser. SIGCSE 2024. New York, NY, USA: Association for Computing Machinery, Mar. 2024, pp. 1154–1160.

[31] A. J. Nelson, S. V. Nelson, A. M. Linn, L. E. Raw, H. B. Kildea, and A. L. Tonkin, "Tomorrow's educators … today? Implementing near-peer teaching for medical students," *Medical Teacher*, vol. 35, no. 2, pp. 156–159, Feb. 2013.

[32] B. Gyori, "Mentorship Modes: Strategies for Influencing Interactive Learners," *Interdisciplinary Journal of Problem-Based Learning*, vol. 7, no. 1, 2013, number: 1.

[33] M. K. Anderson, L. S. Tenenbaum, S. B. Ramadorai, and D. L. Yourick, "Near-peer Mentor Model: Synergy within Mentoring," *Mentoring & Tutoring: Partnership in Learning*, vol. 23, no. 2, pp. 116–132, Mar. 2015.

[34] P. Garcia, M. Perez, D. Farrell, S. Bork, B. Ericson, and J.-L. Mondisa, "Supporting Mutually Beneficial Near-Peer Mentoring Relationships Within Computing Education Programs," in *2021 Conference on Research in Equitable and Sustained Participation in Engineering, Computing, and Technology (RESPECT)*, May 2021, pp. 1–9.