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Work In Progress: Technical Consulting as an Experiential Form of Peer Tutoring

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Abstract

This work-in-progress paper presents an initial study on an instructional innovation for first-year undergraduate engineering. The innovation involves a new, experiential form of peer tutoring wherein upper-class students function as technical Project Consultants for first-year student teams as they design and build a project. The process by which a student team decides that they would benefit from technical consultation, and then selects and uses the services of the peer tutor as a Project Consultant, models as closely as possible the analogous process of hiring a consultant in a real-world engineering project. This paper first presents the design and goals of this program. Then, the procedures developed for selecting, training, and implementing the Project Consultants will be shared. Next, results will be given from feedback collected from both the Project Consultants and the students. This feedback came from brief questionnaires collected from the students and Consultants at the project completion. A lead finding is that the program was used sparingly by the students, with a perceived lack of value being the most common reason for not using this resource. Nevertheless, the Consultants reported a very positive experience working with those teams who chose to participate.

Introduction

Experiential learning techniques cause a learner to have a direct sense experience with class tasks that replicate real-world tasks [1]. Experiential learning is closely associated with problem-based learning, as both techniques center the learner in the course progress by allowing them to make meaningful, autonomous decisions. This co-creation of the educational experience often leads to increases in the learners' motivation, emotional investment, and enjoyment of the course experience [2].

Peer tutoring involves targeted instruction by fellow students. The purpose of the work to be presented here was to develop a new pedagogical technique that uniquely integrates experiential education and peer tutoring with existing project-based learning. Peer tutoring is a well-established and studied field [3]. As will be described, the term peer tutoring is used here in a somewhat different context from existing literature, in that the content of the tutoring is unique to—and originally identified by—the student receiving the help. The program described here was not meant to reinforce or improve learning of core course content or specified course learning objectives.

The context for this technique is an 8-credit, 2-course sequence taken in the first year as a hands-on, project-based foundation to engineering practice and solution-making. The class is taken in sections of about 32 students. Many sections of the course are offered at Northeastern University, a medium-sized, private, 4-year university in an urban setting. In sections led by the author, a spring semester design project requires each team of 3 or 4 students to create an original, physically interactive, electronic game that is publicly exhibited and played. Resources available to the students include a makerspace, a kit of Arduino-based electronics parts, and a budget of $100 that they can choose to spend on additional materials and components.

The design project requires student teams to integrate a wide range of course concepts: user-focused design thinking, hands-on fabrication, iterative prototyping, computer programming, basic

circuitry, and technical communication. Each team must pull together all of these concepts from amongst a membership of only 3 or 4 first-year students. What's more, every team separately conceives and designs their own game, so every team has a unique set of technical challenges to overcome. Given the complexity of this work, student teams would benefit enormously from the availability of a targeted, learn-on-demand resource available throughout their project, especially if that resource feels like a natural, real-world practice that provides genuinely useful assistance in completing the project.

Last year, the author developed and carried out a new experiential peer tutoring activity whereby upper-class engineering students acted as Project Consultants, available upon request by a project team for in-person or virtual consultation. Each project team was given 2 "free" half-hour blocks of Project Consultant time. After those blocks were used, teams were allowed to "purchase" additional consultation time. The "payment" was in the form of a $1 reduction in the project team's budget. The purpose of the "free" blocks and low but non-zero cost of obtaining additional help was to provide a low barrier to teams who needed the Consultant help, yet maintain some disincentive to teams abusing a free resource.

Whenever a team decided they'd like to obtain help from a Consultant, they could choose one to "hire" from a list of all the Consultants in the program. The team reached out to them to schedule a mutually agreeable time and were asked to give advance notice on the topic(s) with which they want to receive help. The Project Consultants were trained such that their interaction was much more aligned with focused instruction that enabled a team to solve their own problem, as opposed to directly solving the problem for the team. In this way, working with a Project Consultant served to both advance the progress of the team's project and reinforce the broader course outcome of increased engineering self-efficacy.

A small amount of internal funding was used to support an hourly wage for the Project Consultants. The program began initially in Spring semester 2020. The COVID pandemic caused the projects to be essentially halted that semester, and so the consultant program halted as well. The program and funding were carried over to the Spring semester of 2021. The program was modified to be amenable to the hybrid teaching modality in use then. Thus, the results described here pertain to a program that was originally conceived as an essentially in-person activity but run as an essentially remote activity.

Specific research questions that were sought to be addressed were: 1) How much will student teams use a Consultant program, especially when learners are remote? 2) What barriers might prevent student teams from using the program more? 3) Which project topics do students feel the most need for outside assistance? 4) Do the Consultants find the program to be personally rewarding?

Program Implementation

The first step in creating the consultant system was to recruit a set of students to serve as the consultants. The upperclass students chosen to be the Project Consultants were selected from students who took the author's class in previous years. They were asked to participate based on: aptitude in communicating technical concepts, expertise in one or more areas relevant to the projects, and demographic representation. The last point, demographics, was considered especially important as this was a first year engineering course, and the Consultants were being presented as exemplary students. Thus, it was strongly desired that students of as many cultures, gender identities, backgrounds, and academic majors could see themselves represented. Most students asked were excited to take part and agreed. Those who declined expressed a lack of availability as the reason.

After finding a set of seven Consultants, a brief and informal training session was run. The session consisted of a lunch discussion about how to best help students. The discussion was led by the author but was allowed to progress naturally. Consultants were asked at the start to reflect on previous times where they sought formal or informal help on classwork or where they provided such help. We then discussed when those experiences were positive and when they were not. Other discussion topics included: how the students can be connected with information sources, how to facilitate students to make their own decisions, and how to provide technical advice without doing the work expected of the students. In addition to these strategies, logistical considerations were also discussed, such as filling out timesheets for payment and how to fill out the Contact Report created to track the usage of the program.

Consultants were asked to introduce themselves to the students by a few means. First, Consultants were asked to submit their name, email address, and a brief written blurb describing their general availability and areas of expertise. These data were compiled into a document about the Consultant program distributed to the students (this document is described more later). Since this program was being run in the context of a hybrid learning model for the class, each Consultant was also asked to record a brief video. It was hoped that the videos would help humanize the Consultants and lower the emotional barrier students might feel in reaching out for help. Finally, we had one Consultant join class via video link for a brief, live introduction. This also was done to help reduce any emotional barrier to students in asking for help.

Figure 1 shows the document distributed to the students to describe the Consultants program. It has been edited to remove the personal information on the Consultants themselves. As can be seen, this document explains the purpose of the program in terms of both the improved project outcome and as an experiential learning tool, describes the logistics of obtaining consultant help, and then introduces the Consultants with their contact information.

Usage and Survey Results

At the end of the semester, surveys were distributed to the students and the Consultants. The students were surveyed anonymously using a long form end-of-class survey. The survey included questions about the class generally as well as the Consultant program specifically. The Consultants were surveyed anonymously as well, though with only seven Consultants, they may have understandably considered their identity tied to their responses. The survey questions are provided in the Appendix.

The response rate on the students' surveys was almost 60% (65 / 110). Of the respondents, just over 25% (17 / 65) reported that their team met with a Consultant at least once. Roughly equal amounts of in-person and virtual help sessions were reported. Figure 2 shows that the students' opinions about their meeting with the Consultant were generally quite positive: 82% either Agreed or Strongly Agreed that the meeting was helpful, and 88% Agreed or Strongly Agreed that the meeting was easy. Roughly equal amounts of in-person and virtual help sessions were reported.

Students who chose not to meet with a Consultant listed several reasons why they chose not to. Figure 3 shows that the three most common reasons by far related to: 1) not feeling that they needed help, 2) wanting to do the work themselves, and 3) it seemed like more trouble than it was worth. Only one student stated that they had trouble figuring out how to obtain help from a Consultant. The main cause of the program being used less than expected, therefore, is a perception among a significant portion of the students that this program was not valuable.

Consultants

Purpose

We all need a little help sometimes. If your team wants to obtain an hour of outside help, a team of consultants is now available. These consultants have been carefully selected based on their technical expertise, ability to communicate, and excellent work on a Cornerstone project similar to this semester's.

Skills to be Obtained

- Self-assess a need for external consultation on an aspect of your project

Details

Anytime your project team would like to speak with someone for advice, reach out by email to one of the consultants or, if you're not sure who you want to work with yet, post a message in the Consultants team on Microsoft Teams. Email address and other information about each consultant is given on the next page.

When reaching out to the consultants, send an email or post a message in the Teams chat that very briefly describes your project, what assistance you are looking for or questions you have, and what timeframe you have for receiving the help. If a consultant is able to provide help, they will arrange with you a mutually agreeable time to meet in person or a way to obtain the help digitally. All of these details about where, when, and which topics are independently arranged between your team and the consultant. Keep in mind that you may need to contact more than one consultant before finding one that is able to provide the help you want within your needed timeframe.

Your project team is hereby given two 50-minute blocks of time with a Project Consultant for free. If you wish to "purchase" additional consultation time, you must make a "payment" in the form of a $1 reduction in your team's budget for each additional hour. Please include any consultant-based budget reductions at the bottom of your cost accounting spreadsheet, below the row that shows the sum total of all purchase amounts.

List of Consultants*

Firstname Lastname (email@school.edu)

I am a third-year electrical engineering major with lots of experience in robotics. I can help with C++, electronics/circuitry, Arduino, and soldering/wiring. I am able to meet any day of the week and would be happy to chat either in person or virtually via Teams.

Figure 1. The writeup distributed to students describing the Consultant program. *Note that all seven Consultants were listed, each with a self-written blurb description. One anonymized example is shown here.

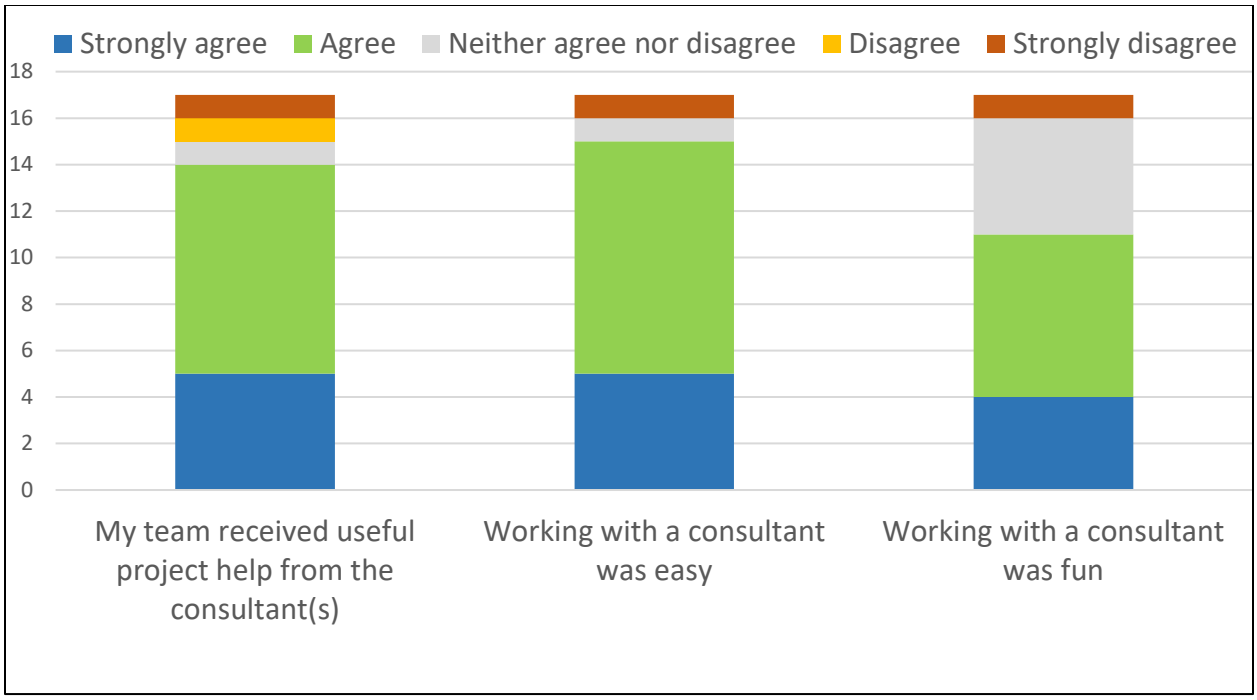

Figure 2. Of the students who reported working with a Consultant, their level of agreement with each statement regarding the experience.

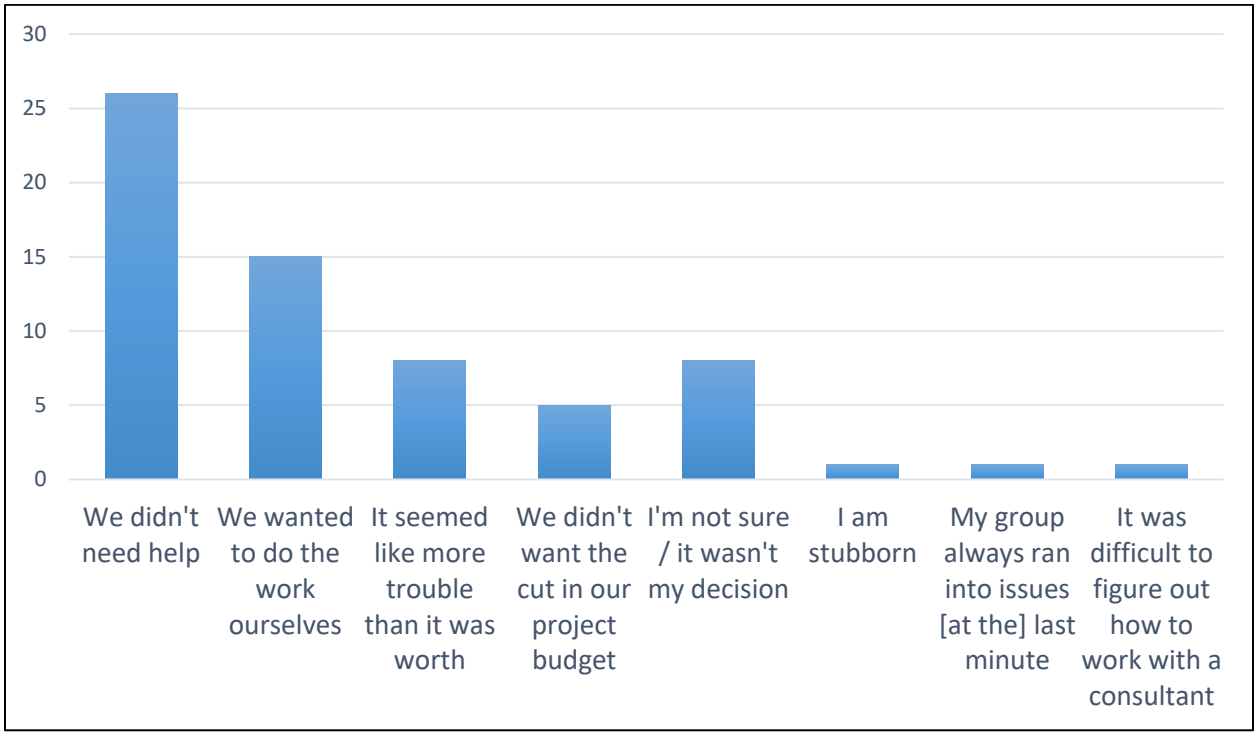

Figure 3. Of the students who reported *not* working with a Consultant, their reason(s) for not doing so. Students could pick more than one reason.

The response rate on the Consultants surveys was 100%. Of the seven Consultants, only five actually ended up working with teams. The five Consultants who did provide help had a total of seventeen help sessions. Note that this number does not match any numbers from the student surveys, since a Consultant might meet with multiple students in one meeting with a team. It was initially expected that teams would request help about programming more than any other topic, since that is the area for which more students begin the class with less prior experience. Figure 4 shows that Arduino programming was, indeed, one of the two most common topics for which a Consultant was asked to provide assistance. Nevertheless, Consultants reported receiving just as many requests for help with a project conceptualization topic as with an electronics or code topic.

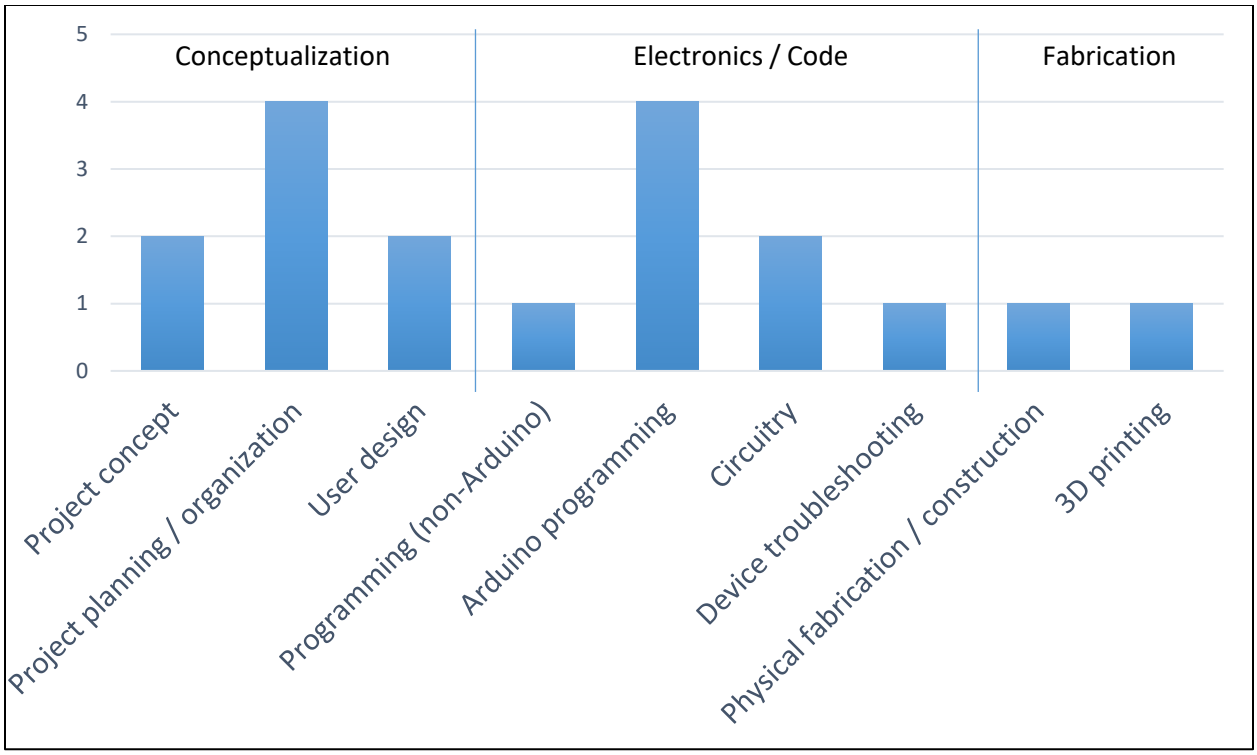

Figure 4. As reported by the Consultants, the topics for which teams requested help. From left-to-right, the first three topics relate to project conceptualization, the next four relate to electronics and code, and the last two relate to fabrication.

The two Consultants who didn't work with any teams suggested several reasons why. The main reason, mentioned by both, is that they felt first year students might have been nervous to reach out. The program was set up so that the initial contact had to be done by email to a specific Consultant or by posting a note in the Microsoft Teams channel created for this purpose. Most teams were hesitant to pick one Consultant to reach out to, and since the Teams channel was open to all students, having to post a public request for help likely created a significant social hurdle to a team wanting to start the process. This theme of needing to reduce the barrier to request help was also mentioned by the Consultants who were able to meet with teams. A suggestion was made by one to allow for quick options over chat rather than having to schedule a formal session of 30 or 60 minutes.

The Consultants all expressed interest in participating in the program again in the future, even with a modified compensation structure. Figure 5 shows the results. Using a Likert scale response where 5 represented Strongly Agree and 4 represented Agree, the Consultants gave an average response of 4.6 for whether they would participate as Consultants if the program were run again with hourly pay as compensation, 4.4 if the program offered 1 or 2 credits as compensation, 4.1 if the program were run entirely on a volunteer basis. All of the five Consultants who worked with teams Strongly Agreed that working with teams was fun, and all Agreed or Strongly Agreed that the teams received useful help from the consultation.

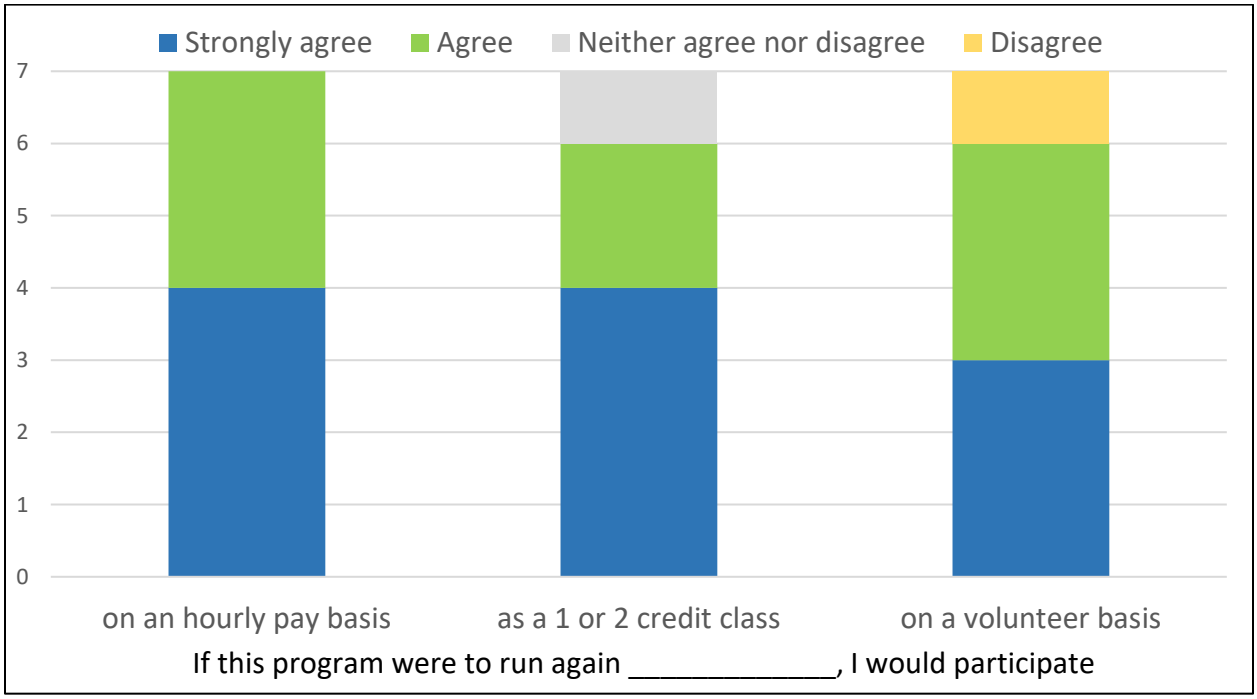

Figure 5. The Consultants' level of agreement with each statement regarding what incentive structure would allow them to participate as a Consultant in the future.

Future Program

For both the Consultants and students who used the program, the program seemed to be a success. Both parties generally found the interaction to be easy, useful, and fun. Nevertheless, the program saw only light-to-moderate usage, much less than expected. If the program is to run in the future, significantly more effort would go in to facilitating the process of teams making the initial contact with the Consultants. Several ideas are being considered. First, now that instruction has returned to a fully in-person modality, Consultants will be asked to come to class to make face-to-face introductions with all of the students. Next, a system of simple, private messaging will be created so that teams can send quick text chats to the Consultants to request help in place of sending an email. A suggestion from one Consultant was to allow teams to receive help via text conversations, rather than just the more formal 30- or 60-minute meetings. This method was suggested as an emotionally more comfortable way to communicate for many students. Still, the desire for increased usage of the program must be balanced against the desire to have the system replicate as closely as possible the use of Consultants in industry practice.

Another significant change being considered for future implementations of the program regard the Consultant compensation. The funding to support the hourly wage during the pilot year came from competitively awarded instructional innovation funds. This support will not be available in the future. It is possible that sufficient numbers of Consultants can be found who are willing to work as volunteers. Still, that arrangement seems like it might lead to poorer results, with less "buy-in" from the Consultants. So, the creation of a new upper-level elective course on Technical Consulting is being considered. This course will combine class learning on consulting with practical experience in the form of this Consultant program.

Conclusions

The Consultant program described in this paper is intended to provide multiple benefits. First, it facilitates the receipt of technical help on the students' projects and therefore improve the project results. Second, it is intended to increase interaction between first year engineers and a diverse set of upper-class engineers who have been successful in their college career. Third, it introduces students in the class, which focuses on engineering practice, to technical consulting in an experiential way. The program seemed to be successful in accomplishing these goals for the students and Consultants who participated, however usage was spare. Future work will focus on increasing utilization of the program by enabling more students to see the value gained relative to the added effort.

References

[1] D.A. Kolb, *Experiential Learning: Experience as the Source of Learning and Development*, Upper Saddle River, New Jersey: Pearson Education, 2014.

[2] M. Buchmann and J. Schwille, "Education: the overcoming of experience," *American Journal of Education*, vol. 92, pp. 30-51, 1983.

[3] K.J. Topping, "The effectiveness of peer tutoring in further and higher education: a typology and review of the literature," *Higher Education*, vol. 32, pp. 321-345, 1996.

Appendix

► Questions in the student survey that related to the Consultant program:

I. Did your team work with one of the Consultants during this semester's project? (Yes / No)

If answered Yes:

1. How many time(s) did your team work with a consultant?
2. Which Consultant(s) did your team work with?
3. Which topic(s) did you want help with?
4. How did you work with your Consultant? Select all that apply
   (In-person / Virtually / E-mail / Other)
5. Indicate your level of agreement with the following statements:
   (Strongly disagree / Disagree / Neither agree nor disagree / Agree / Strongly agree)
   a. My team received useful project help from the consultant(s).
   b. Working with a Consultant was easy.
   c. Working with a Consultant was fun.

If answered No:

1. Why didn't your team use a Consultant? Check all that apply.
   (We didn't need help. / We wanted to do the work ourselves. / It was difficult to figure out how to work with a consultant. / It seemed like more trouble than it was worth. / We didn't want the cut in our project budget. / I'm not sure--it wasn't my decision.)

► Questions in the Consultant survey:

1. How many time(s) total did you work with Cornerstone teams?
2. Which topic(s) did you help with?
3. How did you work with your consultant? Select all that apply
   (In-person / Virtually / E-mail / Other)
4. Indicate your level of agreement with the following statements:
   (Strongly disagree / Disagree / Neither agree nor disagree / Agree / Strongly agree)
   a. The team(s) received useful project help from me.
   b. Working with a team was easy.
   c. Working with a team was fun.
5. Please indicate your level of agreement with the following statements (in all cases, imagine you are still a student in this hypothetical future):
   (Strongly disagree / Disagree / Neither agree nor disagree / Agree / Strongly agree)
   a. If this program were to run again on an hourly-pay basis, I would participate again.
   b. If this program were to run again but as a 1 or 2 credit class instead of hourly pay, I would participate again.
   c. If this program were to run again without pay or credit, I would participate again.
   d. Other students besides me would be interested in being a Consultant in the future.
6. If you were to run this program in the future, what would you do differently?