Work In Progress: Is Our Capstone Mentorship Model Working?

Dr. C. Richard Compeau Jr, Texas State University

C. Richard Compeau Jr. is a Professor of Practice in the Ingram School of Engineering, and the Electrical Engineering Program Coordinator. He is interested in teaching and curriculum development. His work is typically project-specific for the EE Capstone courses, with an emphasis on applied electromagnetics.

Dr. Austin Talley P.E., Texas State University

Dr. Austin Talley is a Senior Lecturer in the Ingram School of Engineering at Texas State University. Prior to joining the faculty at Texas State University, Dr. Austin Talley worked as a manufacturing quality engineer for a test and measurement company, National Instruments, in Austin, TX. Dr. Austin Talley is a licensed by state of Texas as a Professional Engineer. Both of Dr. Austin Talley's graduate degrees, a doctorate and masters in Mechanical Engineering, manufacturing and design area, are from the University of Texas at Austin. Additionally, Dr. Austin Talley holds an undergraduate degree from Texas A&M University in Mechanical Engineering. His research is in engineering design theory and engineering education. He has published over 30 papers in engineering education journals and conference proceedings. He has worked to implement multiple National Science Foundation (NSF) grants focused on engineering education. He has been an instructor in more than ten week long summer K-12 teach Professional Development Institutes (PDI). He has received multiple teaching awards. He has developed design based curriculum for multiple K-12 teach PDIs and student summer camps.

Work In Progress: Is Our Capstone Mentorship Model Working?

Capstone design as a culminating experience has existed for many years and is required by ABET. In many programs, students perform work that is experiential and team-based in nature, as opposed to problem sets and lab reports associated with other classes. One goal of capstone is to prepare engineering students for the workplace. An area of improvement in our program was the mentorship experience that many new graduates will encounter when employed. As a result, five semesters ago the Electrical Engineering program at Texas State University implemented a mentorship model in which second semester capstone students were assigned to mentor first semester capstone students. It was felt that first semester students might gain valuable insight and direction since they were speaking with peers who possess a student perspective and who are speaking the same language. Anecdotal evidence suggested that the mentorship model was working and as a result the other two engineering disciplines, Industrial Engineering and Manufacturing Engineering, also adopted the mentorship model. The effectiveness of our mentorship program had not been measured until this semester, via post-mentoring surveys that were administered to all three engineering disciplines at the end of the Fall semester. These surveys included Likert items that probed seven aspects of mentorship and two free-response prompts. As a result, students stated that mentors were helpful with documentation, technical aspects, and presentation feedback. Mentees suggested that formalized meeting times with their mentors be established, which we intend to implement for the Spring 2020 semester. This study has led to faculty discussions about sharing best practices, and helping to improve the mentorship model in addition to having a Capstone Committee that goes further than just planning Senior Design Day but that also includes methods. We plan to improve our research instrument and administer both start-of-semester and end-of-semester probes to yield comparative data.

Introduction

The engineering capstone mentorship system was first implemented at Texas State University for the Fall semester of 2017 in Electrical Engineering (EE). At that time, EE had always been a two-semester capstone sequence whereas the capstone courses in the other two engineering disciplines, Industrial (IE), and Manufacturing (MFGE), were one-semester in duration. Both of those disciplines have switched to two-semester capstones, MFGE for the last two semesters, and IE for one. While student feedback has been positive it was neither formalized nor quantified, which is the intent of our study.

Background (of mentorship)

Famous American philosopher William James exemplified his belief in mentorship with the statement "act as if what you do makes a difference. It does."(1). Capstone course is about providing the student the learning opportunity to experience engineering in a culminating experience. Many program Capstone courses involve formal and informal faculty to student mentoring. This has been shown to have positive effects on the students(2-5). Multiple studies have identified faculty mentorship of capstone teams as an key element of capstone experience (6-8). Student peer to peer mentoring has also been shown to be effective with respect to freshman retention (9,10). This research explores what are effective ways to have student peer to peer mentoring in engineering senior capstone.

Mentorship Model

The mentorship system was implemented for two reasons. Mentorship of recent college graduates in engineering is commonplace (11) and our Industrial Advisory Board members communicated that early exposure to being mentored would be of value. The second reason was that second-semester students could train the first-semester students, having been through the first half of the program.

For EE there were two sets of assignments:

- Each first-semester team was assigned a second-semester team as mentors
- Each first-semester student Project Manager (PM) was assigned a second-semester PM as mentor

A system was put in place to allow for an unequal number of Design-1 and Design-2 teams.

Mentors were chosen based on their current project. For example, if a Design-2 team had already been working with a specific sponsor they were assigned to mentor a Design-1 team that is also working with that same sponsor. Or, mentors were matched by project technical requirements. If a Design-2 team had been working with a specific technology they were assigned to mentor a Design-1 team working with the same (or similar) technology.

Mentors had several responsibilities such as participating in Design Reviews and Progress Presentations and scoring their mentees, reviewing and signing off various mentee documents

such as the Statement of Work, Functional Specification, and so forth, in addition to regularly meeting with their mentee teams.

EE has run the mentorship system for five full semesters as of the time of this writing with very few changes. IE and MFGE were previously one-semester capstone courses but have evolved to two-semester courses and have subsequently adopted the mentorship system. IE has run the mentorship system for one semester and MFGE for three. While student feedback has been positive it was neither formalized nor quantified, which is the intent of our study.

Research Instrument

A total of four surveys were created to be administered to both first- and second-semester capstone students, at the beginning and the end of each 15-week semester. Each survey contains 16 Likert items plus two free-response questions. A five-point Likert scale was used, ranging from Strongly Disagree to Strongly Agree. Each Likert item was posed at least twice for verification of responses and were spaced apart in the instrument, for example,

> *Our mentor had very limited accessibility*
> *Our mentor was available and accessible to us*

As this is a work in progress, at this time only the end-of-semester surveys have been administered to Design-1 and Design-2 students of all three engineering disciplines.

There are other elements of capstone which would be desirable to measure, such as the actual performance of the team and the depth and breadth of the project. We have observed that both internal and external factors have a very large influence on actual performance and project depth. These factors include, but are not limited to: the nature of the project, how well the Sponsor defined the project, the Sponsor's availability, the internal Faculty Advisor, and the distribution of skill sets on the student team. Consideration of these elements is beyond the scope of this study.

Results

Responses were scored for positive statements such that Strongly Disagree = 1, Disagree = 2, Neutral = 3, Agree = 4, and Strongly Agree = 5. Point values were reversed for negative statements, i.e., Strongly Agree = 1. The responses from each student were individually tallied by averaging the point values of the positive and negative statement, and were subsequently averaged to construct the data tables below.

Table 1: Aggregated Responses to End-of-Semester Likert Items

Likert Items	Design-1 Responses, n=76			Design-2 Responses, n=40		
	Mean	Std Dev	Range	Mean	Std Dev	Range

Future students should look forward to being mentored	3.80	0.73	3.5	N/A	N/A	N/A
Mentoring improved team relationships	3.79	0.78	4	3.71	0.83	3
Mentor helped understand the course documentation	3.89	0.85	4	3.79	0.78	2
Mentor was accessible	3.62	0.80	4	3.55	0.77	3
Mentor had the necessary skills	3.88	0.83	4	4.01	0.74	2
Mentor was helpful	3.59	0.92	4	3.49	0.59	2
Value was gained from mentoring	3.53	0.94	4	3.74	0.77	2.5
Mentoring was enjoyable	N/A	N/A	N/A	3.93	0.78	2

Table 2: Discipline-Specific Design-1 Responses to End-of-Semester Likert Items

End of Semester: First-Semester Students			
Likert Items	EE n=47	IE n=13	MFGE n=16
Future students should look forward to being mentored	3.90	3.81	3.50
Mentoring improved team relationships	3.90	3.77	3.47
Mentor helped understand the course documentation	4.09	3.62	3.53
Mentor was accessible	3.73	3.27	3.56
Mentor had the necessary skills	4.02	3.96	3.41
Mentor was helpful	3.71	3.42	3.36
Value was gained from being mentored	3.67	3.42	3.22

Table 3: Discipline-Specific Design-2 Responses to End-of-Semester Likert Items

End of Semester: Second-Semester Students			
Likert Items	EE n=23	IE n=13	MFGE n=4
Mentoring improved team relationships	3.96	3.23	3.88
Mentor helped understand the course documentation	4.11	3.04	4.38
Mentor was accessible	3.76	3.12	3.75
Mentor had the necessary skills	4.24	3.50	4.38
Mentor was helpful	3.68	3.08	3.75
Value was gained from mentoring	4.04	3.15	3.88
Mentoring was enjoyable	4.20	3.23	4.63

Standard deviation and range were not tabulated for the discipline-specific responses in Table 2 and Table 3 because these data are subsets of the data presented in Table 1. It is our intent to provide more statistical results as this study accumulates more data.

Free-Response Questions

Two free-response prompts were posed to each group of students. These prompts concerned giving examples of how mentorship was of value and how our mentorship system might be

improved. Student responses fell into several categories, the results of which are shown in Figures 1 and 2.

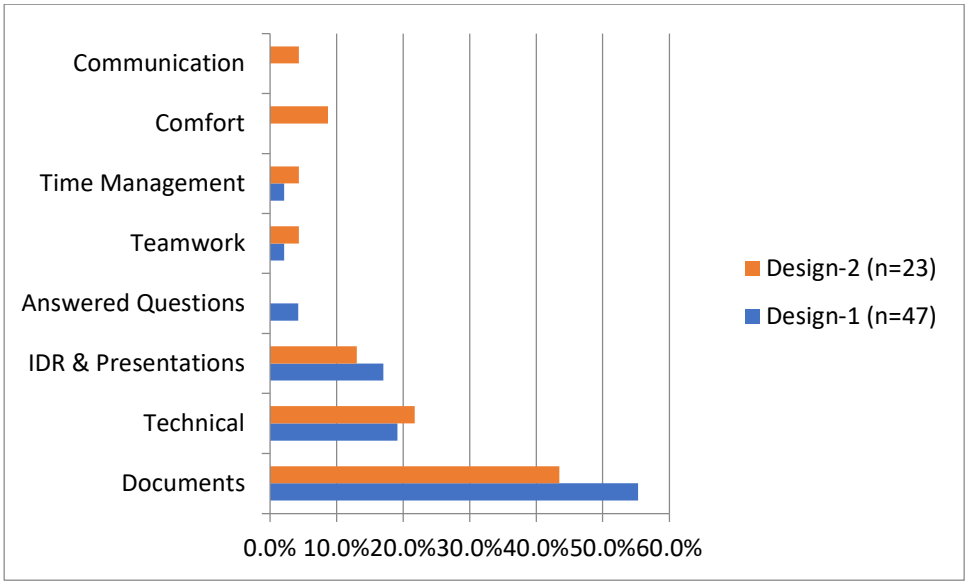

Figure 1: End-of-Semester Responses to "Give A Specific Example Of How Mentorship Was Of Value" Prompt, n=70

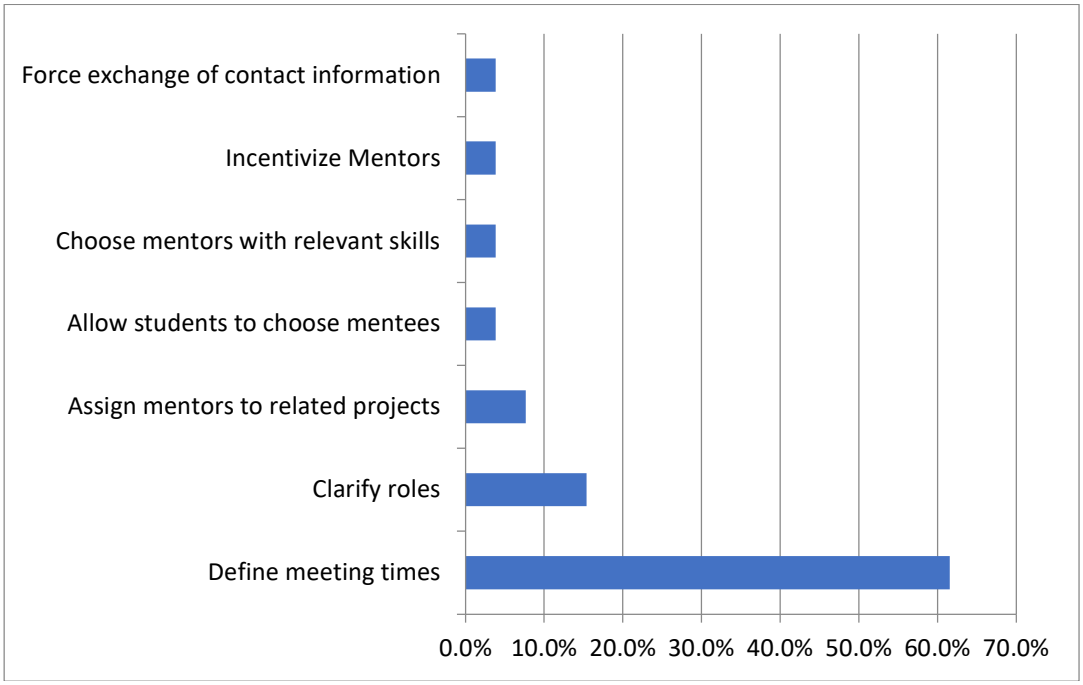

Figure 2: Design-2 End-of-Semester Student Responses to "Please Suggest Improvements To Our Mentorship Model" Prompt, n=26

Each free-response statement was categorized to create Figures 1 and 2. However, several student comments were noteworthy. When answering the question of specifically how their assigned mentor was of value, one Design-1 student wrote, *"[our mentor] Came to a team meeting and worked with us on strategizing more as a team."*

In response to the question of how Design-2 students believed that they helped their assigned Design-1 team, two students stated, *"What was the most question asked was in regards to team chemistry, patience, team work and how to "manage" hard-to-work with team members,"* and, *"Being able to relate with them when we were Design-1 and lost."*

When Design-2 students were asked to suggest ways in which the mentorship system could be improved, one Design-2 student wrote, *"Require a meeting at least once every week. This will benefit Design-1 teams greatly."*

Discussion and Conclusions

With the 5-point Likert scale, a score of 3 indicates a Neutral position, i.e., neither agreeing nor disagreeing with the statements. Since all aggregated responses shown in Table 1 ranged from 3.49 to 4.01, an agreement with the statements is suggested. This indicates that our mentorship model may be working to some extent but with opportunity for improvement.

The aggregated data indicates a very large range of responses for Design-1 students with a smaller range of response from the Design-2 students. No explanation for this range of responses is offered, but it is our intent is to collect more data over the next several semesters and to incorporate some visual data displays.

The strongest areas of response for Design-1 students as shown in Table 1 were the value of the mentor regarding course documentation, and that the mentor had the skills necessary to help them. The result regarding documentation was not surprising as our students typically struggle with this aspect of the course.

The differences in responses between the disciplines as captured in Table 3 was somewhat surprising given the responses of the IE students being mostly close to neutral. This may not be significant due to the small sample sizes and we did not test for statistical significance.

Figure 1 shows a reasonable correlation between Design-1 and Design-2 student perceptions. Another result tending to support our mentorship system was 20% of the Design-1 students stating that they had received technical assistance from their Design-2 mentors. Unlike documentation and presentation feedback, technical assistance is much more project-specific. This may indicate that our methods of matching mentees to mentors is working to some extent.

One result of this study is to expand the purview of our Capstone Committee to go beyond planning for Senior Design Day and to include teaching methods. The data gathered in this study provides for more concrete discussions amongst the disciplines in terms of sharing best practices, and helping to improve the mentorship model.

Future Work

Our plan for the future has several elements. The first is to incorporate student suggestions for improvement, which most notably was to define meeting times and clarify roles. We expect to implement this in the upcoming semester.

We will improve our research instrument based upon the results stated in this paper. This will be done via our Capstone Committee, which represents all three engineering disciplines. Finally, we intend to continue to administer the instrument and follow cohorts through the program. Some redesign of the research instrument will be necessary to perform this study.

References / Bibliography

(1) Quotation Celebration Samuel Rodenhizer November 3, 2017 https://quotationcelebration.wordpress.com/2017/11/03/2847/

(2) Evaluating a science diversity program at UC Berkeley: More questions than answers J. Matsui, R. Liu, C. M. Kane CBE—Life Sciences Education, 2003

(3) Dixon, G. (2015, June), *Capstone and Faculty Mentors/Advisors/Coaches* Paper presented at 2015 ASEE Annual Conference & Exposition, Seattle, Washington. 10.18260/p.23662

(4) Bjorklund, S.A., Parente, J.M. and Sathianathan, D. (2004), Effects of Faculty Interaction and Feedback on Gains in Student Skills*. Journal of Engineering Education, 93: 153-160.

(5) Sherwood, J.L., Petersen, J.N. and Grandzielwski, J.M. (1997), Faculty Mentoring: A Unique Approach to Training Graduate Students How to Teach. Journal of Engineering Education, 86: 119-123.

(6) Marin, J.A., Armstrong, J.E., and Kays, J.L. (1999), Elements of an optimal capstone design experience. Journal of Engineering Education, 88: 19-22.

(7) Jhu, Na,. (2018), Effectiveness of involving the industrial and business professions into mechanical engineering capstone course. : International Journal of Mechanical Engineering Education, 46: 31-40.

(8) Dougherty, J., and Parfitt, K. (2013), Student and practitioner collaboration in an online knowledge community: Best practices from a capstone course implementation. Journal of Architectural Engineering, 19: 12-20.

(9) Johnson, J., & Niemi, A. D., & Green, M. G., & Gentry, L. E. (2014, June), *Management and Assessment of a Successful Peer Mentor Program for Increasing*

Freshmen Retention Paper presented at 2014 ASEE Annual Conference & Exposition, Indianapolis, Indiana.

(10) Green, M., Niemi, A., and Roudkovski, M., "Implementing an Industrial Mentoring Program to Enhance Student Motivation and Retention", Proceedings of the 2012 American Society for Engineering Education Conference & Exposition, Annual Conference, 2012.

(11) Strada Education Network and Gallup, "Mentoring College Students to Success," 2018 Strada-Gallup Alumni Survey..