BOARD # 32: Work in Progress: Testing the Effects of Quality Engineering Coursework on Biomedical Engineering Students' Career Expectations and Goals.

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Background

Biomedical Quality Engineers (QEs) are oftentimes the last line of defense to ensure the safety and reliability of crucial medical devices. Their biomedical engineering (BME) background equips them with a cross-disciplinary education that traverses topics like instrumentation, biomechanics, and laboratory skills. This foundation creates a flexibility in cross-functional teams that few other engineers have, making them the ideal Quality Engineer in the medical device industry [1]. We define Quality Engineering careers according to the job titles the American Society for Quality consider Quality Engineering, such as manufacturing engineer, consultant, auditor, and more [2]. Fortunately, we found that over 40% of entry-level biomedical engineering jobs are in Quality Engineering and 70% require knowledge of QE skills [3]. Unfortunately, we also learned that undergraduate BMEs are unaware of Quality Engineering, which deters them from seeking QE careers [3]. They instead prefer Research and Development (R&D) positions, which they struggle to obtain at entry levels because of a lack of experience or specialization, leading them to settle for the readily available QE positions [3], [4].

As a result of this prior research, we propose that if BME curricula included an introduction to QE principles alongside those of R&D, students would be more prepared for their future careers. To explore the impacts of introducing QE concepts in BME curricula, we are studying a new BME Master's program in medical product development. This program teaches both design principles as well as QE principles. We interviewed students as they started and completed this program to understand how their perceptions of QE and R&D roles change. This will allow us to increase the alignment between what BME programs teach and what BME careers are available.

We seek to answer the following research questions:
1. How do students interested in BME industry careers perceive different career options and what are their goals and outcome expectations regarding those careers?
2. How do the learning experiences provided by the proposed intervention affect students' interests and outcome expectations regarding BME careers?

Theoretical Framework

We used Social Cognitive Career Theory (SCCT) to guide our interview questions and transcript analysis [5]. SCCT is used across STEM education literature to explain how career interests and goals are formed and what influences career decisions [6], [7]. This framework includes many components of a student's career decision-making process (e.g., background, learning experiences, outcome expectations, career goals, etc.) and how these components interact. We learned from our previous research that we most wanted to impact students' learning experiences and outcome expectations through our proposed intervention in order to align students' interests and goals with their career achievements [3]. Therefore, we focused our interview questions on learning experiences and outcome expectations.

Methods

The participant pool for our study was comprised of students in University of Michigan's new medical product development Master's program. The program instructors have experience teaching traditional BME and product development courses and also have experience working in industry. They introduced Quality Engineering principles to the students through their own lectures as well as through guest lectures by invited industry professionals. The students apply the principles they learn in class to a team project that spans the length of the program.

After our study was deemed exempt from further review by the University of Michigan IRB (HUM00240612), we recruited ten students who were beginning the Master's program and provided them with time slots to join a focus group. Based on their availability, we conducted two focus groups, one with three participants and one with seven. We chose to use focus groups because we expected to see many different influences on participant learning experiences and outcome expectations. Focus groups are ideal in exploratory research to discover complexities in participant responses, which fit the goals of our pre-program data collection [8]. During the focus group, we asked them about their perceptions, interests, and goals regarding different BME engineering careers. We also asked them why they entered the Master's program and where their career perceptions originated. We recorded and transcribed these focus groups, leading to 46 pages of data.

After students completed this one-year Master's program, we emailed them again, inviting them to participate in a one-on-one interview over Zoom. We conducted seven semi-structured interviews in the Summer and Fall semesters of 2024. We did not require these students to have participated in the earlier focus groups and we did not track this information. This decision was made for two reasons: 1) to allow for as many participants as possible, regardless of prior participation, and 2) because responses during the focus groups were not easily ascribed to participants given overlapping voices and responses. We also recorded and transcribed the interviews, which produced 103 pages of data.

We are using NVivo software to analyze these transcripts, applying the components of SCCT as *a priori* codes. After we complete this round of coding, we plan to inductively code the data to catch any relevant data that may not directly map to SCCT. Finally, we will review the data in these codes as a team for salient themes and answers to our research questions.

Preliminary Results and Discussion

The data have so far confirmed our previous findings. Multiple participants expressed being unaware of Quality Engineering and related fields as undergraduates. Some participants learned about QE through career fairs and networking as undergraduates. The participants viewed R&D engineering as the most coveted role for BMEs whether or not they themselves wanted a career in that field. This can be seen in the excerpt below, from one of the focus group participants as they began the Master's program.

> I think my perception especially in the first couple of years of undergrad was like "R&D is kind of the golden job," just because when I think of engineering I think of creating things. I don't think of regulating things. I think of like, "oh I have this problem and I want to solve it so I have

> to create something." And I think it's not until later in my undergrad and grad school that I learned about other options and saw really the breadth of engineering, especially biomedical engineering because people even go into patent law, go to med school. [Participant 8, Focus Group 2]

This quote and others begin to answer our first research question regarding how students perceive BME industry careers and from where these views develop; participants described their early undergrad outcome expectations as R&D being the highly coveted job and the only job considered for BMEs. Participants reported minimal learning experiences related to Quality Engineering as undergraduates. The learning experiences they did have often came from other disciplines, as seen by Participant 3 in our first focus group, who said "I had classes where we would go over Quality Engineering principles, but they were always industrial design classes. They're under a different umbrella. I don't think I ever had a biomedical engineering professor go over quality standards." These two quotes show the lack of career-related learning experiences in BME curricula, and through SCCT, we know that learning experiences, or lack thereof, can greatly influence a student's interests and goals. Even just an introduction to QE through the Master's program impacted students' perceptions of QE, as evidenced by our third interviewee:

> Like undergraduate, I had a lot of biology background. We learned a lot of biology in different classes. I think some of that time definitely could have been spent teaching us about quality engineering roles and manufacturing engineering roles, what we actually do when we get a job. I think that would have made me more open to apply to quality and manufacturing jobs because like I said earlier, I didn't look into manufacturing jobs until my second semester of grad school, so in January of this year. Before that, I had just been looking into R&D engineering jobs. [Participant 3]

This participant suggests that their learning experiences in the Master's program changed their goals and actions. The participant shifted away from applying to R&D jobs, a change they credit to learning about other roles for biomedical engineers. They echo what we hypothesized in our previous research: that exposure to QE and other lesser-known career options as undergraduates would have improved their job and internship search. These results begin to answer our second research question regarding how the Master's program impacts students' career perceptions and goals. We expect that our completed analysis will provide more insight into these answers.

Future Work

We plan to finish coding the transcribed interviews and review the codes for emergent themes. From our current analysis, we have seen that perceptions of QE and R&D have indeed changed as a result of the Master's program. However, we recognize that it would be challenging for BME departments to add entirely new Master's programs. Therefore, we are left with the question: Which specific aspects of the curricula affected their career perceptions the most? Answering this question would suggest topics for BME professors to incorporate into their existing coursework. Therefore, we are conducting another round of interviews with the second cohort of the Master's program as they finish their first semester. These interviews will help us further answer our research questions and refine our recommendations to BME departments. (We have nearly finished conducting these interviews but still need to analyze the new transcripts along with completing the previous analysis).

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