The Value of Co-Curricular Experiences: Perspectives of Third Year Biomedical Engineering Students

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Abstract. *Many studies have examined student engagement in university settings as a predictor for learning and development, finding that generally, higher engagement is linked to gains in professional outcomes and persistence. Engineering student engagement research has been performed on co-curricular experiences and has led to an increased emphasis from institutions on students' participation in those experiences. Similarly, BME students regularly engage in co-curriculars to supplement their experience in the formal curriculum because of concerns about their professional marketability when they graduate. To help students make an informed co-curricular engagement choice, it is important to understand not only what professional outcomes students gain from their co-curriculars as has been previously studied, but also what about the co-curricular is valuable to their initial engagement and continued participation. This study employs a qualitative study design and the four dimensions of subjective task value described in Eccles' expectancy value theory of motivation to explore BME students' engagement in co-curricular experiences. The goal of the study was to better understand why students participate in co-curricular experiences beyond the findings of previous studies which focus on the technical and professional outcomes of participation as well as more deeply explore the way students relate their participation to their preparation for future careers.*

The results of the study indicated that BME students are largely motivated to participate in co-curricular experiences for their utility value in leading to a career in BME, which is consistent with outcomes-focused prior studies. Beyond that, students discussed the ability to connect how they see themselves as a biomedical engineer and a general interest in the work and non-career related opportunities available to them through their co-curriculars. While the discussion of cost was minimal in our study, time was also a factor for students' decision to participate in co-curriculars. These additional findings indicate that students can also be motivated to participate in co-curriculars through other means than just the outcomes studied in prior co-curricular literature.

Introduction

Student engagement in higher education settings has long been studied as a predictor for college student learning and development [1]. Broadly, studies of student engagement have often examined relationships between a student's educational experiences and the outcomes of interest, finding that, in general, higher engagement was linked to gains in outcomes such as learning and persistence [2], [3]. In particular, engagement in co-curricular settings, or experiences outside the classroom, has been linked to the development of several technical and professional outcomes for engineering students such as leadership, ethical decision making, teamwork, and communication [4]–[9]. Beyond those outcomes, co-curricular engagement has also been linked to outcomes such as self-efficacy and a sense of belonging, which can improve retention and persistence in engineering students [4], [5], [9]. Research on co-curricular experiences has led to an increased emphasis from higher education institutions on students' participation in co-curricular experiences [8], [10]. Biomedical engineering (BME) undergraduate students have explicitly implicated co-curriculars as a key part of preparing them for professional careers in their undergraduate experience [11]. BME students often choose to engage in one or more co-curricular experiences to supplement their professional development through the formal curriculum because of concerns about their professional marketability upon graduation [11], [12].

Because a student's decision to engage in a co-curricular experience is largely non-compulsory, understanding what informs students' choices to engage is an emerging area of research for engineering education [13], [14]. Findings from such research can help educators support the development of effective co-curricular programming and advise students in paths to participation. Fisher et al. [5] explored engineering students' selection processes through a synthesis of previous findings on co-curricular engagement; their framework details "types" of co-curriculars and the outcomes linked to them. In order to help students make an informed engagement choice as well as inform "what types" of co-curriculars are available to students, it is important to understand not only what professional outcomes students gain from their co-curricular experiences, but also what else about the co-curricular is valuable to their initial engagement and continued participation.

This study focused on BME students' engagement in co-curricular experiences to better understand why they participate in co-curricular experiences and how they view their participation in relation to their preparation for their future careers. Qualitative data was collected from semi-structured interviews to examine two types of co-curricular experiences in which BME students frequently engage at one Midwestern university.

Background

The study of student engagement in higher education has roots in Astin's (1984) [15] concept of involvement and Pace's (1998) [16] research on a related concept he called quality of effort. Both scholars postulated that the more time and energy a student devotes to the academic experience, the more that student will learn. Astin argued that involvement, or the investment of physical and psychological energy towards an experience, occurs on a continuum and has both quantitative (e.g. time on task) and qualitative (e.g. useful study strategies) features [15]. Astin and Pace's work is the basis for the National Survey of Student Engagement (NSSE) which collects five categories of information about students: participation in educationally purposeful activities (e.g. interacting with faculty or peers), what institutions require of them (e.g. amount of reading or writing), perceptions of features of the environment related to academic success, demographic information (e.g. gender, race, socioeconomic status, major, etc.), and estimated growth in various outcomes since college [2], [3]. While there is some debate on the predictive power of NSSE, studies using NSSE have linked student engagement in co-curricular experiences to student learning outcomes, increased retention, and four year graduation [8], [9].

Beyond NSSE, many other studies have linked student outcomes to co-curricular experiences. These studies often focus on collecting data on "who" they are studying by identifying the characteristics of the student population, "what types" of co-curriculars support students' learning by selecting one or more co-curricular experiences, and "what outcomes" are achieved by assessing specific student outcomes [6], [7], [17]–[19]. For instance, a study by Young and colleagues [6] collected data on African American engineering students in a variety of co-curricular activities that the researchers classified into three categories (engineering clubs, underrepresented minority (URM) clubs, and other clubs). The study analyzed the perceived development of communication, professionalism, lifelong learning, teamwork, and reflective behavior skills related to co-curricular participation. Some findings from the study include higher reported teamwork and reflective behavior related to participation in any of the three categories of co-curriculars, lower reported communication skills for students participating in URM clubs when compared to peers who did not, and higher reported teamwork skills with increased involvement in engineering and other clubs. Using a similar approach, a study by Litchfield et al. [7] assessed the differences between engineering students and practicing engineers who were involved and not involved in engineering service experiences. The study found that both populations perceived similar levels of technical skills, but that participants with engineering service experience reported significantly higher professional skills, statistically controlling for potential relationships between skills and age, gender, and grade point average. A study by Carter et al. [18] also sought to study engineering students in a specific co-curricular environment, undergraduate research, to determine effects on student outcomes like communication, teamwork, and leadership skills. An important finding of this study was the effect self-selection into co-curriculars like undergraduate research can have on studies using self-report measures of student outcomes as a comparison tool. The study found that students who engaged in undergraduate research tended to report higher skills, but when accounting for both curricular and classroom experiences, few differences were seen between students who did or did not participate. This and similar work have contributed to knowledge about "what types" of engagement in co-curricular experiences are most significant for engineering students. Until Fisher et al.'s recent work, however, a thorough review of the potential relationships between specific co-curricular opportunities and potential engineering student outcomes had not been performed [5].

Using their review to develop a framework, Fisher and colleagues [5] categorized the various types of co-curricular experiences and documented what outcomes could be linked to the co-curricular types. The extensive set of outcomes identified include: Civic Responsibility, Creativity, Critical Thinking, Cross-Cultural Skills, Disciplinary Knowledge, Ethics, Global Awareness, Humanitarianism, Interpersonal Communication, Memory, Networking, Organizational Management, Problem Solving, Public Speaking, Self-Confidence, Self-Direction, Strategy, Teamwork, Time Management, and Written Communication, which they link to 22 types of co-curricular experiences. They suggest that this work could be used to help advise engineering students in identifying and selecting co-curricular experiences with which to engage. While these findings may inform students' decision making processes based on desired outcomes, it does not account for other student motivations for participating in these optional educational experiences. In fact, few studies [20], [21] exist that examine if the outcomes in the literature align with what motivates students to engage in co-curricular experiences. If researchers and practitioners desire to encourage student participation in co-curricular experiences, we must also understand why they choose to engage.

Further, studies have not focused on the field of BME, where co-curriculars play a very important role in the undergraduate experience. Berglund [10] quoted BME baccalaureate graduates' views of the importance of co-curricular involvement in their experience; students said things like: "You really had to go beyond the classroom to learn about other opportunities… (p. 47)" and "If the goal is for students to land jobs right out of college… BME programs should strongly encourage students to participate in research… (p. 49)" [11]. Biomedical engineering students often share the concern that they will be 'jacks of all trades, and masters of none', with limited marketability to industry [12]. In an effort to address these concerns, BME students often look to co-curricular experiences to round out their undergraduate experience. Because BME students are emphasizing the need to incorporate co-curriculars into their undergraduate experience [11], [12], BME educators need to help guide students in selecting co-curriculars that align with their wants and needs.

Study Design

This study was guided by the following research question:

Why do BME students participate in one or more common co-curricular experiences?

Data to inform this question were collected as part of a larger longitudinal, qualitative study of BME students' experiences in two co-curricular experiences. Qualitative research primarily seeks to understand the lived experience of participants asking questions about how people interpret their experiences or what meaning they attribute to their experience [22]. This paper used an interpretive, conventional content analysis approach to establish findings [23], [24]. In performing the content analysis, it was found that the data could be connected back to theory, which is described in the results and discussion.

Study Site & Co-Curricular Experiences

This study was conducted with students in the BME department at a large, research intensive, public university in the Midwest United States. Students enroll in one of three concentrations within the undergraduate major: bioelectrical, biochemical, and biomechanical. In addition to coursework, students in the BME department often participate in one or more co-curricular experiences before graduation, but co-curricular participation is not required as part of the curriculum. Common experiences include the two studied (Multidisciplinary Design Experience, or MDE, and Undergraduate Research) along with other professional and departmental societies and internship opportunities. The multidisciplinary design experience and undergraduate research experiences were selected for this study because 1) a high percentage of students in the department participate in one or both experiences 2) they exemplify two different "types" of co-curricular experience based on Fisher's categorization [5] 3) similar experiences have been frequently studied in engineering education and 4) students typically engage with the MDE and research experiences for an extended time allowing for longitudinal data collection which is part of the larger study design. These criteria allowed for selection of co-curriculars where study participants could be recruited, compare and contrast the experiences, as well as utilize previous work to inform the questions and analyses of this study.

Multidisciplinary Design Experience (MDE)

The MDE student group focuses on addressing healthcare problems by fostering interdisciplinary work in global health and applying design and entrepreneurship strategies. While approximately half of the 300 student members are BME majors, many other majors participate in MDE (e.g., electrical engineering, mechanical engineering, materials science, computer science, public health, business, etc.). Students can participate in the organization in multiple ways: as a design incubator participant, on a design team, on a travel team, or as a board member.

Undergraduate Research Experience

Undergraduate research provides students with an opportunity to get exposure to research. It is commonly recommended that undergraduate students gain research experience at the university where the study took place, though what kind of research is not specified. There are several mechanisms for students to become involved in research, through independent study credit, for hourly pay, or volunteering. It is not uncommon for research experience to vary dramatically between labs, with regards to the tasks performed by undergraduate researchers or the level of input taken in project decisions.

Participants

Using purposive and snowball sampling [25], 14 students entering their third year, who were also planning on engaging in at least one of the two co-curriculars studied (MDE and undergraduate research) over the 1.5 years study period, were invited to participate. Fourteen participants is within the range of a typical sample size in a qualitative study [26] (p. 179); qualitative research studies rarely seek to generalize results but rather ask questions that allow for an in-depth understanding of a specific environment [22], [23]. Participants varied by self-reported gender, race/ethnicity, pursued concentration, level of engagement with the co-curricular as categorized by the first author, and career aspirations (see Table 1 and Table 2 for details).

Table 1. *Participant Demographic Data (n = 14)*

Gender	Female (11)	Male (3)	
Race/Ethnicity	Asian (6)	Hispanic/Latinx (2)	White/Caucasian (6)
Co-Curricular	MDE (9)	Research (11)	Both (6)
Concentration[1]	Biochemical (6)	Biomechanical (6)	Undecided (2)
Career Aspirations[1]	Short Term • Gap Year (2) • SUGS[2] (7) • Doctoral (3) • Industry (2)	Long Term • Doctoral (2) • Industry (12)	

Table 2. *Participant Co-Curricular Level of Engagement at Time of Data Collection*

	MDE Participants (9)			**Undergraduate Research Participants (11)**		
Level of Engagement	High (7)	Middle (0)	Low (2)	High (4)	Middle (6)	Low (1)

Data Collection

Before data collection began, this study was determined to be exempt from IRB regulation. Semi-structured interviews lasting 45 minutes to 90 minutes were conducted to explore student perspectives regarding the goals of the co-curricular, reasons for joining, their experiences, and how they would describe the co-curricular to a friend. In-depth interviews, like the ones

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[1] Concentration and Career Aspirations data was compiled using questions in the second interview of the full study.
[2] SUGS is the Sequential Graduate Undergraduate Study program offering a one year Master's degree after completion of the Bachelor's degree at our institution.
(#) Indicates the number of participants in that category.

conducted in this study, allow for the interviewer to ask follow-up questions that encourage participants to provide answers that move beyond simple responses and into more complex thought processes. Questions were developed by the research team, piloted, and adjusted to facilitate better discussion with participants and improve the researchers' understanding of meaningful experiences students had through their participation. A second set of interviews at the end of the semester was performed as part of the larger study and some data from those interviews has been included in this paper where indicated. All interviews were completed in Fall 2019 and transcribed verbatim for analysis. The first author performed all interviews and employed memoing strategies to further inform and adjust interview questions as needed to explore the research question [23].

Data Analysis

An interpretive qualitative approach aligned with conventional content analysis was used to explore and understand the attributes of a co-curricular experience that students found meaningful [23], [24]. Students are identified in the analysis using the pseudonyms they chose. Coding in qualitative research is a process of assigning a word or short phrase to summarize or capture salient attributes of a portion of qualitative data [27] which, in the case of this study, was transcribed interviews. The analysis process started with descriptive coding of the transcripts to identify areas of the interview related to the research question. Then, categorical codes were developed to identify common categories of discussion throughout the interviews. Categorical codes were then grouped by the co-curricular discussed and analyzed to capture meaning within the groups. The steps taken in the analysis process align with rigorous qualitative data analysis recommendations [28].

By organizing categorical codes into groups, it was found that participants' discussions of their experiences could be interpreted using subjective task value (STV) as defined in Eccles' expectancy value model. Subjective task value is a central construct of Eccles' expectancy-value theory of achievement motivation (EVT) [29]. EVT seeks to explain how individuals choose behaviors based on their outcome expectations and the value they place on that outcome [30]. Subjective task value can be broken into four dimensions:

1. Attainment Value: A task has attainment value if it provides a way to confirm or support an aspect of how one sees one's self.
2. Interest Value: A task has interest value if an individual enjoys or expects to enjoy doing the task.
3. Utility Value: A task has utility value if it benefits future plans.
4. Cost Value: A task can also have perceived cost(s) associated with performing the task.

While EVT is more commonly used to predict a subject's behavior, for this paper, the STV construct of EVT was used to assess students' perceived value of co-curricular participation. This approach is similar to that used by May in a study of engineering students' experiences with service learning [31]. May assessed the value of a service learning program by examining student perceptions of eight values categories previously developed by the researcher (i.e. intrinsic, altruistic, impact, attainment, career, cost, camaraderie, community values). Using this method, May found that career value was a prominent theme across student respondents and made suggestions for improving the program.

Instead of asking students to respond to pre-determined STV categories, interview responses were categorized into codes and mapped to the four STV dimensions (attainment, interest, utility, cost). The results of this study compare and contrast what value students place on their participation in two different co-curricular experiences as well examine common values across experiences.

Results

For both co-curricular experiences, MDE and undergraduate research, resultant codes could be categorized as one of the four subjective task values of attainment, interest, utility, or cost (see Table 3 and Table 5 for examples). Some codes were consistently identified for both MDE and research (i.e. having a community, learning course and engineering concepts through application, and it takes a lot of time). The least frequent value discussed was perceived cost. Students participating in the different co-curriculars tended to differ in their discussion of attainment and interest values. MDE participants tended to articulate more attainment value, while research participants more often described interest values. Expressions of utility value were most numerous for both groups. When discussing the codes that were categorized as utility values, participants often related them to their utility for preparing them to enter an engineering professional setting or develop relevant professional skills outside of the classroom. Within these discussions, evidence was found of students' perceived difficulty with getting a job with only a BME bachelor's degree, which was interpreted as a strong motivator for BME students to engage in co-curriculars and improve their career outlooks.

Multidisciplinary Design Experience

The nine MDE participants described 11 different subjective task values (see Table 3). Most of the values were associated with utility and directly aligned with developing the competencies necessary to work in industry: communicating in a professional setting, being an organization and/or team leader, working in a team, designing in a BME context, or networking with industry and stakeholders. While there were only two codes for attainment value, both were shared by the majority of the participants. Eight participants discussed the value of having a community and seven mentioned a desire to help others through their work. Only one interest value was identified in our study: travelling somewhere new. Very few participants discussed potential costs of engaging in the MDE; the only code associated with perceived cost was the amount of time required to engage fully. Despite that acknowledgement, participants described the time investment as worth it. Exemplar quotes are provided in Table 4.

Table 3. *MDE Inductive Coding Descriptions*

SVT Dimension	Codes	Participants describe…
Attainment Value	*Having a Community*	having people they can count on, finding their "group", or gaining a community.
Attainment Value	*Helping Others Through My Work*	the ability to help, influence, positively impact others through their work.
Cost Value	*It Takes a Lot of Time*	the time it takes to engage in the co-curricular as substantial and potentially conflicting with other priorities.

Interest Value	*Travelling Somewhere New*	the ability to travel both domestically and abroad.
Utility Value	*Exploring Industry Careers*	the ability to gain new insights on what BME professional settings (e.g. industry, graduate school, medicine) are like.
Utility Value	*Communicating in a Professional Setting*	the ability to get exposure to or develop skills in various forms of professional communication (e.g. written, presented, in meetings).
Utility Value	*Being an Organizational and/or Team Leader*	the ability to get exposure to leadership positions or develop leadership skills.
Utility Value	*Working in a Team*	the ability to work with a team for an extended time.
Utility Value	*Designing in a BME Context*	the ability to gain design exposure in a context that they enjoy (BME problems).
Utility Value	*Networking with Industry and Stakeholders*	the ability to engage with and learn about a wide variety of industries and stakeholders.
Utility Value	*Learning Course and Engineering Concepts through Application*	the ability to learn by doing or the desire to improve classroom learning by applying knowledge in context.

Table 4. *MDE Subjective Task Value, Corresponding Codes, and Representative Quotes*

Attainment Value: *Having a Community* "MDE is a place really will help foster growth in whatever direction you want to take it, whether it's growing a sense of community and having a family or a team that you can count on…" - AJ *Helping Others Through My Work* "I decided to join MDE because I am interested in global health. I think that I would love to see a world where you live or how much money you have doesn't dictate what your quality of healthcare is. I wanted to be in an organization that was working toward addressing those disparities." - Ernest	***Interest Value:*** *Travelling Somewhere New* "It's given me the opportunity to travel *within the United States* because that was part of the *SOUND* trip. There's obviously more opportunities to travel I think with the *SPA* trip, and then just individual design team trips as well." - Detroit Lions Fan	***Cost:*** *It Takes a Lot of Time* "I think classes are always a priority for me. I know I can maybe take a step back. I actually recently had a conversation with a friend about potentially still trying hard in my classes, but maybe trying to spend a little bit less time actually studying outside of class so that I do have time to commit to my co-curriculars where I really am learning a lot more than I sometimes am in the class, which is really hard for me to say and probably even going to be harder for me to do." – Ernest
Utility Value: *Communicating in a Professional Setting* "Like, yes, MDE is very interdisciplinary... I'm hoping that's how project teams in the future will be like in the workplace where you'll be working with a bunch of people from different areas. And… as a biomedical engineer,		

as someone who has been a part of MDE, you could be the one to connect the nurse to the electrical engineer and be able to understand what they're both saying." - AJ

Being an Organizational and/or Team Leader
"I think also leadership, there are a lot of leadership opportunities if you are committed and if you're willing to devote your time and energy." - Al

Working in a Team
"I wanted to get the experience of working on a team and really bonding with that team on a single project over the course of several years and not in sort of a competition style where you build the robot..." - Ernest

Designing in a BME Context
"I think that MDE has shown me what engineering design really is, and what kind of a process it can be." - Timmy

Networking with Industry and Stakeholders
"We are sponsored by several medical device companies, so we host different information sessions, networking events. And that way, there are opportunities for professional development. And project teams, I think they work with mentors from medical device companies, so they have connections, that way. And the travel teams, we definitely learn a lot from different organizations and from the people in the community." - Student M

Learning Course and Engineering Concepts through Application
"Yeah, I was interested in learning about materials because I was interested in the material background, but I ended up getting put on a different (sub)team. I learned a lot about circuit design and circuit testing, which is helping in some of my classes right now." - Detroit Lions Fan

Exploring Industry Careers
"I think that, so far, if I was not involved in MDE, and I was only taking my BME classes and even just only involved in research outside of that, I don't think that I would understand biomedical engineering as an industry as well as I do now, and the kinds of collaboration and the kinds of hard work and long-term work that go into product development." - Timmy

Undergraduate Research Experience

The 11 participants who engaged with undergraduate research discussed a total of 12 subjective task values (see Table 5). Research participants discussed fewer values that related to developing industry relevant engineering skills. Three codes were identified that could be categorized as utility values in the context of industry skills (i.e. communicating research, problem solving in the moment, and learning course and engineering concepts through application). Unique to the research experience, participants also discussed values related to navigating research and academics post-graduation (i.e. having a mentor, and formal recognition) which were also categorized as utility values. Participants also talked about mentorship and recognition in a way that could relate to attainment values. When participants described the experience as in line with how they perceived themselves they were coded in the attainment dimension and named “gaining confidence through mentorship” and “gaining confidence through recognition”. Other codes that were categorized as attainment values include: “contributing to the field with my work” and “having a community”. Within the codes that mapped to attainment identified in this study, participants mostly described positive experiences; however, one participant described a negative experience related to the code “having a community”. They described the discomfort they experienced in a new research community they joined by saying:

> *“When I first joined the research lab, when I first joined the (BME) lab, it wasn't really awkward. People knew I was an undergrad, people understood that I could do things at some*

point, I would learn to do things. But now, moving into a different lab, people don't understand that I can do things, and it's just really awkward because I'll ask them for something and they'll be like, "Oh, let me do that for you." But I can be like, "Oh, I know how to do that. It's not that hard. I can do it myself." – Honey Nut Cheerios Lover

Similar to MDE participants' desire to explore BME industry, research participants expressed a desire to explore BME research, a code which was determined to be related to interest value. Another interest value code was the desire to study a topic they find interesting in general. Interest value codes were the most commonly discussed by research participants (7 participants for each category). While minimal in comparison to the total number of participants, more participants discussed the time investment associated with participating in research than participants in MDE. When talking about time in research, students discussed that the time necessary to do well took away from opportunities to pursue internships or affected grades. Table 6 provides exemplar quotes for each of the categories discussed by undergraduate research students.

Table 5. *Research Inductive Category Descriptions*

SVT Dimension	Category	Participants describe…
Attainment Value	*Gaining Confidence Through Mentorship*	the impact a mentor can have on their confidence in their ability to perform work.
Attainment Value	*Gaining Confidence Through Recognition*	the impact gaining formal recognition can have on their confidence in their ability to perform work.
Attainment Value	*Having a Community*	having people they can count on, finding their "group", or gaining a community.
Attainment Value	*Contributing to the Field with my Work*	the satisfaction of knowing that the work they did contributed to the field.
Cost Value	*It Takes a Lot of Time*	the time it takes to engage in the co-curricular as substantial and potentially conflicting with other priorities.
Interest Value	*Exploring within Research*	the ability to explore their interests in various research fields and see what they enjoy doing in research.
Interest Value	*Studying Something Cool*	the ability to research or learn about something that interests or intrigues them.
Utility Value	*Communicating Research*	the ability to share or communicate the work they through various modes of communication.
Utility Value	*Formal Recognition*	the ability to gain formal recognition for the work they did in order to demonstrate preparedness for future endeavors.
Utility Value	*Having a Mentor*	the ability to ask advice, understand nuance, or hear about experiences from more senior members of the lab.

Utility Value	*Problem Solving in the Moment*	the ability to solve problems, make decisions, or troubleshoot in the moment.
Utility Value	*Learning Course and Engineering Concepts through Application*	the ability to learn by doing or the desire to improve classroom learning by applying knowledge in context.

Table 6. *Research Subjective Task Values, Corresponding Codes, and Representative Quotes*

Attainment Value: *Having a Mentor* “I think I appreciate how awesome my mentor has been and I mean that with 100% honesty. She really believes in me a lot and I think that's helped me a lot...” - Ernest *Formal Recognition* “I was kind of told that if I work hard enough and have initiative, that I can get onto a paper, which I feel like that's kind of professional.” - Cleo *Having a Community* ‘It sounds kind of cheesy, but especially transferring into engineering, I kind of have had this cloud hanging over my head like, "Oh, I don't know if I belong here. I feel like I'm kind of behind everyone," and it's been very helpful being like, "No, you're doing something important. You're good at this," and, "This is something you can do and you're good at."’- Sparks *Contributing to the Field with my Work* "Honestly, I would tell them that it's very rewarding. Especially if they do research that is in a field that they care about, it feels like you've been taking from this field, learning about this field for a while or have been interested in it for a long time, and to finally be able to do something to push the knowledge boundary of it just a little bit is pretty cool." - Timmy	***Interest Value:*** *Exploring within Research* "I definitely was interested in research and I was kind of at a crossroads at the end of last year, like going into junior year and not knowing what I wanted to do with my BME degree, if I was interested in doing research or industry, or going to grad school… I felt like I couldn't really make the decision without trying it, and I like the idea of just knowing more, learning more, having more skills." - Sparks *Studying Something Cool* "Also, if I have things to do, I guess the project will be a success, just in general. Things to do that I'm interested in. That'll make this project a success for me." - Honey Nut Cheerios Lover
Utility Value: *Communicating Research* "I think just making presentations, talking to people, communicating what you learn is a big thing too..." - Bianca *Formal Recognition* "A lot of it comes that I want to have experience and just have something to put on my resume, but it also sounds really interesting and it will be really cool to be a part of something that matters, that can, in some way, help people." - Cleo *Problem Solving in the Moment* "I guess I feel like I'm less reliant on people. I think if there's a problem, I can figure out how to fix it better. I'm better at just kind of thinking in the moment just because you don't know what's going to happen and there's been days where it's like everything (that) possibly that could go wrong, goes wrong. And it's always the day that my mentor isn't there." - Bianca *Having a Mentor*	***Cost:*** *It Takes a Lot of Time* “I guess it's different if you've had internship opportunities… But it's hard because there's not enough time and the only time you can take off of school is summer. But you can only really do one thing per summer. So for me, if I wanted to do my PhD, an internship isn't necessarily in my best interest because grad schools don't really care about that… So if I wanted to do an internship, it would take away from my skills as a researcher. But then if it's grad school and if I want to go into industry… How can I say that I'm ready for

"And also… just having a mentor. I didn't really know anyone who had gotten their PhD in BME before so going through that process is a lot easier. …It's going to be a lot easier to handle because he's gone through it." - Bianca *Learning Course and Engineering Concepts through Application* "I would tell them that it's really a practical good experience and that, (there) definitely are connections to things you're learning in class. I didn't really like my material science class, so getting to now work with polymers and like, "Oh no, that this happens because of this property." I think is really cool." - Samantha	that when I haven't had any internship experience?" - Bianca "I was really worried that in doing it my grades were going to go down, which is why I didn't do it for so long…" - Sarah

Similarities Across Experiences

The most consistent similarity between the two groups of students was their emphasis on utility values and expression of the need to seek out such opportunities to fill a gap in their education. This emphasis could be linked to previously documented student and researcher discussions about the perceived difficulty in getting a job with only a BME bachelor's degree [11], [12]. Evidence that many of our participants share this sentiment is indicated by the few participants anticipating entering the job market with their bachelor's degree (3 participants) as well as in discussions by participants in their interviews:

> *"And I feel like all schools, it's not necessarily Large Midwestern University's degree isn't good. It's more just the BME degree in general is very broad compared to other engineering degrees, which isn't a bad thing. I want to do grad school, so it doesn't really matter but a lot of people come into Large Midwestern University. They're like, "I want to be BME," and then people are like, "You're not going to get a job." That's what you hear from all of the other majors, "You're not going to get a job," or, "Only if you want to do grad school," because a lot of jobs or companies do expect you to have more knowledge which is why you need to do grad school to focus on what you want to do, which is fine for me." – Bianca*

> *"I think that ... I don't know. It's kind of hard to say. I think I've been a bit more pessimistic about it lately just because of what I've been reading about and just hearing from my peers and staff stuff about how hard it can be to get a job in BME. Also, just the realization that I'm halfway through and I still don't feel like I have enough concrete skills to be able to be valuable in a workplace, but I think there is value in the fact that you sort of have a really good baseline for being able to go and do anything within the healthcare industry that you want to do, which I think is really good." – Ernest*

> *"So we just get a lot of introductory material in a lot of different disciplines. So I feel like going immediately out of college, we know a little bit about a lot of things, and that might not help us be competitive in the job market immediately coming out of college, which might make something like another engineering degree a little bit more valuable, if you're just looking at undergraduate work." – Timmy*

Discussion

In this study, evidence was found that students immerse themselves in co-curricular experiences that they believe have utility value for their future career aspirations, but that motivations to participate can also relate to their general interest in the field and their personal connection with the experience. Building skills, creating connections, and getting career advice were all discussed as ways students could improve their career outlooks. More specifically, MDE participants found the opportunities to develop professional skills like communication, leadership, and teamwork along with learning technical content and how to design valuable to their experience. While research participants discussed skill development less frequently than MDE participants in their interviews, they saw utility in the formal recognition they gained through papers and presentations as well as in knowing people who had already navigated graduate school.

Beyond its usefulness for their future careers, participants valued their co-curricular experiences for allowing them to connect aspects of their identity with their major or department (attainment value) and found value in exploring what they enjoyed about the various facets of BME (interest value). Typically, MDE participants talked about attainment value as having a community to which they belonged, or as doing work that helps others as aligning with their personal values. Research participants discussed the interest value dimension of their co-curricular participation more frequently than the MDE participants. They expressed the value of doing research coming from the opportunity to explore their interests, and if they had found that, to do work and ask questions that they found interesting. Students also discussed categories in the cost dimension associated with participating in co-curriculars, though less frequently than interest values. Time was the biggest cost consideration for students who felt they had to make choices between the types of co-curriculars to engage with or the time lost for coursework because of their engagement in the co-curricular.

Finally, the results of this study highlight the important discussion surrounding BME students' perceived difficulty with the job market beyond graduation. Regardless of co-curricular participation, many of the participants anticipated entering industry as a long-term career goal (12 of 14 participants), but discussed the desire or need to specialize before doing so. They linked this desire or need to specialize with the broad interdisciplinary nature of their undergraduate degree. As the evidence of both a perceived and measured gap between BME undergraduate degrees and placement in industry builds, efforts to understand and close the gap are becoming increasingly important [12]. Despite this gap, students in our study described their degree as valuable and appreciated the broad exposure to multiple disciplines as a way to explore and keep their career options open upon graduation.

Conclusion

This work was performed at one institution and studied two of the many co-curricular experiences available to students. As such, this work highlights important aspects of students' experiences that warrant further investigation, but cannot account for all of the values students place on their co-curricular participation. Future studies may wish to use these methods to compare and contrast student experiences in other common co-curricular opportunities, such as internships or professional societies. The results of this study indicate that BME students are motivated to participate in co-curricular experiences for their utility value in leading to a career in BME. These findings relate to two important aspects of previous engineering education discussions 1) BME students are concerned that the curricular experience is not sufficient for career placement upon graduation [11], [12], and 2) some previously studied professional and technical outcomes of co-curricular experiences are motivating factors for student participation [5]. While the discussion of cost was minimal in our study, time as a factor for students' decision to participate in co-curriculars warrants further investigation, particularly within a major where students are indicating that co-curriculars are necessary for professional preparation. Beyond the utility value of participation, students discussed the ability to connect how they see themselves as a biomedical engineer and a general interest in the work and non-career related opportunities available to them through their co-curriculars. These findings indicate that students can be motivated to participate in co-curriculars through other means than just the outcomes so heavily studied in prior co-curricular literature.

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