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Measuring the Impact of Extra-/Co-Curricular Participation on Professional Formation of Engineers

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Measuring the Impact of Engineering-Focused Extra-/Co-Curricular Participation on Professional Formation

ABSTRACT

While most current research on teaching and learning is conducted in the classroom, evidence suggests that the quality of a student's learning is also affected by experiences outside of the classroom (i.e., extra-/co-curricular experiences). Engineering students have available to them a rich variety of learning opportunities outside of the classroom – such as competition teams, undergraduate research experiences, and service-learning organizations – which reinforce and strengthen the knowledge they gain through engineering coursework while enhancing their self-efficacy in academic and engineering skills. The goal of this project is to determine which features of engineering students' professional formation are impacted by their participation in engineering-focused extra-/co-curricular activities – specifically, competition teams, undergraduate research, and service-learning organizations. The first phase of this study, reported in this paper, involves the implementation of an electronic survey to measure the impact of engineering-focused extra-/co-curricular activities on students' academic achievement and self-efficacy. Academic achievement is measured using questions from the Statics Concept Inventory [1], and self-efficacy is measured using a series of questions from self-efficacy survey items [2] that ask students to rate on a six-point Likert scale their capability in (a) specific engineering skills such as working with machine and engineering design, and (b) general engineering coursework. Based on the results from the survey administered to junior and senior mechanical engineering students at two universities and the two-sample t-test with a 95% confidence interval analysis, this study demonstrated that students who had participated in any engineering-focused extra-/co-curricular activity had a higher mean in each survey item. This shows that engineering students' engagement in engineering extra- and co-curricular activities enhance confidence and reinforcing academic and professional skills by strengthening the knowledge they gain through engineering coursework.

Introduction

Engineering education research is richly populated with studies on the learning, activities, and teaching methods that occur within the classroom. For many students, though, the quality of learning is defined by a combination of experiences that occur both inside and outside of the classroom [3]. Engineering students have a wide array of extra-/co-curricular options available to them that help them grow professionally and reinforce the knowledge they gain through engineering coursework. Some examples include interning for engineering companies, competing in engineering-related challenges through competition teams, designing devices to serve a person's or community's needs through service-learning opportunities, and undergraduate research to solve an engineering problem.

The goal of this research is to examine the impact of participation in engineering-related extra-/co-curricular activities on the development of engineering students. A deeper understanding of the benefits offered by non-traditional learning environments such as extra-/co-curricular activities will benefit students, educators, and administrators; as an example, the option for students to incorporate extra-/co-curricular experiences such as competition teams into their education allows them to take more ownership over their education, thereby encouraging them to become more motivated and self-regulated learners. Although the ultimate goal is to learn about how extra-/co-curricular activities impact a student's academic achievement, professional formation, and self-efficacy, the content of this paper is limited to examining the impact of such activities on academic achievement and self-efficacy only.

Background

As the prevalence of out-of-classroom learning experiences grows, education scholars seek to understand the details of extra-/co-curricular involvement more deeply. Consequently, certain aspects of extra-/co-curricular involvement – such as motivation for participation and the benefits of participation – have been explored for certain activities but still are not well understood. For example, evidence from a variety of sources suggests that involvement in certain out-of-classroom activities leads to stronger intellectual development as measured by GPA, analytical skills, and critical thinking skills. However, these studies focus on a broad range of activities including studying [4], participation in living-learning communities [5, 3], and service activities such as volunteering, community outreach, and service learning [6]. Other benefits of extra-/co-curricular participation include development of professional skills (communication, leadership, and time management, for example) and factors related to personal development, such as self-confidence and identity. Students' motivation for participation in extra-/co-curricular programs includes personal alignment with the interests and goals of the organization, the chance to create a positive impact, and advice from family or mentors. A complete review of outcomes and motivations associated with extra-/co-curricular participation is provided in [7].

The use of the term "extra-curricular" and "co-curricular" varies in literature, and the information that is known about the influence of extra-/co-curricular participation tends to focus on wide-ranging activities. Here, we are primarily interested in the impact of a collection of specifically engineering-focused activities that appear likely to enhance academic and professional skills: competition teams, undergraduate research, and service-learning projects. Because the National Survey of Student Engagement identifies undergraduate research and service learning as high-impact practices, the literature is somewhat more populated with information about these than about competition teams [8]. However, engineering programs have also begun to view competition teams with increased value, recognizing their potential to help students develop crucial professional and academic skills such as networking and design. It is becoming increasingly common to treat extra-curricular competition teams as curricular, combining them with capstone courses so that students are encouraged to take a more rigorous approach to their design while gaining course credit for their work [9]. As competition teams gain popularity, some researchers are seeking to understand the impact of including informal learning experiences similar to competition teams on a student's academic and professional development. For example, Bland et al. performed a qualitative study examining students' experiences developing professional skills through participation in an engineering competition team [10]. They conducted a series of interviews with students on the team in which they learned that with respect to professional skills, students most frequently discussed their professional and ethical responsibility as engineers but also often mentioned the need for self-management (i.e. the skills needed to maintain participation on the team while also completing their studies) and task management (e.g. setting goals to complete a larger task).

Similarly, Kusano and Johri conducted interviews with students working in a manufacturing lab and supplemented these interviews with naturalistic observations [11]. They learned that this informal learning experience provided students with a sense of motivation and confidence that also extended to their schoolwork, and it gave the students a sense of ownership over their work and learning.

Regarding self-efficacy, Bandura argued that people's beliefs regarding their capability to perform an activity dictated motivational levels and course of action [12]. Research at the undergraduate engineering level has focused on exploring undergraduate students' self-efficacy to understand their persistence and academic achievements [2], [13-17]. For example, a quantitative study by Ponton et al. explored the association of self-efficacy and subjective task values with achievement-related behaviors from 163 undergraduate engineering students [17]. This study's regression analysis demonstrated that academic self-efficacy contributed to students' choice, effort, persistence, and degree continuation. In recent years Maramil et al. developed the Engineering Academic Perceived Competence scale to measure and assess student beliefs about their performance and capabilities as engineering students and future professionals [2]. This scale has been used in other research. For example, Robinson's [13] quantitative study explored how undergraduate engineering students' motivation transitions in their first two years of college. They adopted a construct from the Maramil et al. scale to investigate participants' confidence in mastering engineering academic content and academic success. Some of their findings indicate that students' confidence in their academic performance capabilities decreased by their second year, and this was possibly linked to their learning environment and motivational support [13].

Based on this background, our study expects to extend previous research by examining the impact of extra-/co-curricular activities on academic achievement and self-efficacy.

Methodology

Survey Design and Participant Pool

The goal of this research is to determine the impact of participation in engineering extra- and co-curricular activities on students' academic achievement and self-efficacy. For the purposes of this research, engineering extra- and co-curricular activities are limited to the following: competition teams, undergraduate research, and service-learning organizations. Academic achievement and self-efficacy are both measured via an online survey where participants are drawn from two pools of students: (1) junior and senior mechanical engineering students at a large public, research-intensive university, and (2) junior and senior mechanical engineering students at a small private, teaching-focused university. Students in their junior/senior year are chosen so that all participating students have had some opportunity for exposure to engineering-focused extra-/co-curricular programs during college. A breakdown of participants' demographic information is presented in Table 1.

Table 1

Participant Demographics (N=58)

Race	**Black or African American**	**White**	**Asian**	**More than one race**	**No response**
	2	40	8	1	7
Ethnicity	**Hispanic, Latino, or Spanish origin**	**Middle Eastern or North African**	**No response**		
	3	2	53		
Sex	**Male**	**Female**	**No response**		
	40	13	5		
Gender Identity	**Cisgender**	**Transgender**	**No response**		
	2	4	52		
Institution	**Teaching-focused University**	**Research-intensive University**			
	16	42			

The survey is divided into two parts. The first portion, intended to measure self-efficacy, consists of Likert scale questions from the assessment instrument developed and presented in [2] which separates self-efficacy measurements into two domains: general engineering self-efficacy, which relates to mastery of engineering coursework, and engineering skills self-efficacy, which relates to mastery of engineering skills such as design, working with/building machines, and solving computational problems. In Maramil et al., all measured self-efficacy variables correlated significantly with intent to persist in engineering [2]. The goal of this work is to determine whether higher self-efficacy scores also correlate to participation in engineering-focused extra-/co-curricular activities.

The second portion of the survey, intended to measure academic achievement, includes a subset of multiple-choice questions drawn from the Statics Concept Inventory [1]. We expect that the authentic, hands-on experience offered by extra-/co-curricular activities such as competition teams and service-learning projects will improve learning outcomes associated with physical reasoning that can then be applied to solving real engineering problems. The Statics Concept Inventory is chosen as the medium for assessing academic achievement for several reasons. First, statics is a fundamental course for mechanical engineering students and has been shown to be an effective predictor of how students will perform in subsequent classes such as dynamics [16] and capstone design [1]. Second, although it is possible to measure academic achievement through GPA, grades may not be the best indicator of academic performance, as the validity of grades has been called into question [19]. Finally, it was necessary to settle on an approach for which it would be possible to facilitate a more direct comparison between the two universities. Choosing an approach such as final exams felt impractical since course content can differ drastically at different institutions. Since statics is such a fundamental course for mechanical engineers, it is reasonable to assume that students from both institutions are familiar with the content and should feel comfortable answering the questions. The use of the statics concept inventory also explains why the current study is limited to mechanical engineering students – it is difficult to find a method of comparison that scales across multiple institutions and multiple majors. Additionally, since statics is a course that mechanical engineering students typically take within their first or second year, any advantage that survey participants may have gained from just having taken the course will likely be negated by focusing on juniors and seniors, making it more likely that their performance on the statics concept inventory is due to other factors such as participation in competition teams.

The Statics Concept Inventory contains a total of 27 questions with 9 categories of problem styles, each containing 3 problems within a category. Each category targets a particular skill that students proficient in statics should be able to exhibit. We anticipated that 27 questions would be too burdensome for most survey participants to complete and therefore reduced the number of questions to 9, where 3 categories were chosen, and all 3 questions in each category were used. Target topics included the following: (1) static equivalence, which contains questions regarding static equivalence between forces, couples, and combinations, (2) rollers, which contains questions regarding the direction of a force between a roller and a rolled surface, and (3) negligible friction, which contains questions regarding the direction of force between frictionless bodies in point contact.

In addition to a section of self-efficacy questions and a section of statics questions, participants were asked to self-report some additional information. They were asked first to identify all of the categories of activities in which they participate, where options include: (1) service-learning organizations, (2) competition teams, (3) undergraduate research, and (4) a type of activity not listed. In a separate question, they were asked to expand on their answer by listing the specific activities and organizations in which they are involved. Participants were also asked to report their GPA and demographic information [2]. The order of the survey was as follows: (1) self-efficacy questions, (2) extra-/co-curricular activity information, GPA, and demographics, and (3) statics concept inventory questions. This is an important detail because some survey participants chose to stop when they got to the concept inventory questions, a behavior we somewhat anticipated and prepared for by requesting extra-/co-curricular and demographic information prior to these questions. Although we can only speculate about the reasons they may have chosen to stop, one likely possibility is that the statics questions were perceived as harder. In total, 58 participants (combined from both schools) completed the self-efficacy questions, and 34 participants completed the statics concept inventory questions.

Challenges and limitations

The original timeline for conducting this research coincided with the height of the COVID-19 pandemic. Because students were largely unable to participate at all in the extra-/co-curricular programs of interest during this time, it seemed unwise to attempt data collection when students were not affected by their participation in these activities. We consequently delayed our data collection until the 2021-2022 school year, when students were participating in these programs more regularly. However, it is still likely that COVID-19 affected students' engagement in these programs and the results we obtained. Regarding the data we collected, the academic achievement portion of the survey, in particular, may have been affected by the lapse in participation during 2020 and 2021. For example, we used the statics concept inventory because we expected that statics questions would capture the potential for greater physical reasoning skills that may arise from activities such as competition teams. Since students had not been participating in these programs for over a year when the data was collected, it is possible that the physical reasoning benefits they may have gained under different circumstances were not adequately captured.

It is also possible that there is a better tool than the statics concept inventory to capture students' academic achievement, particularly since a sizable number of study participants were unwilling to complete the statics questions. Other metrics such as GPA and final exam performance are imperfect for the reasons listed in the Methodology section, among others. For example, if we use final exam performance on a statics exam to measure academic achievement, it is likely that the scores students obtain are coming primarily from their participation in class rather than their extra-/co-curricular involvement. It is possible that a planned future activity for this study – conducting interviews with students, as explained in the "Future Work" subsection of this paper – may shed some light on how extra-/co-curricular participation impacts their academic achievement.

The sample size is also smaller than we would have preferred, leading in some cases to numbers too small to yield meaningful results (e.g. only four participants were involved in a service learning activity, so the results for this type of activity should not be examined in isolation). A part of this small sample size is also likely due to COVID-19. At the time that data was collected, students were still mostly engaging in their classes and schoolwork online and adding on another online task may have seemed unappealing at the time. It is likely that collecting more data in the future using a similar survey would alleviate many of the concerns that arose due to COVID-19.

Lastly, our study focus was investigating students who participated in extra-/co-curricular activities. Therefore, we did not explore other students' activities that could be sources of self-efficacy and impact students' performance. Not choosing a specific extra/-co-curricular activity and exploring that in depth enabled us to identify activities students considered as fitting in this category during our pilot phases. However, future work could choose specific activities and explore them in depth in an effort to separate confounding factors or experiences.

Analysis and Results

A two-sample t-test with a 95% confidence interval was performed to compare responses provided by two groups of participants. Table 2 presents results for the self-efficacy portion of the survey, where "Group A" refers to survey participants who had participated in any engineering-focused extra-/co-curricular activity, and "Group B" refers to survey participants who had not. Survey participants responded to the self-efficacy prompts shown in Table 2 on a scale from 1 to 6, where 1 represents "completely uncertain" and 6 represents "completely certain." Table 2 provides the mean, standard deviation, and *p*-value for each individual prompt as well as the cumulative self-efficacy score, where a single participant's cumulative score is represented by the average of all of their responses. Group A was always higher though statistical significance varied.

Table 2. Self-Efficacy Results

	Group A (*n = 28*)		Group B (*n = 30*)		*p*-value
	Mean	SD	Mean	SD	
General Skills					
I can master the content in the engineering-related courses I am taking this semester.	4.64	0.95	4.47	0.63	0.4059
I can master the content in even the most challenging engineering course.	4.18	0.82	3.57	0.94	0.0106
I can do a good job on almost all my engineering coursework.	4.96	0.92	4.60	1.13	0.1865
I can learn the content taught in my engineering-related courses.	5.12	0.83	4.90	0.92	0.1798
I can earn a good grade in my engineering-related courses.	4.64	0.99	4.30	1.18	0.2370
Experimental Skills					
I can perform experiments independently.	4.46	0.97	4.27	1.08	0.4662
I can analyze data resulting from experiments.	4.82	1.02	4.60	1.10	0.4314
I can orally communicate the results of experiments.	5.04	0.79	4.77	1.14	0.3030
I can communicate the results of experiments in written form.	4.75	0.97	4.60	1.10	0.5849
Hands-On Skills					
I can work with machines.	5.29	0.81	4.53	1.14	0.0056
Given the necessary tools and resources, I can build machines.	5.07	1.09	3.80	1.30	0.0002
I can assemble things.	5.50	0.79	4.73	1.28	0.0089
I can disassemble things.	5.57	0.63	4.90	1.32	0.018
Design Skills					
In the world around me, I can identify a design need.	4.71	1.18	4.60	1.04	0.6965
I can develop design solutions.	5.14	0.59	4.80	1.03	0.1293
I can evaluate a design.	4.86	1.04	4.53	1.01	0.2346
I can recognize changes needed for a design solution to work.	5.11	0.79	4.53	1.14	0.0304
Cumulative Score	4.94	0.45	4.5	0.69	0.0061

Table 3 presents the results of the Statics Concept Inventory portion of the survey, where "Group A" and "Group B" are defined as they were in Table 2. Note that the number of participants in these two groups is different than in the self-efficacy portion of the survey due to the reduced number of participants who chose to complete the statics questions. Each concept inventory question is multiple choice with a single correct answer, where a correct answer was assigned a score of 1, and an incorrect answer was assigned a score of 0. The cumulative score is presented in two ways – one (unweighted) where each answer was assigned 1 point each, and the cumulative score is the sum of points earned on each question (so, with 9 questions, the maximum score is 9). The second approach (weighted) gives each question a weight based on the number of points it is worth in the concept inventory, and the cumulative score is the sum of the points earned. The last column of Table 3 provides the point values for each question in the concept inventory. In the weighted calculation, the maximum score is 31. The cumulative scores -unweighted and weighted- p-values indicated non-statistically significance.

Table 3. Statics Concept Inventory Results

	Group A (*n = 19*)		Group B (*n = 15*)		*p-value*	Weight
	Mean	SD	Mean	SD		
Static Equivalence						
Question 1	0.21	0.42	0.07	0.26	0.25	5
Question 2	0.42	0.51	0.33	0.49	0.61	2
Question 3	0.37	0.50	0.27	0.46	0.54	4
Rollers						
Question 1	0.63	0.50	0.60	0.51	0.86	3
Question 2	0.74	0.45	0.80	0.41	0.68	3
Question 3	0.53	0.51	0.60	0.51	0.68	3
Negligible Friction						
Question 1	0.32	0.48	0.07	0.26	0.08	4
Question 2	0.16	0.37	0.00	0.00	0.11	4
Question 3	0.26	0.45	0.27	0.46	0.98	3
Cumulative (Unweighted)	3.63	1.89	3.0	1.46	0.30	
Cumulative (Weighted	11.74	6.30	9.13	4.88	0.20	

Discussion and Conclusion

This study examined the impact of participation in engineering extra- and co-curricular activities on students' academic achievement and self-efficacy. The two-sample t-test with a 95% confidence interval demonstrated that students who had participated in any engineering-focused extra-/co-curricular activity had a higher mean in each of the items from the self-efficacy survey and the cumulative standard deviation is lower for these groups as well (see tables 1 and 2)
The results are consistent with previous research [2], [7], [10-11] about the impact of extra-/co-curricular activities on students' academic achievements and their confidence in their capability to perform an activity -self-efficacy-. Suggesting that engineering students' engagement in engineering extra-/co-curricular activities enhances academic skills reinforcing and strengthening the knowledge they gain through engineering coursework. Additionally, engagement in these types of activities also enhances engineering skills critical for their professional formation, as detailed in Table 2.

Based on these results, we can reinforce the importance of providing engineering students with the guidance necessary to choose extra-/co-curricular activities to enhance their learning and strengthen engineering skills while improving their confidence in their academic and professional capabilities.

Understanding the specific benefits that engineering-focused extra-/co-curricular programs offer will allow those in career and academic advising positions to provide targeted advice to students on how to personalize their pathways through college engineering programs, focusing on topics that are interesting to them and finding avenues for strengthening existing skills or learning new ones. The extra-/co-curricular setting also gives students a relaxed, enjoyable opportunity to practice engineering skills in an authentic environment, leading to improved confidence and a stronger personal investment in the extra-/co-curricular work.

Future work

The results presented in this paper represent the first of two planned phases of data collection for this project. The second phase includes two activities – a series of focus groups designed to measure students' professional development and a series of interviews intended to add a qualitative layer of explanation for the results obtained in previous activities. The focus group sessions will implement the Engineering Professional Skills Assessment (EPSA) to measure the development of professional skills such as communication and teamwork. As part of the assessment, groups of students – ideally from the pool of survey participants – are presented with a scenario.

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References

[1] P. Steif, and J. Dantzler, (2005). "A statics concept inventory: development and psychometric analysis" *Journal of Engineering Education, 94*(4), 363-371.
[2] N, Maramil, E. Usher, C. Li, "Measuring undergraduate students' engineering self-efficacy: a validation study". *Journal of Engineering Education, 105*(2), 366-395.
[3] P. Terenzini., E. Pascarella; and G. Blimling (1996). "Students' out-of-class experiences and their influence on learning and cognitive development: A literature review". *Journal of College Student Development, 37*(2), 149-162.
[4] S. Brint; A. Cantwell; and R. Hanneman (2007). "The two cultures of undergraduate academic engagement". *Research in Higher Education, 49*(5), 383-402.
[5] K. Inkelas; W. Zeller; R. Murph; M. Hummel (2006). "Learning moves home". *About Campus, 10*(6), 10-16.
[6] R. Chesbrough (2009). "College students and service: A mixed methods exploration of motivations, choices, and learning outcomes" The University of Nebraska, Lincoln.

[7] D. Simmon; E. Creamer; R Yu (2017).” Involvement in out-of-class activities: A mixed research synthesis examining outcomes with a focus on engineering students.” *Journal of STEM Education, 18*(2), 10-16

[8] National Survey of Student Engagement: The College Student Report: NSSE Technical and Norms Report.

[9] S. Khorbotly and K. Al-Olimat (2010). “Engineering student-design competition teams: Capstone or extracurricular? “*2010 IEEE Frontiers in Education Conference,* October 27-30, 2010, Washington, DC, USA.

[10] L. Bland; S Kusano; A Johri (2016). “Engineering Competitions as Pathways to Development of Professional Engineering Skills.” ASEE 123rd Annual Conference & Expositions, New Orleans, LA. June 26-29, 2016.

[11] S. Kusano and A. Johri (2014). “Student Autonomy: Implications of Design-Based Informal Learning Experiences in Engineering.” 121st ASEE Annual Conference & Exposition, Indianapolis, IN, June 15-18, 2014.

[12] A. Bandura (1997). “Self-efficacy: The exercise of control”. New York, NY: Freeman.

[13] K. Robinson., Y. Lee., E Bovee., T. Perez., S. Walton., D. Briedis., & L. Linnenbrink-Garcia (2019). “Motivation in transition: Development and roles of expectancy, task values, and costs in early college engineering”. *Journal of Educational Psychology*, *111*(6), 1081.

[14] E. Usher; N Mamaril; L. Caihong; D. Ros; and M. Kennedy. "Sources of self-efficacy in undergraduate engineering." In *2015 ASEE Annual Conference & Exposition*, pp. 26-1386. 2015.

[15] C. Burger, J. Raelin; R. Reisberg; M Bailey & D. Whitman (2010). “Self-efficacy in female and male undergraduate engineering students: Comparisons among four institutions”. In *2010 ASEE Southeast Section Conference* (Vol. 9).

[16] N. Fang and J. Lu “A decision tree approach to predictive modeling of student performance in engineering dynamics”, *International Journal of Engineering Education*, **26**(1), 2010, 87-

[17] M. Ponton; J. Edmister; L. Ukeiley; and J. Seiner (2001). “Understanding the role of self-efficacy in engineering education”. *Journal of Engineering Education*, *90*(2), 247-251.

[18] F. Wu; W. Fan; C. Arbona; and D. de la Rosa-Pohl (2020) “Self-efficacy and subjective task values in relation to choose, effort, persistence, and continuation in engineering: an Expectancy-value theory perspective”, European Journal of Engineering Education, 45:1, 151-163, DOI: 10.1080/03043797.2019.1659231

[19] T. York; C. Gibson & S. Rankin (2015). “Defining and Measuring Academic Success” *Practical Assessment, Research & Evaluation*, *20*.