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Which undergraduate student activities develop specific career and leadership skills for Black vs non-Black engineering graduates

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Introduction

Positionality Statement

I am a Black woman, born and raised in the Caribbean, who immigrated to Canada to pursue an undergraduate degree in chemical engineering. During my undergraduate degree I was involved in extra-curricular and co-curricular activities that I feel have helped me develop key career and leadership skills. Upon completion of my undergraduate degree, I have now gone on to apply the skills I have developed throughout my career, including completing a master's program in engineering, working in a more 'traditional' engineering field within oil & gas in Alberta, becoming a wife and mother, gaining my P.Eng license and PMP, starting a non-profit organization and various other social enterprises, pivoting to work in higher education and now coming back to school to pursue a PhD.

Background

In recent years, engineering graduates have begun to have many different career options beyond the traditional technical career paths [1]. Engineering has been cited as developing skills and competencies that have been considered in demand for leadership in many different careers [2]. Beyond the technical skills, the engineering undergraduate experience can help to develop transferable skills or 'soft skills'[3], [4], [5]. The engineering undergraduate experience now includes more than just curriculum, but also other aspects such as internships, student clubs, research and other co-curricular workshops and activities. These activities can help develop key leadership and career skills for engineering students, however not all engineering students may be influenced by certain activities in the same way.

It is known that certain demographics are underrepresented in engineering careers and undergraduate programs. Black people, in particular, continue to be underrepresented in engineering fields [6], [7]. Understanding how Black students develop relevant career and leadership skills could help to better understand the representation of Black engineering graduates in engineering careers.

Motivation and Purpose

Based on my own positionality as a Black woman who felt as though certain activities in my undergrad influence my career skills development, I wanted to understand if this was common across other Black engineering graduates, and if that experience differed from our non-Black counterparts.

This research aims to answer the following research questions: (1) Which undergraduate student activities are most likely to develop leadership and career skills for engineering graduates? (2)

Do the activities that develop leadership and career skills differ for Black vs. non-Black engineering graduates?

Literature Review

Numerous studies have been conducted to attempt to understand the influence of education on skills development and careers. In 2018, the National Academy of Engineering (NAE) released a Consensus Study Report summarizing some of the key findings from various studies that have been conducted in this space [2]. The report noted that in addition to technical skills, the incorporation of non-technical skills or "professional skills" such as communication, social/interpersonal skills, lifelong learning, creativity and innovation, business acumen and societal impact have been growing in demand from industry.

This report leveraged Social Cognitive Career Theory (SCCT) as a framework to explain the educational and career pathways of engineering graduates. SCCT has identified different factors that can lead to career choices, including person inputs (e.g. gender, race/ethnicity, personality traits, etc.) and background/contextual affordances (e.g. home/school environment, socioeconomic status, etc.), which can influence learning experiences, and in turn influence self-efficacy and outcome expectations [8]. This self-efficacy can be defined as the confidence that one can successfully engage in a particular task or leverage a particular skill. SCCT provides a framing for how person inputs might influence learning and can in turn influence skills development. However, even though NAE acknowledges the influence of person inputs or individual demographics, the report did not have specific information on Black engineering students, and only references URM (Underrepresented Racial Minority).

Another study that leveraged the SCCT framework is PEARS (Pathways of Engineering Alumni Research Survey) [9], as well as APPLES (Academic Pathways of People Learning Engineering Survey) [10]. The APPLES study showed that confidence in important career skills was statistically significant between URM students and non-URM students, with URM students reporting higher confidence in senior year then their non-URM counterparts. Chen et al. and Brunhaver showed in the PEARS study how specific learning experiences influenced skills development and career paths, however the PEARS study included limited discussions on race and noted that "Black/African American and Hispanic/Latinx graduates were underrepresented in the overall PEARS population"[9], [11], [12].

With limited work focused specifically on the Black students, Hollomon et. al. and Boyd-Sinkler et. al. conducted reviews to better understand what the literature says about the Black student experience in engineering [7], [13]. Both studies noted the influence of engagement with others, such as peers, faculty and family on persistence in engineering, skills development and engineering identity. Another study led by Blosser, noted the importance of mentorship for Black students in developing persistence and important skills, particularly for Black women [14]. Multiple studies also noted the influence of student clubs, and in particular the National Society of Black Engineers (NSBE), in the success for Black students in engineering [15], [16], [17], [18], [19].

Though these studies provide some insights into the types of student activities and experiences that may develop career and leadership skills for Black engineering students, no work has been done to specifically explore the differences in Black vs non-Black students. Studies have either focused on the Black experience in isolation without comparing to non-Black counterparts, or have had Black students lumped into a catch-all of URM. Holloman et. al. specifically notes in their literature review that "there is a need for larger and more intentional samples" focused on Black engineering students as they relate to the wider population of engineering students. By creating a more intentional sample, we can better understand how Black student experiences and skill development may differ from non-Black students, to better support Black engineering students in their future careers.

Research Design & Method

Conceptual Framework

This research used Social Cognitive Career Theory (SCCT) [8] as the conceptual framework. SCCT posits that learning experiences are influenced by person inputs and contextual factors, these learning experiences can influence self efficacy in specific skills and competencies, which can in turn influence career goals and career choices.

Methodology

Using SCCT as a framework, a survey was designed based on PEARS (Pathways of Engineering Alumni Research Survey) [9]. The survey design was broken down into 4 sections:

1. Undergraduate Information - this section asked the respondent information about their undergraduate education, which institution they attended, when they graduated and which engineering discipline they studied.
2. Undergraduate Influence on Career Path - this section asked respondents about the activities they participated in during their undergraduate degree, which skills they developed and which skills and activities were most influential to their careers
3. Career Path - this section asked respondents about their career path post graduation and asked respondents to provide a link to their LinkedIn profile, if they had one.
4. Demographics - this section asked respondents to identify their gender, race, ethnicity and other demographics

The full survey instrument can be found in Appendix A. As a part of the survey, engineering graduates were asked to identify which skills/competencies they developed through a list of undergraduate student activities. This question was phrased as 'Which competencies do you feel you developed during your undergraduate experiences? (select all that apply)'.

The skills to choose from included:

- Technical skills (Engineering knowledge base, Problem solving, Analytic thinking, Investigation, Design, Use of engineering tools)
- Interpersonal (Teamwork, Conflict resolution, Supporting/motivating others)
- Communication (visual, verbal, written)
- Leadership (Project management, Deciding what problem to solve, Negotiation, Driving change)
- Business / Financial Acumen
- Societal impact (Environmental impact, Equity, Ethics)
- Lifelong learning
- Innovation (agility, creativity)
- Self-Confidence (Self-Esteem, Sense of Belonging)
- Independence (Self-autonomy, Self-sufficiency)

Table 1 below shows the options for undergraduate student activities.

Table 1: Options for Undergraduate Activities and Corresponding Short-form for Analysis

Response	Short-form
Conduct research with a faculty member	Research
Work in an engineering environment as an intern/co-op	Co-op Intern
Participate in a work-study program (non-engineering role or non-research)	Work-Study
Work on technical team-based projects as part of a course	Technical Team Project
Participate in activities hosted by engineering-related student clubs, groups, or community service	Eng Club
Serve as a leader in an engineering student organization	Eng Leader
Participate in activities by student clubs, groups, or community service outside of engineering	Non-Eng Club
Serve as a leader in a non-engineering student organization	Non-Eng Leader

Participate in a study abroad program	Study Abroad
Participate in an incubator or entrepreneurship program	Entrepreneurship
Utilize academic/career advising services	Academic/Career
Participate in a formal mentoring program	Mentor

The survey also asked respondents to indicate if they were willing to participate in a follow-up interview to further describe their undergraduate student experience. A subset of the survey respondents were selected based on race and those who identified as Black. Of the Black respondents who were willing to be interviewed, the interviewees were selected based on participants who had varied careers and participated in different undergraduate student activities. The interviews helped to bring more light on how the undergraduate student activities may have developed specific career and leadership skills.

Results & Discussion

Findings

The survey was distributed to engineering graduates from various institutions across Canada who had completed their degrees at least 5 years prior. 289 participants completed the survey, and of those 115 identified as Black and 174 identified as other 'non-Black' racial groups, the majority of which were White. Survey results were analyzed for the entire dataset and also broken out into 'Black' and 'Non-Black'. Of the Black respondents, 17 were subsequently interviewed.

Communication Skills

Communication skills was noted as one of the more important skills across all career paths, so understanding the activities that develop these skills is important. Figure 1 below shows which activities were noted by respondents to develop communication skills. The technical team projects were most commonly cited as developing communication skills (68%), followed by co-op/internships (56%), then by curriculum (50%).

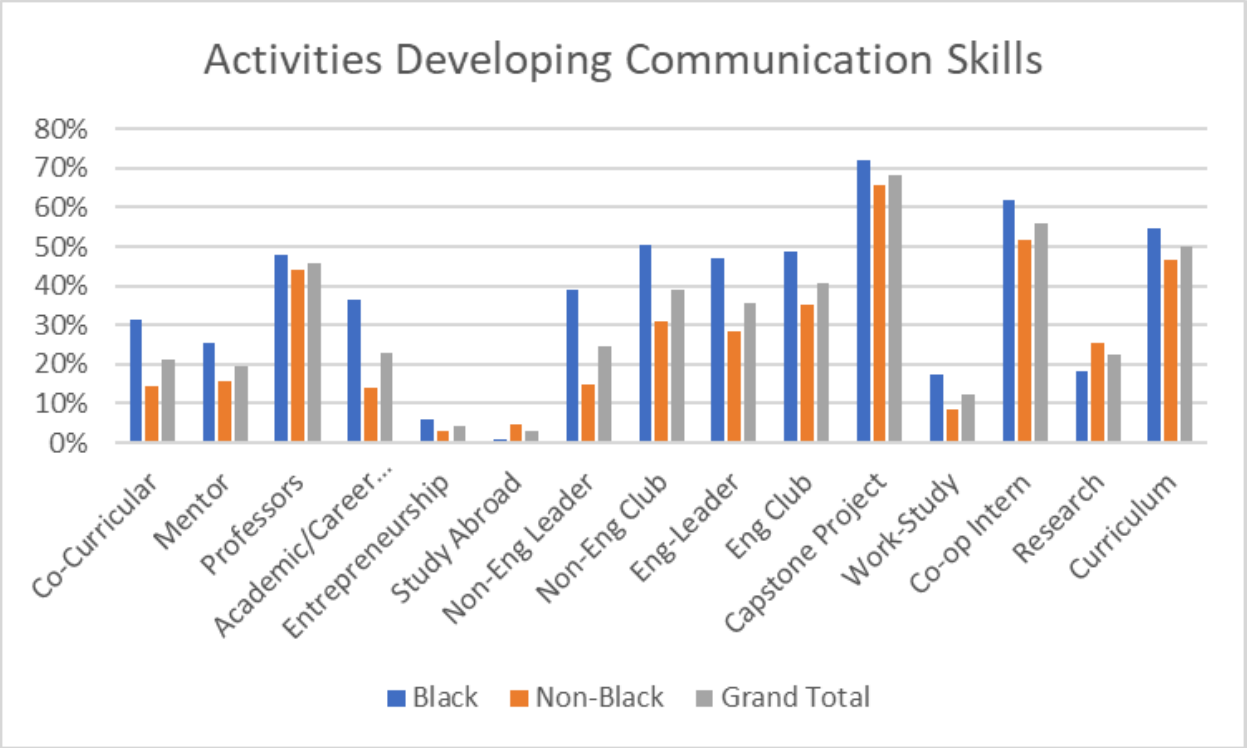

Figure 1. Activities developing Communication Skills

When comparing Black versus. Non-Black, there was a statistically significant difference in the types of activities that develop communication skills ($\chi 2$ (df=14, N=1197) = 37.891, p<.05). Black graduates were significantly more likely to report developing communication skills through student clubs as compared to non-Black graduates, particularly leadership in student clubs. (For example, leadership in engineering clubs was 47% of Black graduates versus 28% of Non-Black graduates, and leadership in non-engineering clubs was 39% of Black graduates versus 15% of Non-Black graduates). Communication skills were noted as most important in every career path, therefore institutions should take note of this being an key aspect of the student experience for Black engineering students. The quotes below illustrate how Black engineering graduates cite student clubs as developing communication skills.

> "I was the community liaison for the Black Students Association, so lots of comms work both to membership and to the broader community and used to write like what I think now would be considered a like almost like a blog posts or a newsletter. So really shaped some of my communication skills in that time."

> "[Skills] were developed through, like, my other extracurriculars that have been a big part of the work that I do now, which then is like, definitely communication skills, definitely intercultural communications or intercultural relationship management."

Interpersonal Skills

Interpersonal skills were also noted as important across all of the different career paths. Technical team projects were most commonly cited as developing interpersonal skills (67%), followed by co-op/internships (53%), as shown in Figure 2. The quotes below help to illustrate how technical team projects fostered teamwork to develop interpersonal skills.

> "The way the teams worked was that each person on the team had a different specialty. So like one person is doing the programming, another person was doing, like, the mechanical aspects, and another person was doing the, like, electrical components.

You form relationships with the people that you might have to work on projects on, especially as I get to those later years, like year three, year four, we have to do like capstone projects and things like that."

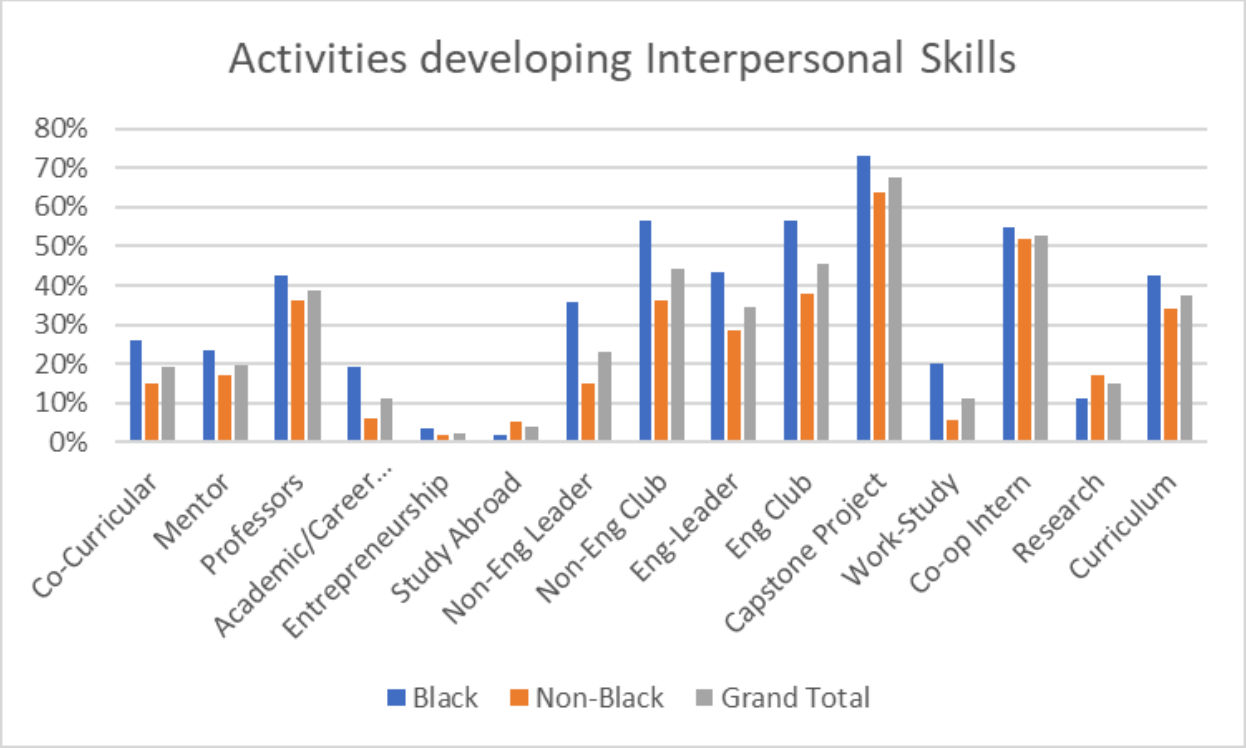

Figure 2. Activities Developing Interpersonal Skills

When comparing Black versus Non-Black students, there was a statistically significant difference in the types of activities that develop interpersonal skills ($\chi 2$ (df=14, N=1234) = 32.285, $p<.05$). Similar to communication skills, Black graduates were significantly more likely

to report developing interpersonal skills through student clubs as compared to non-Black graduates (For example, participation in engineering clubs was 57% of Black graduates vs. 38% of Non-Black graduates, and participation in non-engineering clubs was 57% of Black graduates vs. 36% of Non-Black graduates). The quotes below illustrates the impact of non-engineering clubs on interpersonal skills development for Black engineering graduates.

> "I think I was looking for somewhere to do that because engineering wasn't giving that to me. So certainly, you know, communities, strategic, relationship development, all of that would have come from somewhere else. So I think that was definitely a space where I was able to cultivate those those skills."

> "I would have played intramural basketball, I played like flight football, you know, there's those types of things as well. So intramurals give you another network of people that allow you to stay connected, stay plugged in."

> "I actually do think, like, even just that relationship between like the Caribbean students organization, the Black students organization and the African students organization meant there was this like, you know, constant negotiation of blackness and culture and or ethnicity, sensitivity to it."

Leadership Skills

Leadership was also shown to be important across multiple career paths, and especially for Entrepreneurs. The technical team projects were most commonly cited as developing leadership skills (57%), followed by leadership in engineering clubs (36%), see Figure 3.

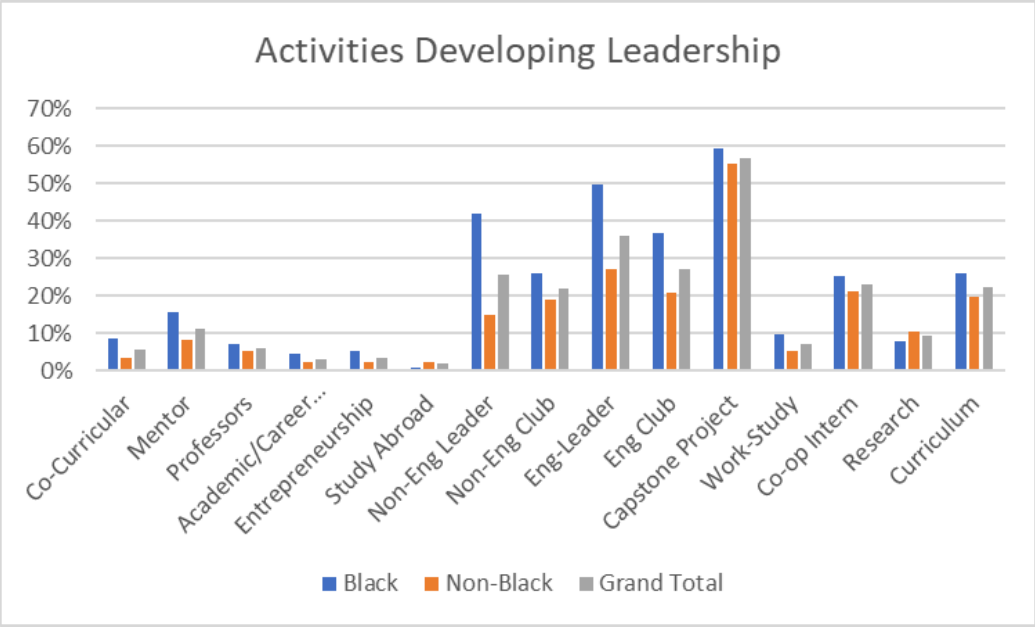

Figure 3. Activities Developing Leadership Skills

When comparing Black versus Non-Black students, there wasn't a statistically significant difference across all types of activities that develop leadership skills, though Black graduates were significantly more likely to report developing leadership skills through non-engineering student clubs as compared to non-Black graduates (42% of Black graduates vs. 15% of Non-Black graduates) ($\chi 2$ (df=1, N=289) = 26.1, $p<.05$). The quotes below exemplify how student clubs helped to develop leadership skills for Black engineering graduates.

> "I was part of the Nigerian Students Association at the school, and that's a part that became the vice president… In terms of leadership skills, that VP role did help."

> "So I was president that year. And that was again, that was a good experience running a team."

> "I was actually the leader of all the Canadian chapters of NSBE. And then eventually I was actually leading all the international chapters of NSBE."

> "So, active involvement in terms of leadership sort of roles, it was student union, NSBE and industrial engineering club. And again, I sort of chose those strategically because they were areas that felt like, I mean, yeah, felt like I, like still somewhat connected to engineering identity"

Self Confidence

Self Confidence was another skill identified as important across a variety of career paths. Co-op/internships were most commonly cited as developing self-confidence (43%), followed by technical team projects (37%), as shown in Figure 4. The quote below is from a Black engineering graduate commenting on how an internship improved their self confidence.

> "I realized I was actually, I was good at it. And I could make a decent living from being an engineer. So I think it was a very pivotal experience for me because I left that internship feeling a lot more confidence in, this is what I want to do. This is what I know I can do and do well."

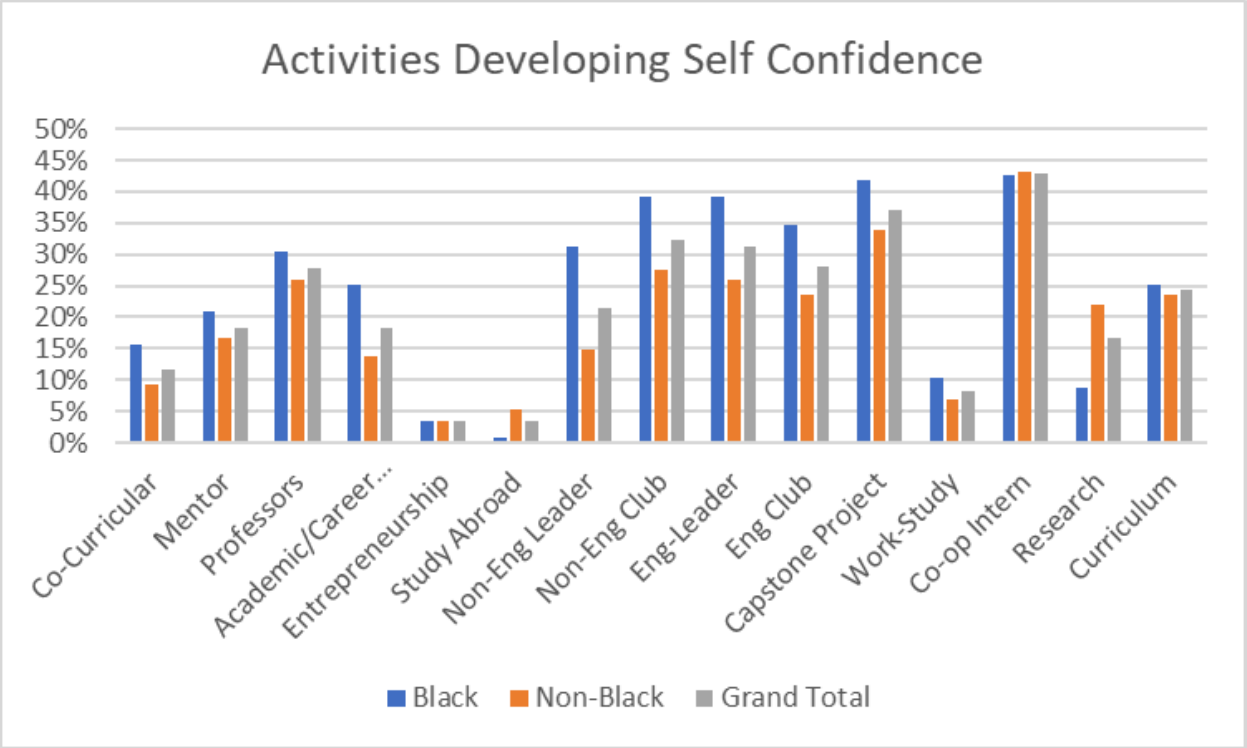

Figure 4. Activities Developing Self Confidence

When comparing Black versus Non-Black students, there was a statistically significant difference in the types of activities that develop self confidence ($\chi 2$ (df=14, N=939) = 27.62, p<.05). In particular, Black graduates were once again significantly more likely to report developing self confidence through student clubs as compared to non-Black graduates (For example, leadership in engineering clubs was 39% of Black graduates vs. 26% of Non-Black graduates, and leadership in non-engineering clubs was 31% of Black graduates vs. 15% of Non-Black graduates). The quotes below are representative of how Black engineering graduates developed self-confidence through student clubs, especially to find a sense of belonging.

> "[Racism] was just kind of this perpetual cycle, which is part of the reason why there were so many student run, like clubs and organizations and student parties that were kind of run by the black population so there was a place for us to actually go where we didn't need to worry about getting profiled or need to worry about getting harassed."

> "There were a couple of prominent black run clubs on campus. So I got involved with some of those clubs, which was also great in terms of helping me with my transition to post secondary."

Conversely, Black graduates were significantly less likely to report developing self confidence through undergraduate research than non-Black graduates (9% of Black graduates vs. 22% of non-Black graduates). This could be due to lower participation of Black engineering graduates in research, and also potentially due to lack of engagement. The quote below illustrates an experience of a Black engineering graduate in undergraduate research.

> "We're just in this essentially windowless room all day. And then we'll go out for lunch or breaks, but it just seemed rather boring actually."

Independence

Independence was cited as an important skill for a number of career paths as well. Co-op/internships were most commonly cited as developing independence, with 42% of respondents saying that co-op/internship fostered independence, see Figure 5. For example, an internship experience helped to foster independence for this Black engineering graduate.

> "It was just a great 16-month experience… also, yeah, just handling as a young student really still, managing things like, yeah, traveling on the company and the company's expense, driving for work, you know, on your own."

The engineering curriculum was also noted to foster independence with 39% of respondents saying that it developed independence. In particular, the interviewees noted how the engineering curriculum developed perseverance and grit.

> "There were courses where the exams were worth 60% or 70% of your final mark, final exams. So it was a lot of pressure, a lot of stress.. But I knew long term that this is what I wanted to do and I just needed to persevere and push through."

> "Yeah, so it was very, it was a very big, like, lesson.. in like time management and like, yeah, managing stress and just trying my best to just stay afloat."

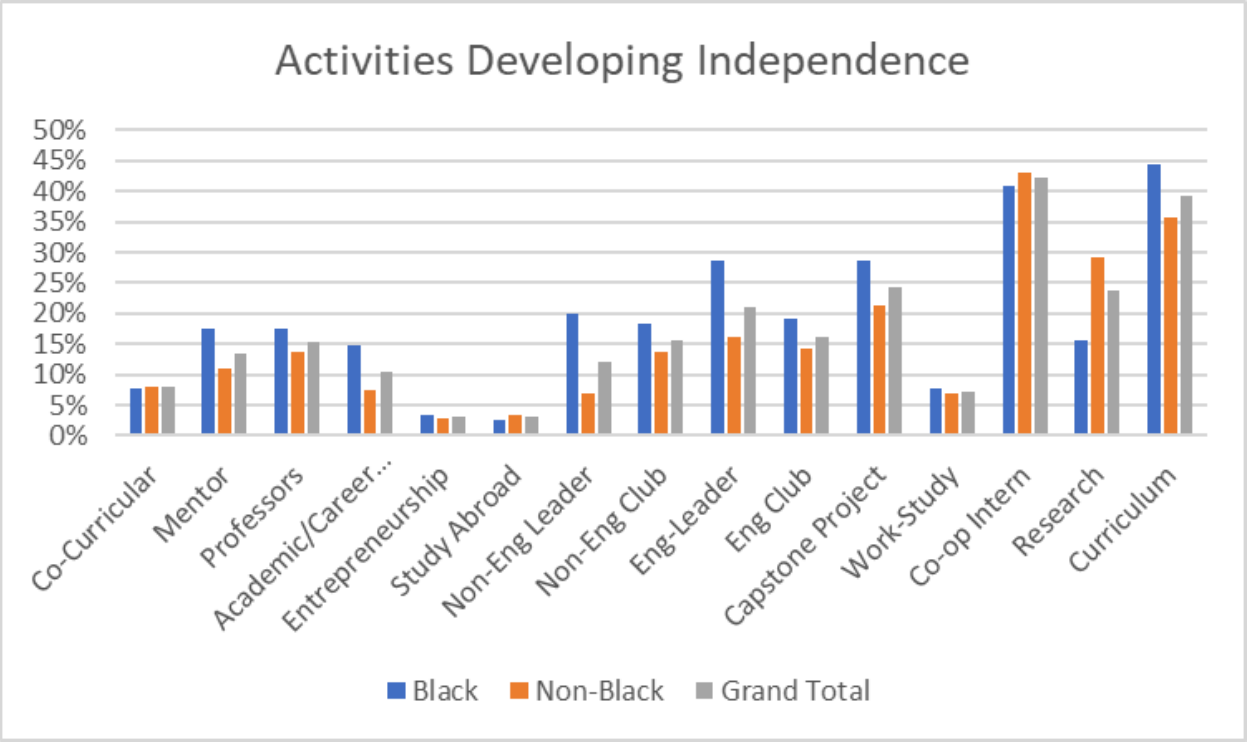

Figure 5. Activities Developing Independence

When comparing Black versus Non-Black students, there wasn't a statistically significant difference in the types of activities that develop independence. However, Black graduates were once again more likely to report developing independence through student clubs as compared to non-Black graduates (For example, leadership in engineering clubs was 29% of Black graduates vs. 16% of Non-Black graduates, and leadership in non-engineering clubs was 20% of Black graduates vs. 7% of Non-Black graduates).

Societal Impact Skills

Societal Impact was least likely to be ranked as important for engineering graduates, however with a prominent aspect of engineering being ethical practice, it is still important to note which activities develop this competency . Engineering Clubs were most commonly cited as developing societal impact skills (25%), followed by non-engineering clubs (15%), as shown in Figure 6.

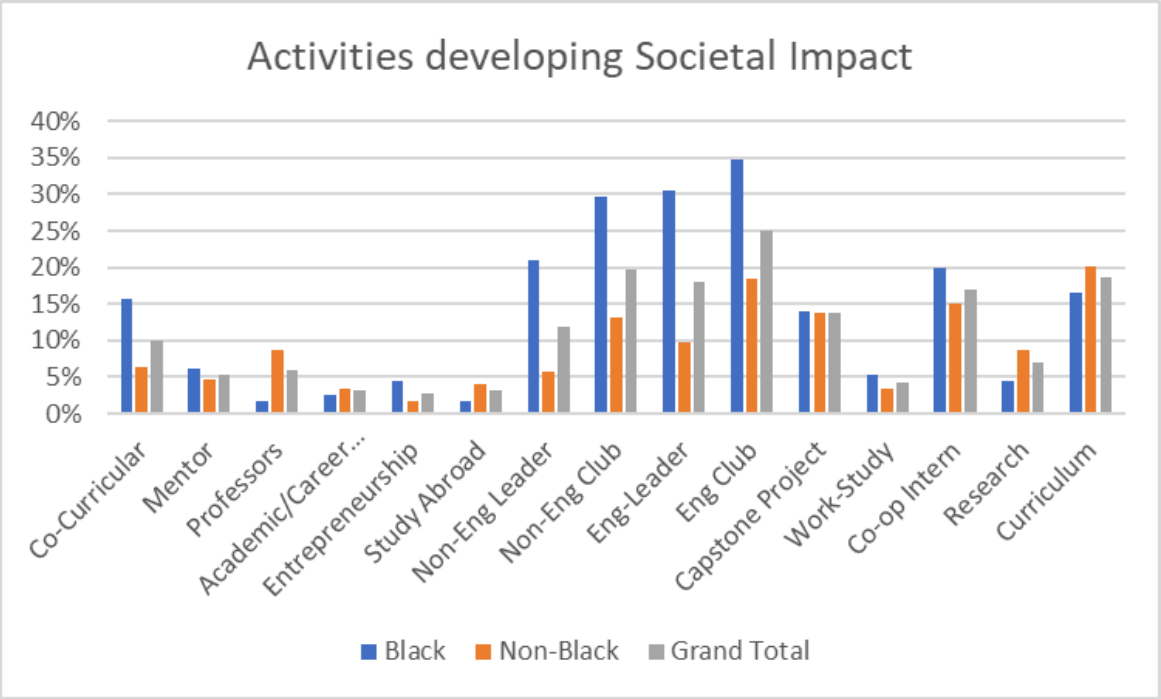

Figure 6. Activities Developing Societal Impact competencies

When comparing Black versus Non-Black students, there was a statistically significant difference in the types of activities that develop societal impact skills ($\chi 2$ (df=14, N=423) = 43.27, p<.05), and though all graduates cited student clubs as developing these skills, Black graduates were more likely to report this (For example, for leadership in engineering clubs, 30% of Black graduates noted it as developing societal skills vs. 9% of Non-Black graduates, and for leadership in non-engineering clubs, 21% of Black graduates noted it as developing societal skills vs. 6% of Non-Black graduates). The quotes below illustrate how participation in a student club fostered the importance of giving back for a Black engineering graduate.

> "But what stood out for me was really that mentoring, I would say coaching kind of bringing others along the pipeline piece, because that was probably the first time that that actually happened, where I felt like I had really influenced someone's future and someone's direction, right? …I think it showed a facet of leadership that's not always talked about, which is sort of seeding the floor to others and also coaching and mentoring and enabling other people to be successful."

> "Through NSBE, I found out about ENGage Summer Camp, and that was a massive total moment for me. ….doing that work to help motivate and encourage other students and Black students to get excited about engineering and science."

Lifelong Learning Skills

Lifelong learning was noted as important in some career paths and less so in others. It was most commonly deemed important for those in Academic career path. The engineering curriculum was most commonly cited as developing lifelong learning skills (36%), see Figure 7. The quote below illustrates how the curriculum can help develop lifelong learning and growth mindset

> "You know, like I failed in, I failed a couple courses in my engineering and still finished. So if I fail some, if some of this fails, I'll still be okay."

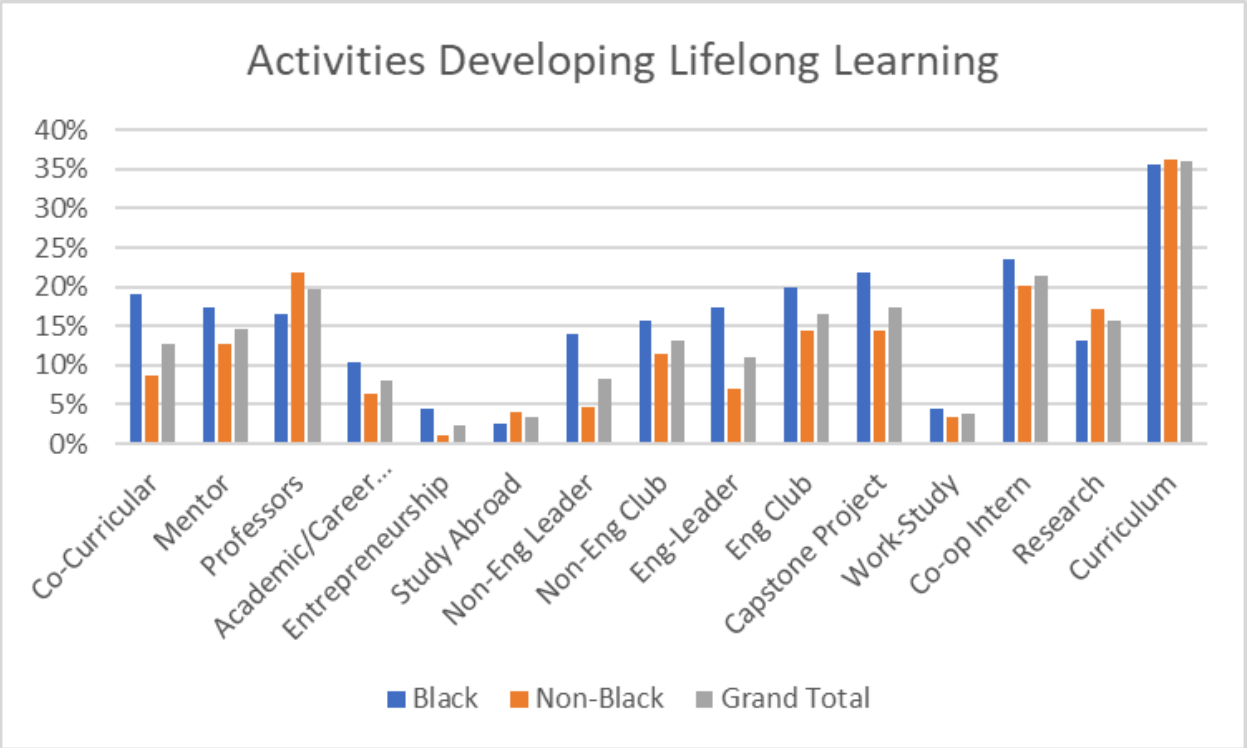

Figure 7. Activities Developing Lifelong Learning Skills

When comparing Black versus Non-Black students, there wasn't a statistically significant difference in the types of activities that develop lifelong learning skills, once again Black graduates were more likely to student clubs in developing these skills (For example, for leadership in engineering clubs, 14% of Black graduates noted it as developing lifelong learning skills vs. 5% of Non-Black graduates, and for leadership in non-engineering clubs, 17% of Black graduates noted it as developing lifelong learning skills vs. 7% of Non-Black graduates)

Innovation Skills

Innovation was only commonly deemed important for Entrepreneurial and Academic career paths, though these skills could be valuable in other career paths. Technical team projects were most commonly cited as developing innovation skills (32%), see Figure 8. The below quotes are examples of students using innovation skills in capstone projects.

> "My capstone project was specifically around like using like alternative fuels. So we did a project on like this sterling engine and we had to find an application for a sterling engine, which essentially is like a heat engine that works on like a temperature difference to convert that temperature difference to mechanical motion. So we came up with a design where we would create a crawler sterling engine powered crawler that could be used for like space exploration."

> "So you had your final capstone in your fourth year. But prior to that, every year, there was like a major design class, and they would teach design principles, but then also there'd be like a design project as part of it…. But it was the opportunity to think outside of the box and be innovative, and just brainstorm and come up with ideas."

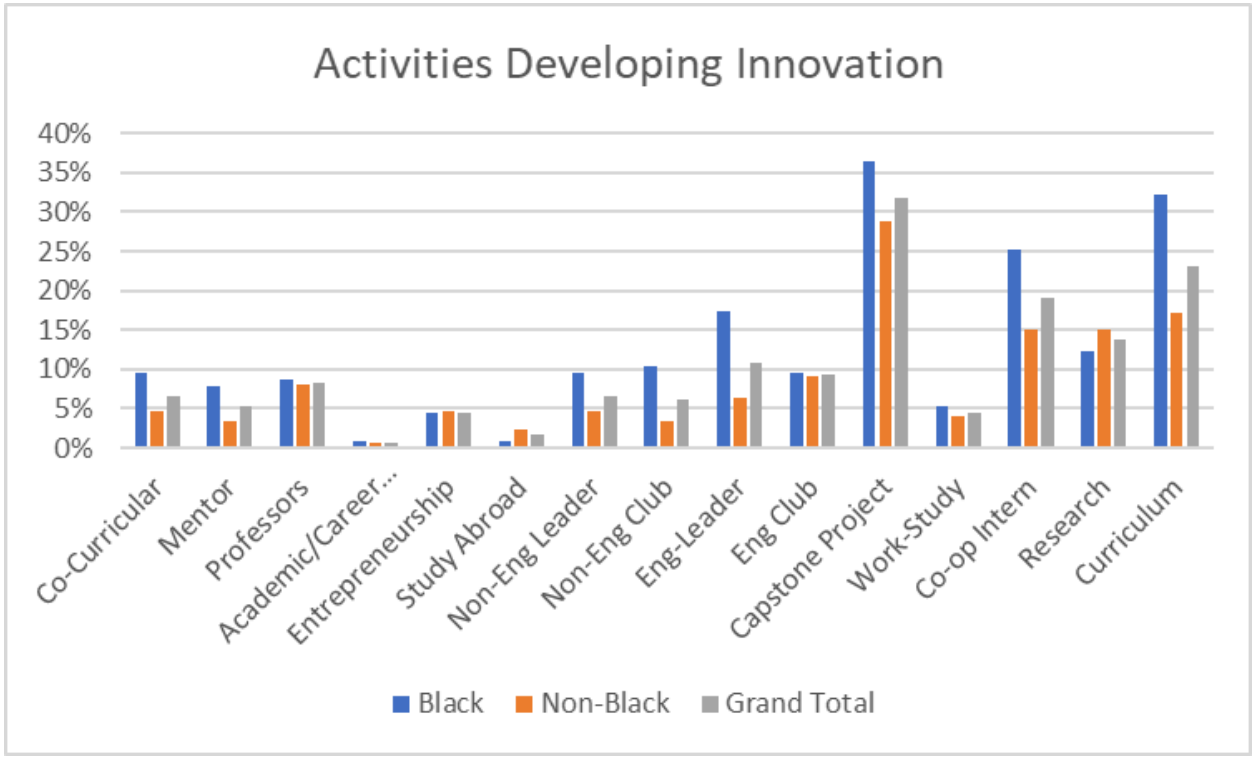

Figure 8. Activities Developing Lifelong Learning Skills

When comparing Black versus Non-Black students, there was not a statistically significant difference across all of types of activities that develop lifelong learning skills. However Black graduates were significantly more likely to cite the engineering curriculum as developing innovation skills as compared to non-Black graduates (32% of Black graduates vs. 17% of Non-Black graduates) ($\chi 2$ (df=1, N=289) = 8.67, p<.05). The quotes below are from Black engineering graduates speaking about innovative and interesting courses in their engineering curriculum.

> "Once I got to like my third year, that's when like started to specialize in, you know, mechanical and automotive and got to work on, you know, or take courses that were a little bit more interesting. So I took like a ceramics course, took some courses on like vehicle dynamics, courses that looked at like powertrain, like engineering and those I found were very fascinating."

> "Lifecycle engineering, that's also a good one. So that's the course of just looking at everything and understanding, you know, cradle to grave of what it takes from an input perspective to gather the resources, process the resources, create the parts, create the inputs to create a final product and then once that final product has outlived its usefulness, what does it take to then break that back down, what can be taken, what needs to go through the rubbish. I thought that that was an interesting concept, you know, I don't think a lot of people know a lot of things are thought of in that way. So I just found that to be very interesting."

> "I chose a course, uh, on like dental and surgical implants. It was a course in biomaterials properties and processing. And there like, I realized I liked the fusion. I liked the intersection. I liked feeling this idea of engineering and materials, but how does that interact or influence biological systems. I liked the duality of it. We make something, it influences biology."

Technical Skills

Technical skills was one of the skills sets that had a statistically significant difference in importance across career paths. Technical skills were very important for Technical Specialists and Academics, and less important for Entrepreneurs and Invisible Engineers. Though Black engineering graduates took Technical Specialists career paths, they were not likely to take Academic career paths. Conversely Black engineering graduates, and especially Black women, were likely to take Entrepreneurial and Invisible Engineer career paths. As shown in Figure 9, the engineering curriculum was most commonly cited as developing technical skills (86%), followed by technical team projects (68%) and then co-op/internships (49%).

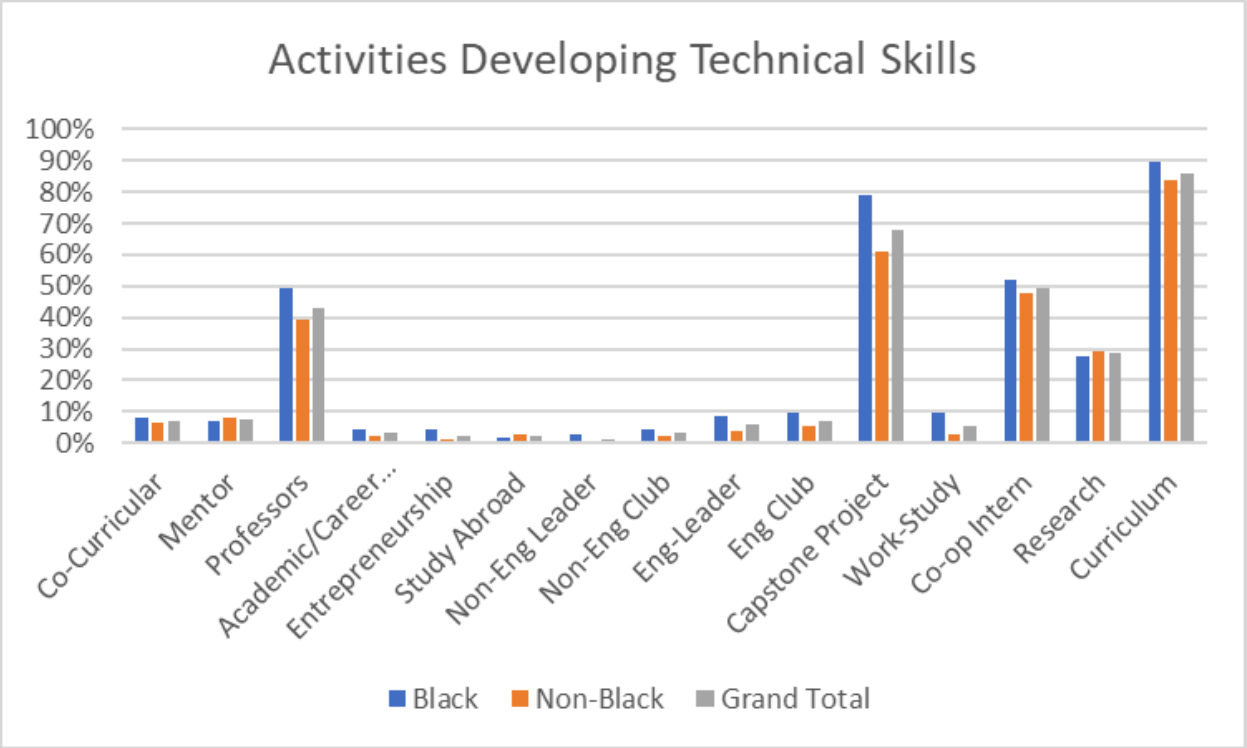

Figure 9. Activities Developing Technical Skills

When comparing Black versus Non-Black students, there was not a statistically significant difference in the types of activities that develop technical skills, though for technical team projects / capstone projects, Black graduates did report these as developing technical skills as a significantly higher frequency than non-Black graduates (79% of Black graduates vs. 61% of Non-Black graduates) ($\chi 2$ (df=1, N=289) = 10.58, p<.05). The quotes below from Black engineering graduates highlight how they developed technical skills through technical team projects.

> "We became experts beyond anybody else in that classroom when it came to AutoCAD, which is not a course that's offered in our program. Like learn that on our own."

> "My senior project was doing the bridge, so, with that, obviously we had to draw the architectural drawings. We had to do the engineering calculations. We had to do the geotech, uh, because it's a bridge, so it obviously has abutments that are over land and pairs that are in the water. Um by that time I knew what coastal was, so there's the coastal dynamics of being in the water and navigation and clearances, and things like that then there's the geotech. So there's the transportation civil side of it, because it's still a road that has feeders, and then as obviously road deck and AASHTO standards and girders, this is the structural side of it, and modeling all of the vents and those structural components."

Business/Financial Skills

Business and Financial skills was another skill that had a statistically significant difference across career paths. This was very important to Managerial and Entrepreneurial career paths, and less important for Academic and Technical career paths. Co-op/internships were most commonly cited as developing business skills (20%), followed by curriculum (19%), see Figure 10.

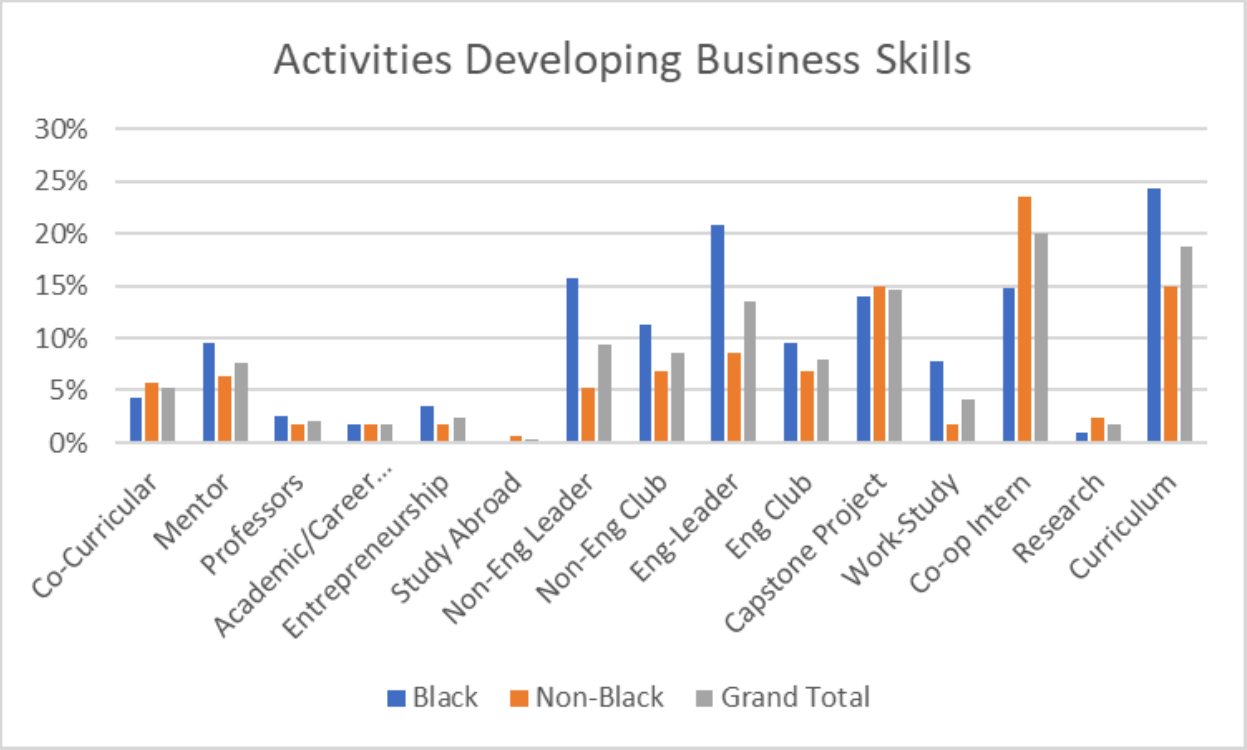

Figure 10. Activities Developing Business / Financial Skills

When comparing Black vs. Non-Black, there wasn't a statistically significant difference in the types of activities that develop business skills, though Black graduates were significantly more likely to report developing business skills through leadership in student clubs as compared to non-Black graduates (For example, for leadership in engineering clubs, 21% of Black graduates noted it as developing business skills vs. 9% of Non-Black graduates, and for leadership in non-engineering clubs, 16% of Black graduates noted it as developing business skills vs. 5% of Non-Black graduates). The quotes below highlight how Black engineering graduates had to leverage business and financial skills in their student clubs.

> "I got into a leadership role at NSBE, my second year as treasurer of the And as part of that, I was heavily involved, I would say, in grant writing. So I started doing grant

writing for the chapter because I was the treasurer and I was seeking funds from various entities, particularly the University of Toronto, but also other social groups around the city to sponsor the team, to attend conferences and hold events like that debate event that I just described, which was an annual thing for us at that time."

"We just had a collaborative board that we would advocate, you know, combine all of our powers, if there are any central issues. ….So for instance, like around voting time, we would all work together on bringing in cash."

Synthesis

When looking across all of the noted undergraduate activities, the main areas of difference between Black and non-Black engineering students for skills development appear to be in student clubs, capstone/technical team projects and academic/career advising, as shown in the Figures 11 and 12. This is explored more in the following section that examines the most influential undergraduate activities for Black vs. Non-Black engineering graduates.

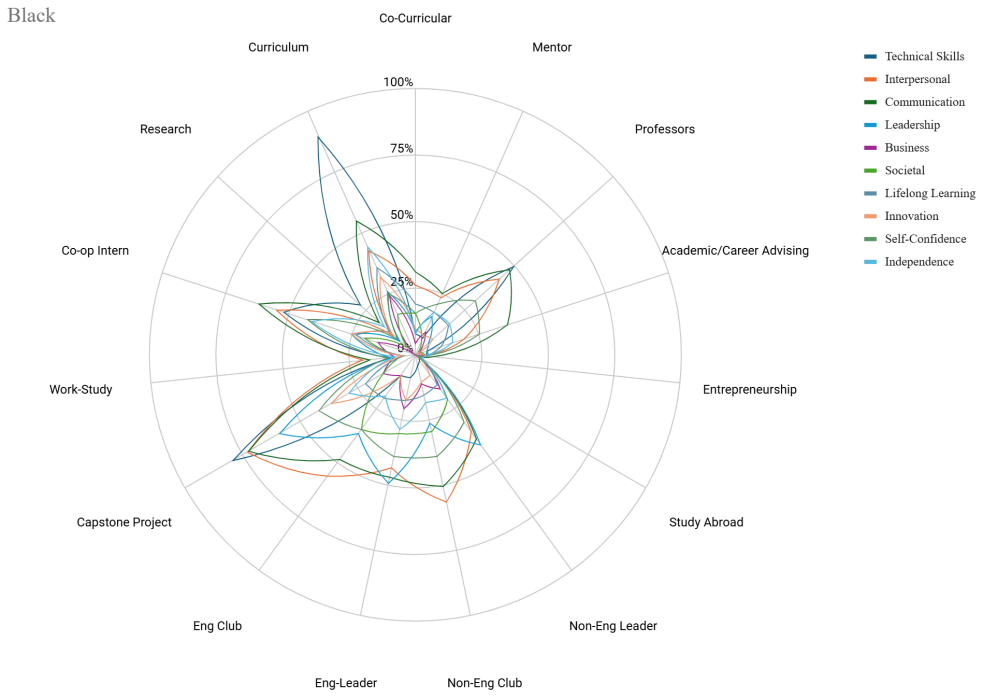

Figure 11. Activities Developing Important Career Skills for Black Graduates

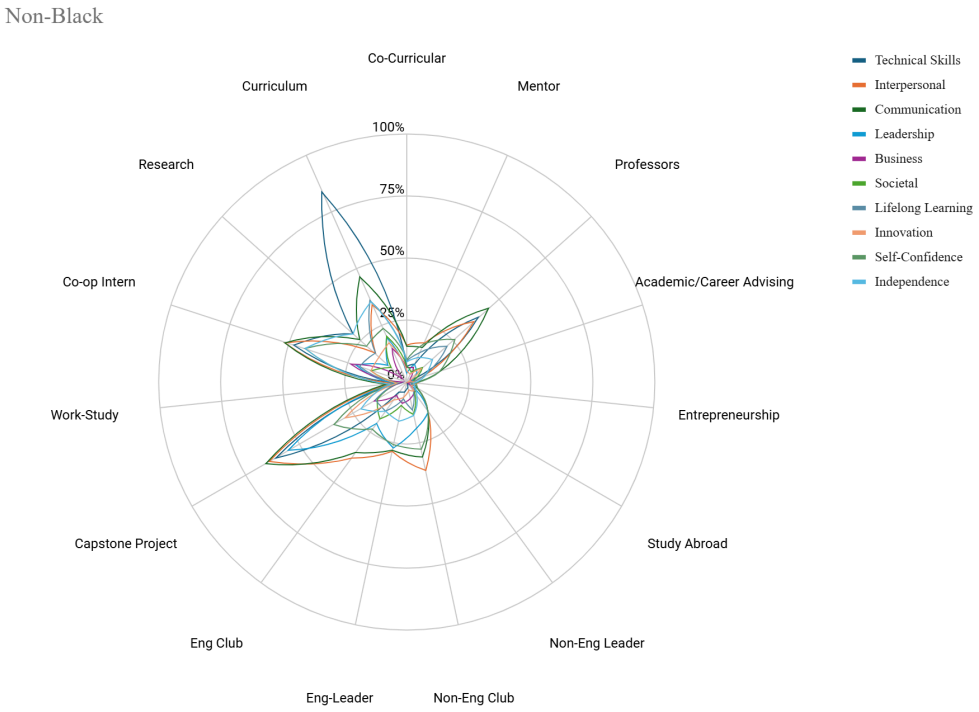

Figure 12. Activities Developing Important Career Skills for Non-Black Graduates

The findings on student clubs align with previous literature that shows the importance of student clubs for Black engineering students. In addition to developing these key career and leadership skills, these clubs can help to foster a sense of belonging, social capital and community cultural wealth amongst the Black community[20], [21], [22], [23], [24], [25] . These student clubs can also act as counterspaces for Black students in an environment where they are underrepresented [26], [27], [28].

For capstone and technical team projects, though they were shown to develop important career and leadership skills for both Black and non-Black students [29], [30] , more work can be done to better explore why there is a larger influence on skill development for Black students than their non-Black counterparts.

And finally, for academic and career advising, though not overly high in relation to other activities, the fact that Black graduates report this activity as developing important skills at higher rates than their non-Black counterparts is worth exploring further, and with academic institutions considering the investment in these activities, as well as how they can address the specific needs of Black engineering students through academic and career advising [31].

Conclusion

Though there has been literature in the past that has focused on development of skills through undergraduate student activities, no work has been done to specifically explore if Black engineering students develop skills through different activities than their non-Black counterparts.

This research aimed to answer the following research questions: (1) Which undergraduate student activities are most likely to develop leadership and career skills for engineering graduates? (2) Do the activities that develop leadership and career skills differ for Black vs. non-Black engineering graduates?

To answer Research Question 1, it was shown that different undergraduate activities developed different types of career skills in engineering graduates. Overall, internships, technical team projects/capstones, student clubs and the engineering curriculum of all of the activity options that were provided. For the development of technical skills in particular, the engineering curriculum was most commonly cited as developing these skills for both Black and non-Black graduates.

Addressing Research Question 2, it was noted that there are differences in the activities that develop careers skills for Black vs. Non-Black engineering graduates. There was a statistically significant difference for Black vs. Non-Black on citing technical team projects/capstones as developing technical skills, with Black graduates statistically more likely to cite technical team projects as developing technical skills than their non-Black counterparts. For the development of Interpersonal Skills and Leadership Skills, Black graduates were statically more likely to cite student clubs as developing these skills than their non-Black counterparts. For developing Independence, Non-Black graduates were significantly more likely to report Research activities as developing skills than Black graduates.

Recommendations

Based on the findings, it is recommended that engineering administrators consider how they can continue to support Black engineering students in technical team projects. This could include removing barriers to participation as well as including options for culturally relevant pedagogy embedded in engineering capstone courses. Employing more Black engineering professors could also support this.

It is also recommended for engineering education administrators to provide additional resourcing and support for Black engineering students to participate and be involved in cultural and identity based student clubs, such as the National Society of Black Engineers.

Overall, this work helps to shed light on the undergraduate activities that develop skills for Black engineering graduates. Future work can aim to explore potential differences for other racialized and marginalized groups in engineering. This work can help engineering administrators and Faculty consider how participation in engineering undergraduate activities may influence Black

and other marginalized groups differently than their counterparts and potentially design experiences that can support all students.

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References

[1] G. Hanson and M. Slaughter, "High-Skilled Immigration and the Rise of STEM Occupations in U.S. Employment," National Bureau of Economic Research, Cambridge, MA, w22623, Sep. 2016. doi: 10.3386/w22623.

[2] National Academy of Engineering, *Understanding the educational and career pathways of engineers*. Washington, DC: The National Academies Press, 2018. doi: 10.17226/25284.

[3] M. Al. Asefer and N. S. Zainal Abidin, "Soft skills and graduates' employability in the 21st century from employers' perspectives: A review of literature.," *Int. J. Infrastruct. Res. Manag.*, vol. 9, no. 2, pp. 44–59, 2021.

[4] D. B. De Campos, L. M. M. De Resende, and A. B. Fagundes, "The Importance of Soft Skills for the Engineering," *Creat. Educ.*, vol. 11, no. 08, pp. 1504–1520, 2020, doi: 10.4236/ce.2020.118109.

[5] S. Nicola, C. Pinto, and J. Mendonca, "The role of education on the acquisition of 21st century soft skills by Engineering students," in *2018 3rd International Conference of the Portuguese Society for Engineering Education (CISPEE)*, Aveiro: IEEE, Jun. 2018, pp. 1–4. doi: 10.1109/CISPEE.2018.8593495.

[6] S. C. Government of Canada, "Occupation (STEM and non-STEM) by visible minority, generation status, age and gender: Canada, provinces and territories, census metropolitan areas and census agglomerations with parts." Accessed: Apr. 29, 2024. [Online]. Available: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=9810045401

[7] K. Boyd-Sinkler, T. Holloman, C. Pee, W. Lee, and J. London, "Black Students in Undergraduate Engineering Programs: A Qualitative Systematic Review," *J. Negro Educ.*, vol. 91, no. 1, pp. 112–124, 2022.

[8] R. W. Lent, S. D. Brown, and G. Hackett, "Toward a Unifying Social Cognitive Theory of Career and Academic Interest, Choice, and Performance," *J. Vocat. Behav.*, vol. 45, no. 1, pp. 79–122, Aug. 1994, doi: 10.1006/jvbe.1994.1027.

[9] H. Chen, M. Grau, S. Brunhaver, S. Gilmartin, S. Sheppard, and M. Warner, "Designing the Pathways of Engineering Alumni Research Survey (PEARS)," in *2012 ASEE Annual Conference & Exposition Proceedings*, San Antonio, Texas: ASEE Conferences, Jun. 2012, p. 25.385.1-25.385.14. doi: 10.18260/1-2--21143.

[10] S. Sheppard *et al.*, "Exploring the engineering student experience: Findings from the Academic Pathways of People Learning Engineering Survey (APPLES)," Seattle, WA: Center for the Advancement for Engineering Education., 2010. [Online]. Available: https://files.eric.ed.gov/fulltext/ED540124.pdf

[11] S. Brunhaver, S. Sheppard, and A. Antonio, "Early career outcomes of engineering alumni : exploring their connection to the undergraduate experience," Stanford University, 2015.

[12] S. Brunhaver, S. Gilmartin, M. Grau, S. Sheppard, and H. Chen, "Not All the Same: A Look at Early Career Engineers Employed in Different Sub-Occupations," in *2013 ASEE Annual Conference & Exposition Proceedings*, Atlanta, Georgia: ASEE Conferences, Jun. 2013, p. 23.930.1-23.930.27. doi: 10.18260/1-2--22315.

[13] T. Holloman, J. London, W. Lee, C. Pee, C. Hawkins Ash, and B. Watford, "Underrepresented and Overlooked: Insights from a Systematic Literature Review about Black Graduate Students in Engineering and Computer Science," *IJEE Int. J. Eng. Educ.*, vol. 37, no. 2, pp. 497–511, Jan. 2021.

[14] E. Blosser, “An examination of black women’s experiences in undergraduate engineering on a primarily white campus: considering institutional strategies for change,” *J. Eng. Educ.*, vol. 109, no. 1, pp. 52–71, 2020.
[15] M. Ross and S. McGrade, “An Exploration into the Impacts of the National Society of Black Engineers (NSBE) on Student Persistence,” in *2016 ASEE Annual Conference & Exposition Proceedings*, New Orleans, Louisiana: ASEE Conferences, Jun. 2016, p. 27280. doi: 10.18260/p.27280.
[16] T. Zephirin and B. Jesiek, “WIP: Unpacking the Black Box: How does a Cultural Engineering Student Organization Support the Persistence of Students of Color?,” in *2018 ASEE Annual Conference & Exposition Proceedings*, Salt Lake City, Utah: ASEE Conferences, Jun. 2018, p. 31255. doi: 10.18260/1-2--31255.
[17] K.-A. D. Hamil, T. Zephirin, and D. Dickerson, “Quantitative Methodological Approaches to Understand the Impact of Interventions: Exploring Black Engineering Student Success,” 2023.
[18] J. A. Henderson *et al.*, “Circle of success—An interpretative phenomenological analysis of how Black engineering students experience success,” *J. Eng. Educ.*, vol. 112, no. 2, pp. 403–417, Apr. 2023, doi: 10.1002/jee.20509.
[19] Ortiz, Morton, Miles, and Roby, “What About Us? Exploring the Challenges and Sources of Support Influencing Black Students’ STEM Identity Development in Postsecondary Education,” *J. Negro Educ.*, vol. 88, no. 3, p. 311, 2020, doi: 10.7709/jnegroeducation.88.3.0311.
[20] C. A. S. Smith *et al.*, “Social Capital From Professional Engineering Organizations and the Persistence of Women and Underrepresented Minority Undergraduates,” *Front. Sociol.*, vol. 6, p. 671856, May 2021, doi: 10.3389/fsoc.2021.671856.
[21] A. Prewitt, W. Eugene, and S. Daily, “Minority Retention And Success In Engineering: Diversifying The Pipeline Through The Development Of Social Capital,” in *2007 Annual Conference & Exposition Proceedings*, Honolulu, Hawaii: ASEE Conferences, Jun. 2007, p. 12.1072.1-12.1072.14. doi: 10.18260/1-2--2374.
[22] J. Martin, D. Simmons, and S. Yu, “The role of social capital in the experiences of Hispanic women engineering majors,” *J. Eng. Educ.*, vol. 102, no. 2, pp. 227–243, 2013.
[23] G. K. Saw, “Leveraging Social Capital to Broaden Participation in STEM,” *Policy Insights Behav. Brain Sci.*, vol. 7, no. 1, pp. 35–43, 2020, doi: 10.1177/2372732219895997.
[24] T. J. Yosso, “Whose culture has capital? A critical race theory discussion of community cultural wealth,” *Race Ethn. Educ.*, vol. 8, no. 1, pp. 69–91, Mar. 2005, doi: 10.1080/1361332052000341006.
[25] D. Tolbert Smith, “‘They are here to support me’: Community cultural wealth assets and precollege experiences of undergraduate Black men in engineering,” *J. Eng. Educ.*, vol. 111, no. 4, pp. 750–769, Oct. 2022, doi: 10.1002/jee.20480.
[26] C. Sutherland, A. Mohammadi, and J. Harris, “Undergraduate Mentors’ Perspectives on Equity-Oriented STEM Outreach,” *Proc. Can. Eng. Educ. Assoc. CEEA*, Nov. 2022, doi: 10.24908/pceea.vi.15842.
[27] K. Thomas, B. C. Coley, M. L. Greene, and J. S. London, “Black Faces, White Spaces: Understanding the Role of Counterspaces in the Black Engineering Graduate Student Experience,” 2021.
[28] D. Dickerson and T. Zephirin, “Exploring the Association of a Cultural Engineering Student Organization Chapter with Student Success,” no. Paper ID #20455, p. 13, 2017.

[29] K. LeChasseur, F. Levey, A. Sabuncu, A. Ebadi, and J. McNeill, “Capstone Projects for Self-Efficacy, Skills, and Successful Careers,” in *2024 ASEE Annual Conference & Exposition Proceedings*, Portland, Oregon: ASEE Conferences, Jun. 2024, p. 48442. doi: 10.18260/1-2--48442.

[30] J. J. Pembridge and M. C. Paretti, “Characterizing capstone design teaching: A functional taxonomy,” *J. Eng. Educ.*, vol. 108, no. 2, pp. 197–219, Apr. 2019, doi: 10.1002/jee.20259.

[31] B. Ash, I. Berry, T. Slack, L. S. Benjamin, and J. A. Henderson, “How Black Males in Undergraduate Engineering Programs Experience Academic Advising,” in *Advances in Race and Ethnicity in Education*, E. M. Hines and E. C. Fletcher, Eds., Emerald Publishing Limited, 2023, pp. 295–313. doi: 10.1108/S2051-231720230000009017.

Appendix A. Survey Instrument

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