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Engineering or Physical Sciences: How to Choose? An Exploration of How First-Year University Students Choose between Studying the Physical Sciences and Engineering

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Engineering or Physical Sciences: How to Choose? An Exploration of How First-year University Students Choose Between Studying the Physical Sciences and Engineering

This paper presents results from an online survey of first-year university students with an aim to better understand how they made their choice of engineering or one of the physical sciences for postsecondary study. In many universities (including the study university of this paper), prospective students can or are required to indicate their preferred choice of faculty or broad program of study (e.g. natural sciences or engineering or business, etc.); some universities require applicants to declare their actual major (e.g. Electrical Engineering or Physics). Students can change their faculty or major later, but doing so can be costly for the student emotionally, financially, or in terms of time. If many students change majors, this could become costly for the university as well, either financially or in terms of the university's metrics of student success. From the perspective of the student, especially high school students, the problem is that the student needs to make a fairly significant life decision, "one that potentially frames aspects of their future" [1], and often must do so based mainly on their prior experience and knowledge, and often without experience of university-level studies to help them to make the decision. The problem of choice between engineering and the physical sciences is compounded by the entrance requirements from high school being similar for both fields since engineering and the physical sciences are similarly grounded in the mathematical, computational, and natural sciences.

Within the broad literature that discusses many aspects of university education in STEM fields (science, technology, engineering and mathematics), there is a modest literature on students' disciplinary choices between specific STEM fields, e.g. [2], [3]. There is also an existing literature on decision-making, including on how students make decisions about their university major (e.g. [1]). However, there is little past research on how students in late high-school and first-year university choose between engineering and the physical sciences, and on what bases they make their choice. Moreover, science and engineering are often conflated in common parlance and in the press. For example, a recent news article about a Ph.D. engineering student doing research using air balloons in Antarctica refers to the student as both an engineer and a scientist [4].

According to statistics from the US Department of Education, close to 33% of undergraduate students change their major at least once within the first three years of their undergraduate studies, and the percentage is slightly higher for students in STEM fields versus non-STEM fields [5]. There is an economic rationale for policymakers to encourage increased education in STEM-related fields in order to support university graduates to remain economically competitive [6], [7]; i.e. efforts to place the right people in the right jobs can be predictive of a nation's success in a future world economy. Against the backdrop of ongoing discussions about "retention" in STEM fields [8], about the role that STEM education plays in a developing a technologically literate and economically competitive national citizenry [6], [9], [10], and even about the formative effect that post-secondary education can have on career paths and life satisfaction [11], this study focuses specifically on how students choose between engineering and the physical sciences. We seek to investigate what factors guide their choice, including their prior knowledge and/or opinions about the differences and similarities between engineering and the physical sciences. Eventually, we aim to help to answer the larger question: How can post-secondary education systems (and even K-12 systems) better advise students interested in engineering or the physical sciences to choose the academic and professional paths that align well with their values, goals, and priorities? This paper is a starting point.

Our inquiry is situated within a critical realist perspective that conceives of knowledge as resulting from the correct understanding of the data of experience, and in which adult or emerging adult students are viewed as operating within horizons of their knowledge and values [12]; within this framework, education can be viewed as constructivist. For this study, we view choice as resulting dynamically, as modelled in common perspectives on decision making, including rational decision making [13] and value-focused decision making [14]. Other theoretical frames that influence the authors' perspectives include Freire's liberation pedagogy [15], cognitive and affective interactions in attraction to and identification with professional careers [16], and new literacies for engineering and science [17].

Purpose and Research Questions

The purpose of this paper is to collect data from participants who are first-year university students in engineering or physical sciences, and to analyze the data in order to better understand how students who are new to university then choose between engineering and the physical sciences.

The methodology is based on the collection and analysis of data from an online survey. This paper examines the outcomes from this survey directed at first-year undergraduate university students, conducted in September 2022. The questionnaire asks respondents about the influence of personal factors on their interest in or decision to study engineering or one of the physical sciences, as well as about their perceptions of engineering versus the physical sciences. The survey also asks about familial, educational, societal/cultural factors that may have influenced their interest or decision, and collects demographic information from the respondents.

Given the plethora of choice that students face entering university, and the need to make a decision fairly quickly about what program of study or major they prefer to enter, and given the context of perceived, and actual, disciplinary similarities and differences between science and engineering, our research questions for this overarching study are the following: 1) What are the perceptions of first-year university students about the differences and similarities between engineering and physical sciences? 2) How does this understanding influence their decision to pursue a post-secondary degree in engineering or physical sciences? This paper will focus primarily on addressing the first question.

Literature Review

There is a substantial literature on STEM education, with respect to the motivations students have to enter STEM fields [18], strategies to encourage students to enter STEM fields [19], gender and other diversity differences between students entering STEM fields in general

[2], on the pedagogical differences between science and engineering [20], etc. There is a smaller literature about students' disciplinary choices between specific STEM fields: these tend to focus on gender or other diversities [21], or psycho-social factors in attraction to STEM [3], or consider choices made by more advanced students such as doctoral students [21].

While academic decision-making has been previously studied by various authors, e.g. [1], [22], a number of studies frame student choice in terms of "buying behavior" in higher education and how their decision to choose a specific academic institution is influenced as a consumer. Towards understanding a broader range of factors, Sundly and Galway [7] used data from a small pilot study at a public university in Canada to study the factors that influence students to pursue engineering as their undergraduate choice. They showed that students' decisions to pursue an undergraduate degree in engineering were mainly influenced by personal factors (e.g., aptitude, personal desire to work in the field), earnings potential, social value/status of engineering as an occupation, academic focus/success in STEM subjects, parental pressure to be academically competitive, and parental advice/encouragement [7], [23].

The authors of this paper are not aware of any literature that investigates how first-year student decision-making occurs specifically in the context of engineering versus physical sciences, and in particular, how students' perceptions and knowledge of engineering versus the physical sciences factor into their choice of field of study.

Methodology and Methods

We used a descriptive quantitative research design for our investigation [24], employing a cross-sectional survey of first-year engineering and physical sciences students at Memorial University, a mid-sized multi-campus Canadian comprehensive university in the province of Newfoundland and Labrador; two of the campuses are located in the cities of St. John's and Corner Brook. Memorial University is also the province's sole university and therefore the only option for studying engineering and physical sciences at the post-secondary level within the province.

The questionnaire for this study (*PSEF-Engineering versus Physical Sciences*) was self-developed for our research questions and target population, but was based on past surveys on related research questions. Specifically we used a modified version of the *Perception of Social and Economic Factors Influencing Engineering and Applied Science Students' choice of degree program* questionnaire (*PSEF-Engineering*) [23]. *PSEF-Engineering* includes items grounded in STEM education literature and in Engineers Canada's 2016 national survey of final year undergraduate engineering students [25], and was pilot tested for validity and reliability [7]. Our survey was also influenced by the following: the *Integrative Pedagogies to Increase the Participation of Women and Other Diverse Groups in Engineering* questionnaire [11]; the *Engineering Students Persistence and Interest Survey* [26]; and the AWE (Assessing Women and Men in Engineering) STEM Assessment Tools [27].

The *PSEF-Engineering versus Physical Sciences* questionnaire includes 40 items, organized into three sections. Section 0 consists of two eligibility questions: the first asks participants who have consented to the survey to confirm their first-year status; the second to indicate their field of study (engineering or physical sciences) in first-year university, or if they are undecided or undeclared, if they are interested in one of these fields for next year.

Based on their field answer in Section 0 they are directed to Section 1 (Engineering) if they are currently in first-year engineering or interested in engineering for next year, or Section 1 (Physical Science) if they are currently in first-year physical sciences or interested in physical science for next year; or if neither condition applies they are redirected to an exit point for the survey. Section 1 starts with 23 questions that asks participants to use a three-point Likert scale to enter their level of agreement (Agree/Disagree/Neutral) with a series of statements about the influence of certain personal, familial, educational, and societal/cultural factors on their interest in engineering or physical science and their decision to pursue or interest in pursuing one or the other in post-secondary studies. Section 1 then asks participants to answer six questions about their perceptions of the fields of engineering and the physical sciences by selecting for each question from a list of possible answers; for each question, "I don't know" is one of the options. Section 2 asks participants nine demographic questions to which they can select the most suitable option from a list, or fill in a box for an answer not listed, or select "Prefer not to respond." Any or all questions in Sections 1 and 2 can be skipped.

Participants: The participants were first-year university students at either Memorial University's St. John's campus or Grenfell campus as of Fall 2022. To participate, participants had to confirm that they were in their first year of studies and that they were pursuing a degree in engineering or the physical sciences, or interested in doing so in the next year. A number of questionnaire items ask respondents to consider their high school experience; given the demographics of Memorial's first-year cohort, an assumption was made that most of the respondents would be fairly recent high-school graduates.

Development and Administration: The survey was developed on Qualtrics and was made available online for one month at the start of the Fall 2022 semester.

Recruitment: We used multiple ethically-approved methods to recruit potential participants including: short informational visits at the ends of classes in relevant courses, with the prior permission from the instructors; displaying electronic and paper posters on the university campuses; sharing the research advertisement in departmental listservs; and posting the advertisement on the student dashboards of the university's online learning management systems.

Rewards: Five participants who completed the survey and entered a separate prize draw survey were randomly selected to receive a $25 CND gift card.

Ethics: The survey and its protocols was approved by the Research Ethics Boards at both campuses of the study university, and the research in this study was conducted in accordance with the Canadian Tri-council policy on ethical conduct for research involving humans [28].

Findings and Preliminary Analysis

In this paper, we focus on outcomes that directly address our research questions. In this section of the paper, we present and discuss outcomes on some of the personal factors influencing participants' choices (Q18-22 of the survey) and on the participants' perception of similarities and differences between engineering and the physical sciences (Q24-29 of the survey).

Out of 233 students who responded to our survey, 38 either did not consent to participate, or were beyond the first year of their academic program. Out of the remaining 195, 67.2% were either enrolled in an engineering program or were interested in studying engineering; 24.7% were either enrolled in a physical sciences program or were interested in studying one; and 8.2% first-year students were neither interested in studying engineering, nor physical sciences. One hundred and sixty-three students responded to the question about their gender, out of which 55.2% identified as male, and 41.7% identified as female.

Personal Factors Influencing Student Choice: These data come from *Section 1*, Q18-23 on personal factors influencing their choice. Questions Q18-22 are given below. Note that Section 1 was in two branches according to participants' indication of their current program of study or their interest for next year, engineering or physical sciences. Thus there are two versions of the following questions indicated by the (/) :
Q18. I am personally motivated to study (engineering / physical sciences).
Q19. I am personally motivated to work as (an engineer / a physical scientist).
Q20. I believe I have an aptitude for (engineering / physical sciences).
Q21. I consider myself "good at math and science."
Q22. I care about helping people and the environment through my work.

These questions were answered on a three-point Likert scale (Agree / Neutral / Disagree). The number who answered Questions 18-22 (Engineering) was 121, and the number who answered Questions 18-22 (Physical Sciences) was, variously, 47 or 48. The results are shown in Figure 1, broken out between engineering and physical sciences. Worthy of note is that there is evidence of stronger identification with their choice for the engineering respondents. While the percentage for Agree ranged from 79.3% (Engineering, "personal motivation") to 54.2% (Physical Sciences, "desire to help"), the remaining respondents were more Neutral than Disagree (maximum rate for Disagree for Engineering was 6.6% for "motivated to work," and 14.6% for Physical Sciences for "desire to help.")

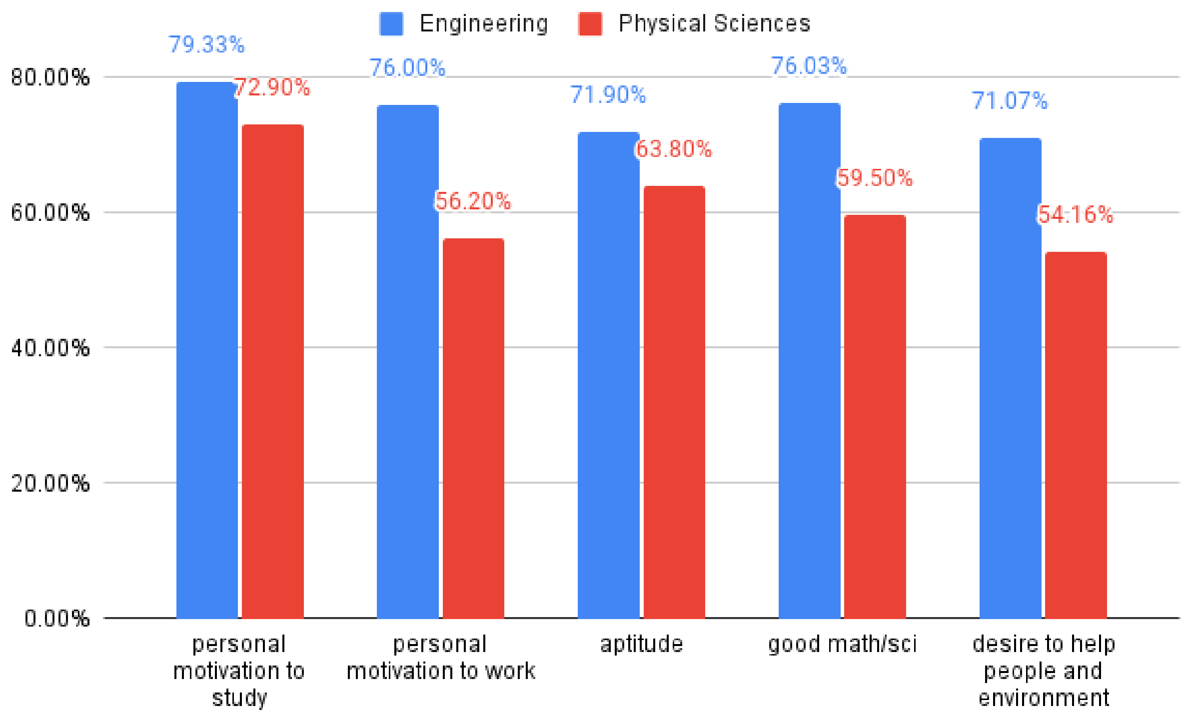

Figure 1: Comparison of personal factors that influence students' decision to study engineering or physical science.

Perceptions Comparing Engineering and Physical Sciences: We were interested in participants' self-reported perceptions comparing engineering and the physical sciences, corresponding to Q24-29 from Section 1 of the questionnaire. We will provide the results of Q24-28 first, followed by a separate discussion of Q29 further below. Q24-28 were posed according to the pattern shown, with four choices of answer:

Q24. Do you believe that one degree has higher prestige than the other when comparing engineering with the physical sciences? [four choices to answer]

- Engineering has higher prestige
- Physical sciences have higher prestige
- Both have the same prestige
- I don't know

Q25. Do you believe that one degree has higher earning potential than the other when comparing engineering with the physical sciences? [four choices to answer]

Q26. Do you believe that one degree is more employable locally than the other when comparing engineering with the physical sciences? [four choices to answer]

Q27. Do you believe that one degree is more employable globally than the other when comparing engineering with the physical sciences? [four choices to answer]

Q28. Do you believe that one degree is more challenging than the other when comparing engineering with the physical sciences? [four choices to answer]

The number of participants who answered Questions 24-29 (Engineering) was 117, and the number who answered Questions 24-29 (Physical Sciences) was 47. The results are presented visually below, broken out with the results per question between Engineering (Figure 2) and Physical Sciences (Figure 3).

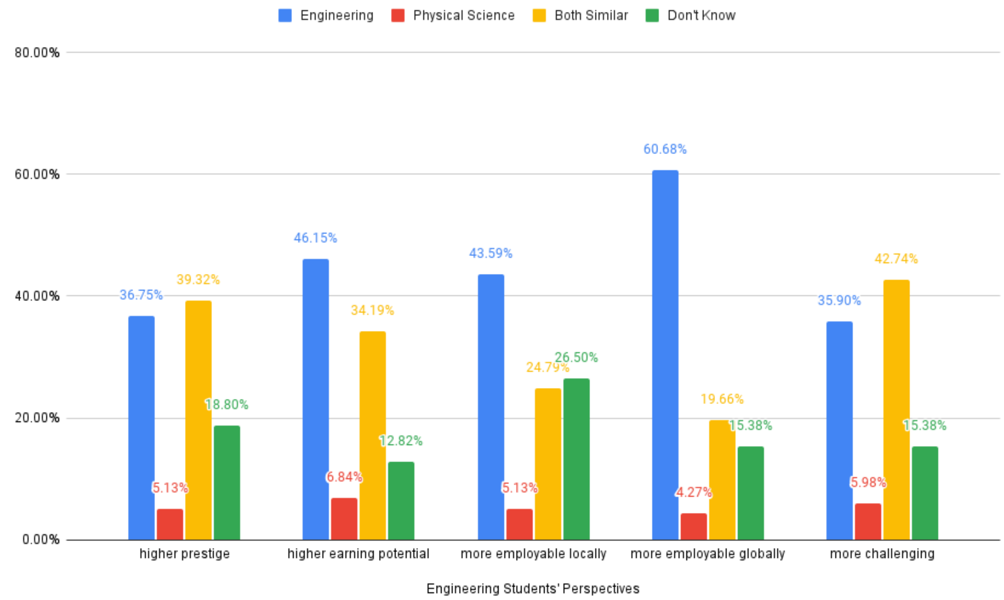

Figure 2: Engineering students' perceptions of engineering and the physical sciences as fields of study, comparing prestige, earning potential, employability, and level of challenge

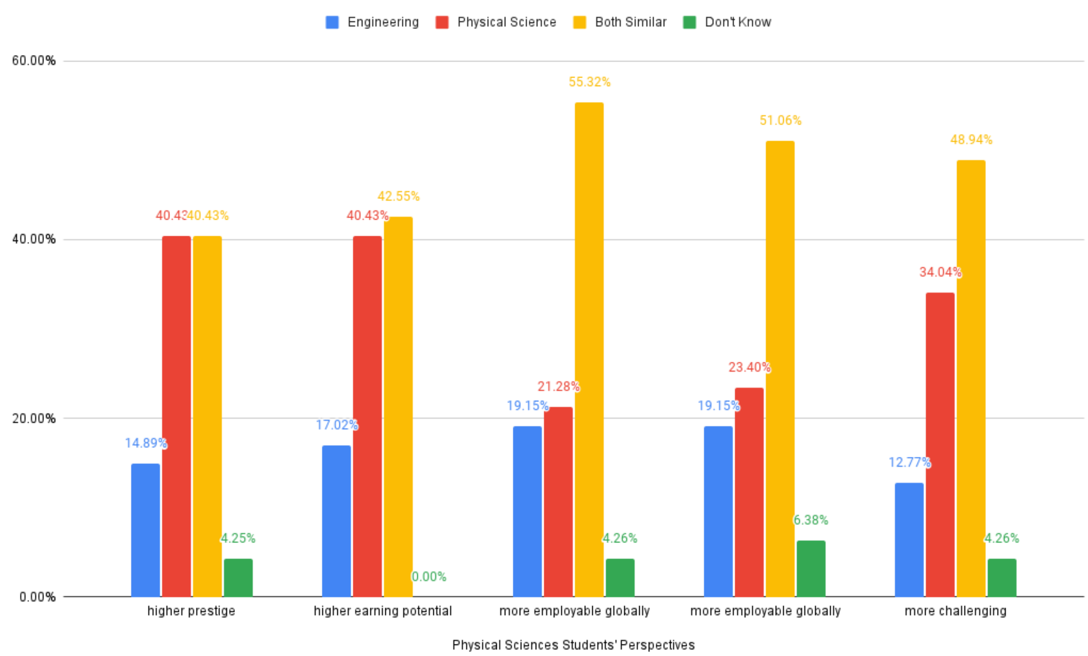

Figure 3: Physical sciences students' perceptions of engineering and the physical sciences as fields of study, comparing prestige, earning potential, employability, and level of challenge

Which degree carries more prestige? Within our data, 36.7% of engineering students thought that engineering has a higher prestige as compared to physical sciences as compared to only 14.89% of physical sciences students. Only 5.1% of the engineering students thought physical sciences had a higher prestige than engineering. Responding to the same question, 40.4% of physical sciences students thought their field was more prestigious as compared to engineering. About 39.3% engineering students and 40.4% physical sciences students thought both the fields had similar prestige. While students from both fields tend to show solidarity towards their respective fields, an interesting observation was that an almost similar percentage of engineering and physical sciences students thought both fields have similar prestige. However, 18.8% engineering students as compared to only 4.2% physical science students responded by selecting 'I don't know.' So, more than 58% engineering students as compared to 44.8% physical science students, were either not sure, or thought both fields were similar. Considering that the similarity in admissions requirements (prerequisites in physics, chemistry, and mathematics) to enter engineering and physical sciences programs at our study site are almost the same, it would be interesting to investigate further specifically how prestige factored into their choice of one over the other for their post-secondary academic study. However, this question is beyond the scope of this paper.

Which degree carries more earning potential? Around 46% of engineering, and 40% of physical sciences students thought that their respective fields offered higher earning potential as compared to the other. Similar percentages of students thought both the fields had similar earning potential. About 12.08% of engineering students selected 'I don't know' which may either raise questions as to what other factors informed their decision, or perhaps indicating their reluctance to speculate on a comparison on earning potential.

These findings can be compared to a question previously asked in the survey ('I preferred to pursue a degree in engineering/physical sciences because it may potentially lead to a well-paying job') to which students responded as 'Agree', 'Neutral', or 'Disagree'. About 74.3% of engineering students and 62.5% of physical sciences students agreed with this statement. We can observe noteworthy differences between their responses to the two questions. Their perception of the earning potential of their respected fields decreased by at least 20% when the question was asked in a comparative form. Since none of the physical sciences students selected 'I don't know' as their response, we can say that 22.1% of the physical sciences students' perception of the economic value of the degree shifted to engineering or regarded both degrees as of equal economic value. A larger data set can provide more insights into this query.

Which degree is locally and globally more employable? Given that Memorial University is the only post-secondary institution in the province that grants university degrees in Engineering and in Science, and given that the university's mission includes a "special obligation to the people of Newfoundland and Labrador," [29] we were interested to understand participant perceptions of the local versus global employability of engineering and the physical sciences. To the question about local employability, 43.5% of engineering students as compared to only 21.8% of physical sciences students stated that their degree was more employable locally. This view was supported by about 19% of physical sciences students who also thought that an engineering degree was more employable locally. A majority (55%) of physical sciences students thought that both degrees had similar chances of employability locally, whereas only

24.8% of engineering students thought that both fields had similar local employability. A similar percentage (26%) of engineering students selected 'I don't know' as their response.

To the question about global employability, 60.7% of engineering students as compared to only 23.4% of physical sciences students stated that their degree was more employable globally. This view was supported by about 19% of physical sciences students who also thought that an engineering degree was more employable globally. A similar percentage of physical science students supported the views of engineering students about the employability of an engineering degree. A majority (51%) of physical sciences students thought that both degrees had similar chances of employability globally, whereas only 19.7% of engineering students thought that both fields had similar global employability.

These findings can be compared to a question previously asked in the survey ('I preferred to pursue a degree in engineering/physical sciences because it may potentially be easy to find a job after graduation') to which students responded as 'Agree', 'Neutral', or 'Disagree'. About 63.6% of engineering students and 52% of physical sciences students agreed with this statement. We can observe an interesting difference between their responses to the two questions. The perception of engineering students about the global employability of an engineering degree as compared with a degree in physical sciences was similar to their response on the stand-alone question about ease of finding a job after graduation. However, the perception of physical sciences students about the global employability of a physical sciences degree as compared with a degree in engineering differs from their response on the stand-alone question about ease of finding a job after graduation (23.4% versus 52%). We have limited data to probe this disparity. However, another question to engage is the reason why these students choose to study physical sciences while being skeptical about career prospects. A larger data set and qualitative inquiry can provide more insights.

Which degree is more challenging? While the solidarity with their respective fields existed between the respondents (35.9% and 34% of engineering and physical sciences students said their respective fields were more challenging), 42.7% of engineering students and 48.9% of physical sciences students thought that both degrees were equally challenging. Interestingly, 12.8% of engineering students said that a degree in physical sciences was more challenging as compared to 6% of physical sciences students who said that engineering was more challenging.

How do both degrees compare with respect to skills and knowledge requirements? Finally, we come to a significant question, one that addresses a core within our first Research Question: What are the perceptions of participants about the differences and similarities between engineering and physical sciences? Section 1, Q29 asks the following:
Q29. Which statement do you think applies when you consider the skills and knowledge needed to study engineering or the physical sciences at university? [3 choices to answer]

- Engineering and the physical sciences require the same skills and knowledge
- Engineering and the physical sciences each require different skills and knowledge
- I don't know

The results are presented visually in Figure 3 below. While both groups responded "I don't know" at the same rate of approximately 19%, the majority responded that engineering and the physical sciences each require different skills and knowledge. About 65% engineering students and 74.5% physical sciences students thought that both degrees required different set of knowledge and skills. The least percentage of students in both groups (16.2% engineering students and 6.4% physical sciences) responded that both the fields require a similar set of knowledge and skills. These findings show that each group tends to focus on the disciplinary *differences* rather than their *similarities*. This is despite both groups of respondents most likely coming from a common educational background in high school.

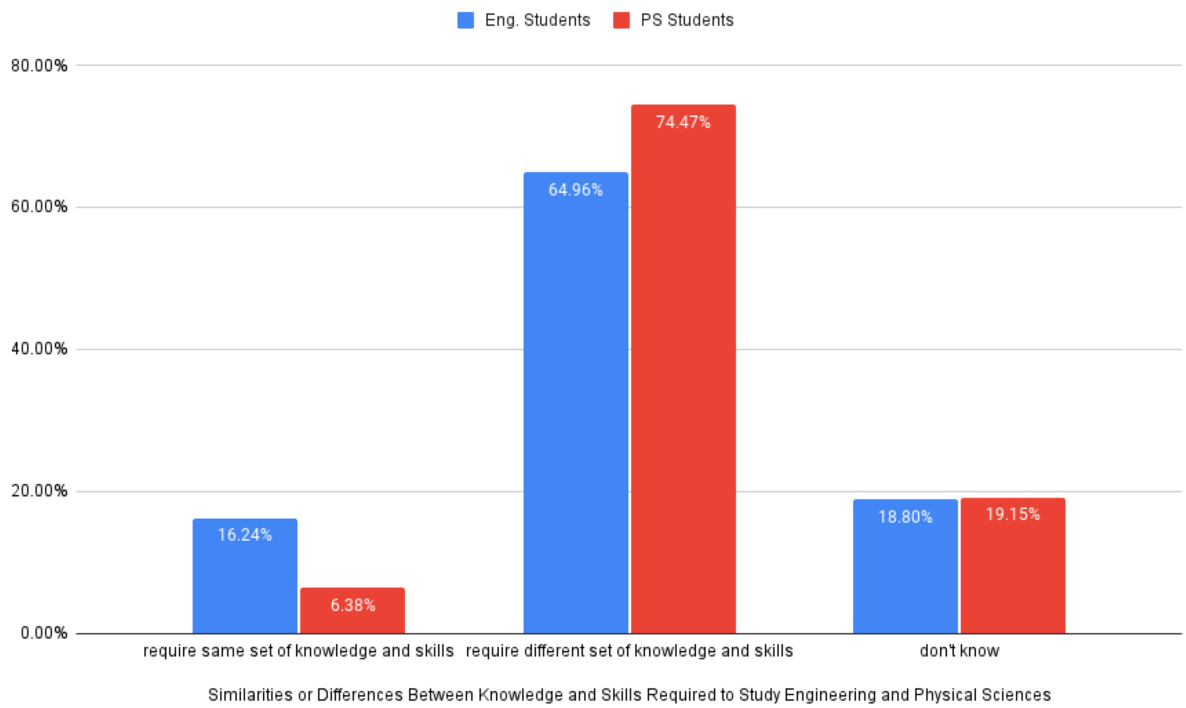

Figure 4: Comparison of participants' perceptions of the similarities or differences between knowledge and skills required by engineering and physical sciences.

We cannot yet determine on what bases the two groups form these perspectives. But at least we now know that the next questions we might ask could try to unpack why such a strong result was obtained in Question 29. What else defines the perceived differences that students believe exist between the fields and why might students hold these views? That question leads us to Research Question #2 of our larger study, which is beyond the scope of this paper and the next step is for us to examine more closely some of the other dimensions we measured in our questionnaire, such as external influences of parents and schools on students' choices and impressions. It is likely that we will need to embark on qualitative research to probe further, based on follow-up interviews.

Discussion

In this section we can offer some speculation on possible connections between our participants' responses and the broader context of engineering and the physical sciences as we understand it. Engineering and the physical sciences are typically classified into separate academic faculties and moreover the licensure requirements of professional engineers (and in Canada, also professional geoscientists) legally distinguish their activities from those of scientists. Moreover, working scientists and professional engineers tend to express the differences between their professions and domains of practice, rather than their similarities. The differences (and similarities) between science and engineering, in their goals, activities, fields of study, level of materials studied, methodologies and cultures, have been discussed by scholars in the philosophy and sociology of science [30], [31], [32], as well as by scholars of the practice of engineering [33] and in the philosophy of engineering [34]. These discussions by scholars often display strong disciplinary perspectives: either of and from science, or of and from engineering; for example, sometimes engineering is viewed as being a subset of science, at other times as sharply distinguished from science. For more on the disciplinary cultures of STEM, see [35].

The legal distinction and self-regulating nature of the engineering profession in Canada is not insignificant, but we initiated this study because we were interested in unpacking the large subject-matter overlaps between disciplines on either side of the science-engineering divide: for example, between physics and electrical engineering, between computer science and computer engineering, and between chemistry and chemical engineering. In spite of the legal distinctions necessary for professional licensure in engineering, engineering and the physical sciences share many common foundations in both knowledge and required skills. These common foundations, and the overlap of their activities, might be the reason why neither the journalist nor the subject of the news article [4] referenced in this paper's introduction expressed a consistent distinction between engineering and physical sciences. Thus there remains a grey area within common or public parlance.

Our study tried to delineate perceptions of the disciplines by new university students, and our findings seem to demonstrate students' strong belief in the differences between the disciplines. We were surprised by the strength of this perception because we assumed that new university students, reflecting on their high school education, might share the perceptions of the "general public" that tend to gloss over the differences, or to conflate the knowledge and skill sets of engineering and the physical sciences. For these reasons, we expected our survey respondents might respond more strongly for disciplinary similarities, or that they indeed might not hazard a guess at all as to the differences (i.e. choosing to respond "I don't know" to this item). Given the existence of scholars' strong disciplinary perspectives and the public blurring of distinctions between engineering and science, our survey respondents' own perceptions of the differences between pursuing a degree in engineering and pursuing a degree in the physical sciences gives us a puzzle to unpack.

One question we can ask ourselves as researchers is whether there was anything about the questionnaire itself that tended to encourage respondents to respond to Q29 strongly in favour of disciplinary differences in skills and knowledge between engineering and the physical sciences. We think not, since the instrument was carefully designed to try to minimize any discrepancies in wording between the Engineering version of the questionnaire and the Physical Sciences version, and to ensure the wording of the question could remain as neutral as possible. To that end, despite the Engineering and Physical Science students answering slightly differently worded questions preceding Q29 in their discipline-selected Section 1, both groups of respondents tended to produce the same distribution of answers in Q29.

Another question to investigate further is whether the findings speak more to theories of choice that show how people tend to identify with their choices and defend their choices once made, through a form of confirmation bias [14]. Additionally, we can investigate the cognitional and cultural contexts that informed respondents' views on engineering and physical sciences. For this, we can turn to the work of the Canadian philosopher Bernard Lonergan. His analysis of common sense understanding reveals the shared meaning and values of a culture, and especially sheds light on human community and power within the community that derives from common perspectives [36]. Further, we can draw on the research methods of French sociologist Pierre Bourdieu and his theory of social reproduction [37]. Bourdieu suggests that certain social groups gain access to certain types of resources or capital (social, cultural, symbolic, and economic) that is reflected in their *habitus*, where *habitus* refers to a person's internalization of their first-hand experiences of the social world in which they live. It leads to development of knowledge, which is meaningful, and seems commonsensical to the individual. The access to various forms of capital gives a certain group the power to shape and reshape social institutions that disseminate knowledge. Thus, social institutions work together to maintain social structures that perpetuate one type of knowledge generated by the dominant group.

Our demographic data suggests that most students who choose to study either engineering or physical sciences tend to belong to highly educated, financially well-off parents, and live in small households. These social attributes give them access to social, cultural, as well as economic capital, thus making the majority of them part of a group that perpetuate the knowledge of a privileged class. According to Bourdieu, these forms of capital are passed on intergenerationally to maintain social dominance of certain socio-economic classes and types of knowledge. If STEM practitioners hold strong beliefs about the disciplinary distinctions (and even hierarchies) in their fields, what is the link between this privileged class and the students who apply to pursue STEM postsecondary education? Our findings are interesting because our participants are first year university students, and their beliefs are grounded in what they learned outside university. Although these students would have usually taken similar science and math prerequisites in high school to enter either program, this fact doesn't seem to change or influence their perception that engineering and physical sciences require different sets of skills. That distinction seems to serve as the dominant narrative, treated as commonsensical, and thus unquestioned. According to Bourdieu such perceptions are perpetuated by the dominant groups that value only one type of knowledge over the other. If the strength of the distinction between disciplines exists for new university students, can those perceptions be traced back to high school? The authors of this paper are interested to pursue that avenue of inquiry by distributing the questionnaire to high school students: more data is needed on how these perceived and actual differences influence perspectives and opinions within society, and especially how these might influence high-school students to pursue engineering or physical sciences as their post-secondary academic choice. Undergraduate students with an interest in either engineering or the physical sciences will usually have selected high-school electives in chemistry, physics, and mathematics, and in most cases, the requirements for admission into both physical sciences and engineering are similar.

Conclusions

Students who excel in mathematics, chemistry and physics in high-school often consider engineering or one of the physical sciences for university level studies. But how do they make their choice? How can the education system better advise them to choose the career that is best for each one of them individually? In this paper, we have presented and discussed preliminary results from a survey on how first-year university students choose between the physical sciences and engineering. Among the findings of this study was a key one that a strong majority of respondents believe that engineering and the physical sciences each require different skills and knowledge. In other words, this finding shows strongly that each group tend to distinguish the disciplinary *differences* rather than the similarities between engineering and the physical sciences. We recognize that the limited size of our sample data collected at a single university is a constraint on the strength of our arguments. Thus, we recommend that more qualitative as well as quantitative research be conducted to progress this area of study. This suggests directions for further work to refine our understanding of student perceptions to provide foundations for improved materials and processes to support the decision making of high-school graduates about what they will study in university.

As authors and educators we believe from both humanist and social justice perspectives that it is important that students be able to choose their fields of study and eventual professions that best address their individual aptitudes and interests and in which they can achieve success and satisfaction. Moreover, in the experience of the authors of this paper (those of us who are university educators in engineering or physical science or researchers in engineering and science education), students who regret their initial choice can suffer emotionally from the situation of an initial choice that was not the best for them. This emotional toll can affect both those who go on to change their major, and those who do not change their major but continue in a field of study or work that does not fully engage them. The results of this study may inform outreach and pedagogy for science and engineering, and thus help to foster greater attraction and retention of undergraduate students in STEM fields, and greater career sustainability and life satisfaction for our graduates.

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