Understanding Persistence in Engineering Education through a Comprehensive Survey Tool

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UNDERSTANDING PERSISTENCE IN ENGINEERING EDUCATION THROUGH A COMPREHENSIVE SURVEY TOOL

Abstract – *The purpose of this practice paper is to describe the development of a survey instrument aimed to broadly capture the engineering student experience from their entry into first year through to graduation. Engineering education faces significant challenges related to addressing student persistence and retention within engineering programs. Equity, diversity, inclusion, and access are stated areas of priority for post-secondary institutions (PSIs) in British Columbia (BC) with the goal to ensure that students of all backgrounds, identities, and demographics are provided an opportunity to thrive without compromise. However, there continues to be a lack of appropriate, desegregated demographic data that can inform how well this goal is being achieved by engineering programs at public PSIs in BC.*

This paper describes the pilot study that was used to develop a survey instrument that intends to fill this information void through a comprehensive, student-facing, and voluntary questionnaire that is made available to engineering students in their first year and their final year of study. Through a set of defined and open-ended survey questions, coded as addressing autonomy, competency, or relatedness to align with the self-determination theory (SDT) framework, and in-person interview sessions, the survey more broadly seeks details -- such as physical and mental health, home life, sexual orientation and gender identity, and belonging -- to better contextualise the student experience than what may typically be captured.

Direct-entry students to the engineering science program at Simon Fraser University (SFU) and first-year engineering students from Vancouver Island University, one of SFU's incoming transfer pathways, were invited as survey respondents. As a follow-up, these students were given the option to take part in a one-on-one, in-person interview to better understand the general survey responses, as no survey response was linked to a specific individual. These conversations uncovered, gathered, and represented the direct student perspective and academic experience and, with the general survey responses, played a crucial role in honing the instrument. It is suggested that by analysing changes within the student cohort from their first to final year of study, an improved picture of the complex dynamics of persistence and retention can be obtained, while the efficacy of initiatives intended to address underrepresentation of specific demographic groupings may be examined. Further, this paper suggests how SDT may provide a framework for understanding the characteristics of those students who persist within their studies through graduation.

The next stage of this project is to expand the use of the survey instrument to other PSIs within the BC Transfer System, including both those hosting engineering schools and those from which students transfer to engineering schools after their first year of studies. It is expected that the instrument will continue to evolve, and support work to develop resources for engineering programs that enhance equity, allyship, and representation. Additionally, these tailored resources provide opportunities for like-minded students to establish support systems, fostering a sense of belonging that produces a unified, resilient, and persistent student body.

1.0 INTRODUCTION

Engineering has a considerable role in addressing many of the challenges facing society. Engineering schools and the engineering professional bodies have increasingly recognized that for the engineering discipline to reach its full potential, all segments of society must be included. Engineering must actively engage and help promote the pursuit of engineering education and engineering careers with those individuals who have been historically under-represented within the field. For example, female participation in the engineering profession is considerably below the proportion of females in society at large (Figure 1). As a result of this differential, Engineers Canada launched the 30 by 30 Engineers Canada initiative which aims by 2030 to increase to 30% the proportion of female registrants.

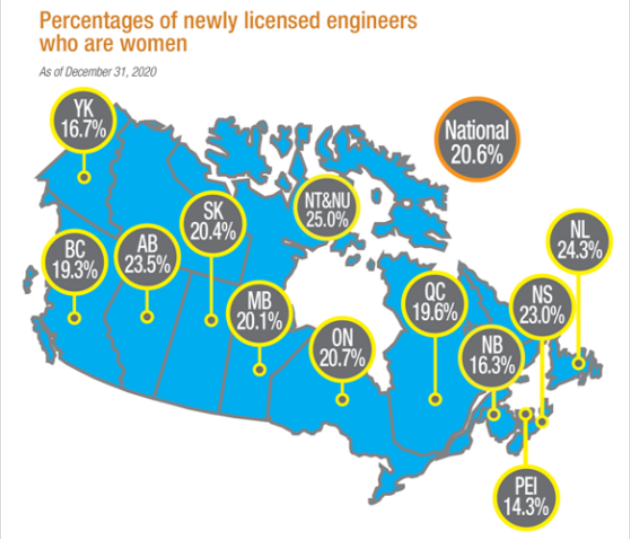

Figure 1. Newly licensed engineers who are women[1]

However, gender diversity is only one dimension, and for many post-secondary institutions in British Columbia (BC), is one that is typically acquired through the admissions office [1]. Although this data has evolved to better capture the gender diversity of students more holistically, under-represented groups also extend beyond the visible (e.g. racialized minorities) to the invisible (e.g. socio-economic status, sexual orientation) [2], [3]. For example, in 2021 almost 7.4% of Canadians lived in poverty[2] while close to 18% of Canadians aged 15 and older met the diagnostic criteria for a mood, anxiety, or substance use disorder over the previous 12 months[3]. This student profile data would typically not be collected by the University Registrar, yet there may be value to do so. Many initiatives aim to provide equitable access for all individuals regardless of their individualised pathways (such as the 30 by 30 initiative previously mentioned) but evaluating their success can be challenging. It has been shown that an environmental scan of the student demographic profile throughout their academic studies may be used to provide some of this required data [4], [5]. Such a scan may not answer the *why* such initiatives are successful (or not), but it can answer the *that* an initiative is successful (or not).

[1]https://engineerscanada.ca/diversity/women-in-engineering/30-by-30 [Available as of 30.Jan.2024]

[2]Statistics Canada. Table 11-10-0135-01 Low income statistics by age, sex, and economic family type

[3]Stephenson, E 2023, "Mental disorders and access to mental health care," Insights on Canadian Society, Statistics Canada Catalogue no. 75-006-X

1.1. Context

British Columbia is a diverse and expansive province where close to 75% of its population reside in larger urban centres in its south-west (e.g., Lower Mainland, Victoria) and southern interior (e.g., Kelowna). The remaining 25% reside in smaller communities located throughout the province. To provide access to post-secondary education to all its citizens, the province has established an integrated network of colleges, teaching intensive universities (TIU), institutions, and research-intensive universities (RIU) that supports student mobility through a formalized transfer system. The BC Council on Admissions and Transfer (BCCAT) is the agency tasked with facilitating admissions, articulation, and transfer arrangements among BC Transfer System member institutions, as well as conducting research to support student and credit mobility. Figure 2 illustrates how the BC Transfer system connects post-secondary institutions in the province, as well as where those institutions are located.

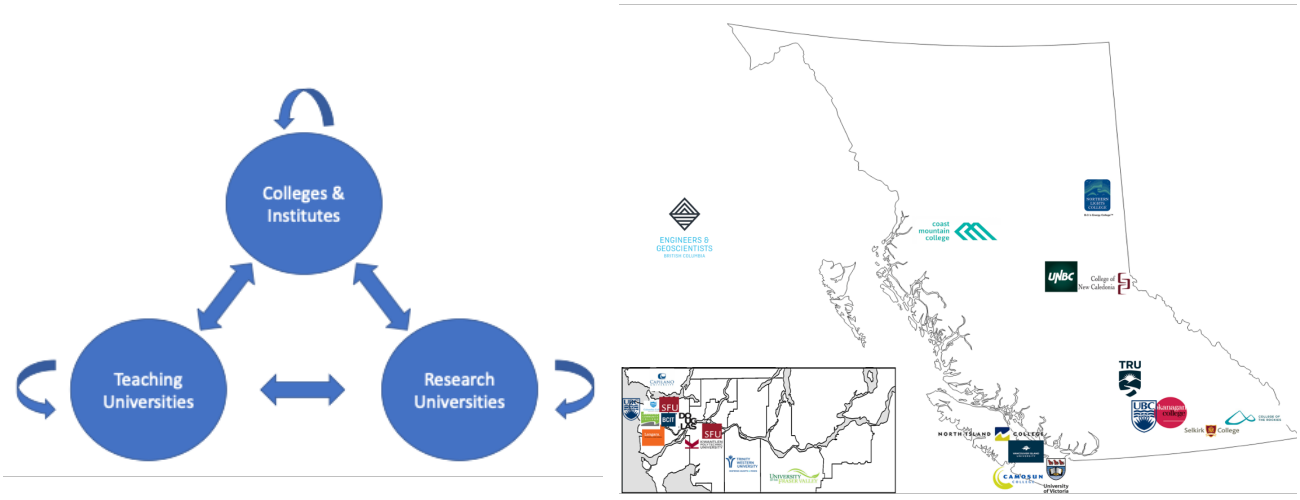

Figure 2. BC Transfer System [Left] and location of most colleges, teaching universities and research-intensive universities in British Columbia [Right].

Approximately 20% of students complete their first year of engineering studies at rural and urban colleges and TIUs before transferring to one of the eight engineering schools[4] in the province to complete their degrees. Differences between the receiving requirements of the engineering schools has traditionally impacted the ability of colleges and TIUs to offer engineering specific courses, and hence limit the access to engineering studies for potential students in their regions. Recently, conversations within the sector led to the development of a common first year engineering curriculum (CFYEC) that aligned the receiving requirements for all engineering schools in British Columbia [6].

The CFYEC project was developed with the goals to:

- clarify the transfer process for sending and receiving institutions.
- improve program efficiencies at sending institutions.

[4]University of British Columbia - Vancouver campus; University of British Columbia - Kelowna campus; Simon Fraser University - School of Engineering Science (Burnaby), School of Mechatronics Engineering (Surrey), School of Sustainable Energy Engineering (Surrey); University of Victoria; University of Northern British Columbia (Prince George), and Thompson Rivers University (Kamloops).

- assist reporting for accreditation.
- expand capacity and improve access to engineering education.
- inspire community engagement and partnerships.
- enhance the learning environment for students.

Because of the CFYEC, most rural and urban colleges and TIUs in BC now offer a defined set of first year courses that allow students in their regions to access engineering education, and transfer seamlessly into an engineering school of their choice to continue their studies. The consistent learning outcome experience for students at all post-secondaries in the province provides an opportunity to explore the demographic differences that may exist between the transfer and direct entry first-year cohort as well as with that seen in the final year of engineering studies.

Two institutions, both signatories to the CFYEC, were piloted to develop and evaluate a survey tool to measure the student profile at the first year and final year of studies. These institutions were Simon Fraser University (SFU), housing the School of Engineering Science (ENSC) program, a receiving institution, and Vancouver Island University (VIU), a sending institution and one of SFU's transfer partners. SFU is a comprehensive university in the Lower Mainland, the largest urban region of BC, and its ENSC program has a typical first-year intake of 250 students. SFU ENSC offers accredited engineering degrees in Electronics Engineering, Computer Engineering, Systems Engineering, Engineering Physics, and Biomedical Engineering, where all direct entry students take a common, two-year curriculum before continuing into one of these five program options. VIU is an open-access, teaching intensive university that offers a one-year engineering transfer certificate to serve a catchment area consisting primarily of rural and urban communities within the mid-Vancouver Island region.

1.2 Overview

This paper is the first in a series that chronicles the development and honing of the survey instrument and the preliminary results, analyses and observations leading from it. The primary purpose of this paper is to summarize the iterative process that was involved in creating the surveys. Subsequent papers will provide detailed analyses of the survey results.

The presentation of the development of the survey mirrors our iterative process, which moved from initial development of a fourth-year survey, follow-up interviews, a reflection based on the responses and literature, followed by a first-year survey, and follow-up interviews. While the primary objective for both the survey and the subsequent in-person interviews was to gather and elaborate on students' nuanced experiences in engineering education that may affect their persistence in engineering, an equally important theme emerged: how students engaged with the surveys, which included participation rates and feedback on the survey itself. The overall process reflects practitioners recognizing a problematic situation in their practice and entering a process of change. The iterative process we subsequently underwent is an example of a "reflective conversation with the materials of the situation" [7], where the situational backtalk (or feedback) was provided by the students.

2.0 FOURTH-YEAR SURVEY

2.1 Fourth-year Survey Design

The first survey we developed was given to fourth-year students in the Summer 2023 offering of ENSC 406 - *Engineering Law and Ethics* at SFU, which is one of the few mandatory fourth-year courses all students must complete as part of their degree requirements. Although the timing of the course offering was a pragmatic reason for starting with these students, they were also our desired starting point given their time and experience in an engineering program.

The survey was formulated to ask questions that did not focus on program-specific issues such as duration of study, academic expectations, and course difficulty. The survey, comprising a total of 41 close- and open-ended questions, covered a range topics inspired by current literature, such as identity [8] - [10] (e.g., *"In what ways does your identity shape your experience at SFU?"*), racism and discrimination [11], [12], (e.g., *"Have you experienced racism, sexism, or other forms of discrimination or stigma since starting your studies at SFU?"*), responsibilities outside of school [13] – [15] (e.g., *Do you have responsibilities caring for a dependent (i.e., child or other)?"*), and a ranking scale for a variety of stress factors [16] – [18] (e.g., campus commute, childcare, building connections at school, etc.) The survey also included Likert-type scale questions on mental and physical health [19], [20] (*"Compared to before you started your studies at SFU, how would you rate your mental health (such as feeling anxious, depressed, or irritable) now?"*), and motivations for choosing engineering as a program (pre- and post-enrollment) based on a variety of factors such as financial security, familial influence, and providing for society [21] (*"Please respond to the following statements using the options given: Giving back to society and making a difference was an important factor for enrolling in engineering."*).

2.1 Fourth-year Survey Response Rate

Students in ENSC 406 received a brief presentation (~5 min) regarding the purpose of the survey and the long-term goals of the study. While students were told they would receive no direct benefit to completing the survey, they were reminded that giving back and helping others was an aspect of professionalism (e.g. engineering code of ethics). Students were also told that the survey would ask whether they would be willing to be contacted for a follow-up interview. Following the presentation, students emailed with a link to the online survey administered through SurveyMonkey.

Figure 3 summarizes the response rates based on the 80 students enrolled in the course into four categories:

- *Started* - number of students who clicked on the survey link and responded to the initial consent question (either *Yes* or *No*).
- *Submit* - number of students who agreed to have their answers be part of the data set.
- *Interview* - number of students who agreed to be contacted for a follow-up interview.
- *Interviewed* – number of students who were interviewed.

The percentages shown in the figure under each category represent the percentage of the class that participated in that activity (e.g., are shown as *Yes*).

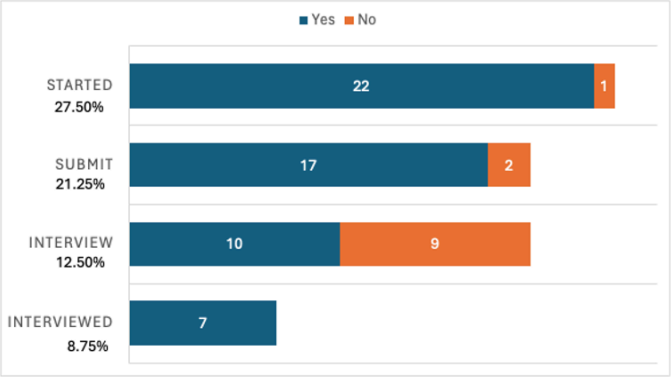

Figure 3: Response rates for fourth-year students

For most questions in the survey, students were able to select a response of *Prefer not to answer* or to skip the question using SurveyMonkey's interface. Figure 4 shows the overall response rate for the survey. Note that branched questions and open-ended questions are removed from this analysis. The *total n* represents all students who started the survey while *consented n* represents only the students who submitted their responses.

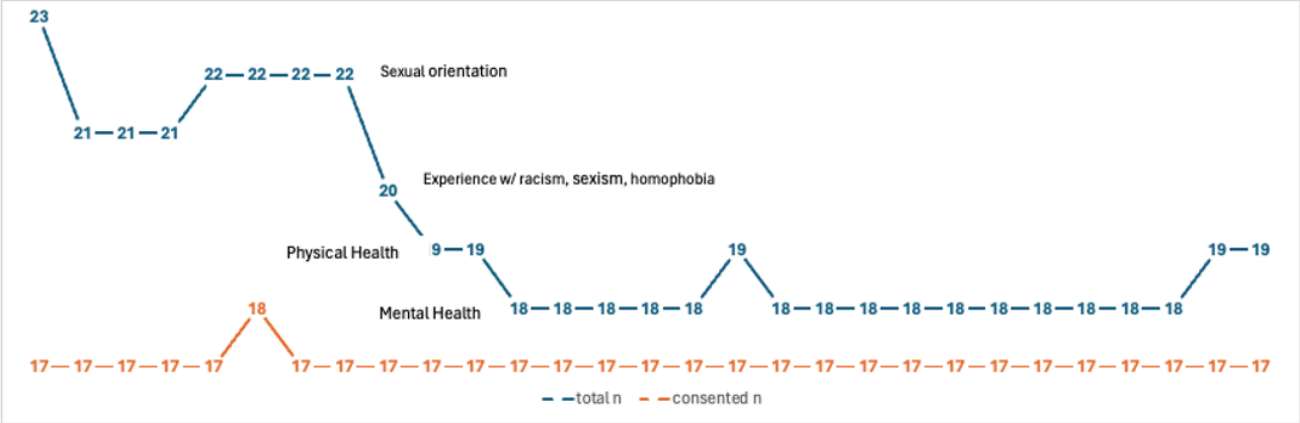

Figure 4: Overall response rates for questions from fourth-year students

The response rate shows that some students stopped participating once questions were asked related to sexual orientation, to experiences involving racism, sexism, and homophobia, and to physical and mental health. To better understand student engagement with the survey, students were categorized as one of

- *Yes* – completed survey and consented for responses to be included in analysis;
- *Skip* – started survey, but did not complete and skipped consent question;
- *No* – completed the survey (to some extent), but explicitly did not provide consent for answer to be included in analysis.

Figure 5 summarizes the response time (in minutes) for each category. A boxplot is used to represent the data of the *Yes* category, whereas individual data points are used for *Skip* and *No* because of the small sample sizes.

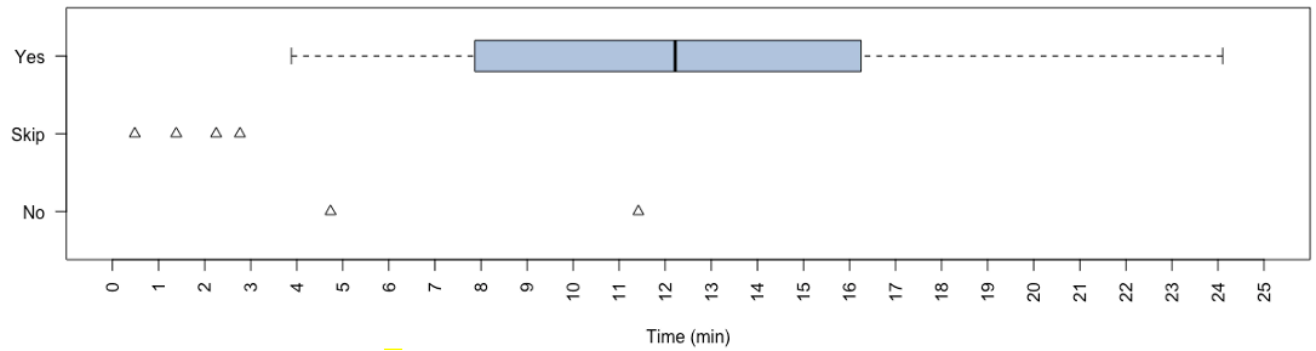

Figure 5: Time active in fourth-year student survey

For visual clarity, the two outliers for *Yes* have been omitted from the graph; the data points are 1716 min [4h:36m:13s] and 521.23 [8h:41m:13s].

As the data demonstrate, students who start the survey but do not complete it (*Skip*) do so in under three minutes. The two students who progressed through the survey, but did not give final consent varied in time, but there is overlap with students who gave final consent. For those who consented (Yes), the median time to completion is ~12 min. As the whiskers of the boxplot show, the range of time to complete varied, and it is questionable whether those who were lower than Q1 (~8 min) were able to sufficiently consider the questions.

All students who completed the survey either agreed or strongly agreed that the instructions for completing the survey were clear and the length of the survey was manageable. Admittedly, these students were the ones who persisted to the end of the survey, so this result does not capture those who left early. Regardless, it is valuable to note that these respondents did not flag anything to address in terms of survey instruction or survey length.

2.2 Self-Determination Theory as a Framework

As we brought together the questions for the survey based on the demographic information, we wanted to collect questions that would capture the experience of students in an engineering school and their motivations to select and continue with engineering, we investigated potential theoretical frameworks that would provide a point of reflection for understanding student responses as well as a means for scrutinizing the types of questions we were asking. The theoretical framework that we selected is Self-Determination Theory (SDT) because it has empirically identified three innate psychological needs (competence, relatedness, and autonomy) that need to be satisfied to allow for self-motivation [22].

Given our interest in understanding why some students persist in engineering while others do not based on individual circumstances, SDT is an appropriate framework because it recognizes that social contexts are importance and "[it] gives context to human nature by describing inherent tendencies and inclinations readily manifested under conditions of environmental supports" [23]. According to [24], who provided an overview of SDT in education practice, it can be used for classroom practice and reforming educational policies. Other studies have used SDT beyond the classroom to support the retention of women in engineering [25], to help develop mentoring activities for under-represented

students in engineering [26], and to understand inclusion in STEM by connecting theory to practice [27].

2.3 Fourth-year Survey Responses and Interviews

Analysis of the survey responses showed that most of the respondents did not consider their identity as a significant factor in their educational experience. With respect to SDT and coding questions based on its three physiological needs, the nature of the fourth-year survey questions were aligned with autonomy**,** followed by competence and relatedness. Some students' responses were also primarily program-related, pointing to the difficulty of courses and exams ("*Exams can be stressful even when taking one course, 'course load' implies to me that I am taking too many courses.*"), the length of the program as a major stressor ("*I don't expect a rigorous degree like engineering lending itself to a fun student life.*"), issues with finding a co-op, and financial difficulties ("*I think a much larger stressor than being away from family is actually the cost of living itself.*"). The concept of identity in the academic space was also discussed ("*So far my identity has not really impacted my experience positively or negatively in my opinion.*"). The breakdown of responses also supplied a new perspective when considering the nature of the questions themselves when asked about potential questions they believe could have been included, one respondent mentioned the importance of understanding degree duration alongside persistence and retention rates ("*If the survey is supposed to answer the question, 'why are people dropping out', it was okay. If it also wanted to ask the question, 'why are people taking so long', I think some questions are missing.*"). Other feedback pointed to incorporating additional questions about motivation, attendance of school events ("… *questions about the current state of student socials, such as clubs, events, etc.*"), personal life, and balance ("*Maybe about balancing social and educational aspect? Lot of colleagues struggle with how much to work/study/socialize.*").

For the semi-structured interviews, questions and prompts were formulated beforehand, and each of the seven participants received the same set. These inquiries encompassed a diverse range of subjects, incorporating a detailed exploration of both new and supplementary queries (i.e., follow-up questions on identity, questions on motivation, etc.). Demographic information was not directly asked; rather, questions were worded indirectly for respondents to elaborate on personal characteristics on their terms, should they feel comfortable doing so (e.g., *"Have you ever felt the need to hide or downplay certain aspects of yourself in order to fit into the engineering environment?"*).

For these interviews, the primary intent was to avoid critiques of the engineering program and instead focus on areas related to equity, diversity, inclusion, and access (EDIA) as well as and personal experience. Practically, however, students' program- and academic- related criticisms cannot be excluded from the narrative as these experiences are critical factors that shape their educational trajectories; therefore, they cannot be viewed separately. To ensure students could still express their thoughts but still touch upon EDIA and personal experience, questions and discussions were aimed to reroute students' program-related critiques and delve into the personal effects of these potentially negative experiences. Take, for instance, a participant that begins a conversation regarding the excess time and effort required in a difficult engineering course. Time management – a struggle for many students – provides the opportunity to ask a follow-up question about their perspectives on the importance of having more time. From here, the participant can reveal additional information about their commitments outside of school, such as caring for a child or family member or having a job to

support themselves financially. Not only would this navigate the conversation through as opposed to away from the academic critique, but it would also validate the participant's feelings over their current situation.

With respect to the tenets of SDT, most of the interview responses involved the concepts of autonomy and competence, followed by relatedness. Similar to their responses on the survey, most students responded with criticisms about the program, with the main complaint being that the program completion timeline was advertised incorrectly. Students felt they had little choice in how to manage their time between difficult courses and their regular lives. Respondents described the engineering education climate as competitive, where feelings of incompetence, fear of failure and difficulties falling behind are easily fostered. Respondents, however, state that they choose to persist despite this, as they cannot see themselves in any alternative program (especially given how much time has already been committed to the program). The concept of identity is not regarded as relevant in the grand scheme of engineering education, as respondents believe that university is mostly for academic purposes as opposed to self-expression (i.e., class attendance, receiving good grades). Friends (particularly in-program) act as good support systems and motivators when wanting to complain about academic hardships and when needing a reminder to keep up (in fear that they will not continue the program alongside them). Respondents did not recall any experiences with discrimination or stigma and believed that SFU ENSC is diverse, though it lacks overall connection among peers and faculty – this is believed to be a cause of personality differences (i.e., introversion) rather than demographic characteristics.

3.0 FIRST-YEAR SURVEY

3.1 First-year Survey Design

The survey responses and feedback supplied by the fourth-year students assisted in updating the development of the online survey for the second round of distribution with first-year students. The first-year student survey was given to students in the Fall 2023 offering of SFU ENSC 105W – *Process, Form, and Convention in Professional Genres* and VIU ENGR 112 – *Engineering Design I*. Both ENSC 105W and ENGR 112 are mandatory first-year courses, and typically completed in the first term of study. Given the time to complete the survey coupled with student feedback that the survey length was reasonable, the survey was modified to add additional questions inquiring about students' encounters and experiences in engineering education on a more personal matter and in the context of EDIA. Specifically, students were asked about their experiences in engineering education with respect to: both their own and their peers' demographic characteristics [28] (i.e., race, sexuality, gender, etc.); the concept of autonomy in group and classroom settings [5] (e.g., *"Identify the role you typically have when in a group project"* and *"Identify the role you would prefer to have when taking part in a group project"*); their sense of belonging [5]; their perspectives on the potential struggles of certain minority groups within engineering [2]; their thoughts on the efforts executed by their engineering program and institution to promote EDIA within the school; their motivations in choosing engineering as a program (pre- and post-enrolment); and the significance (if deemed applicable or relevant) of their identity to themselves and to creating a positive and dynamic learning environment [3], to name a few. As previously mentioned, students were also questioned about their time utilization and management, and how (if at all) it tied into stress (*"What are the top three outside factors impacting how you manage your course load since starting at SFU/VIU?"*). These efforts were made to provide students with questions more directly in line with the project's main goal.

The updated survey was coded with respect to the three psychological needs of SDT, resulting in the following distribution: 39 autonomy; 35 competence; 52 relatedness. Note that more than one code could apply to individual questions. While the foundational work of SDT did not speak to the importance of one need over the other, a meta-analysis of 144 SDT studies conducted by [29] suggests that competence is the strongest predictor of self-determination followed by autonomy and then relatedness. The number of questions in the revised category for each need is in the reverse order of the importance of each need. At this point in the development of an ongoing survey instrument, the number of questions per need should not be inferred as the importance of each need related to one another.

3.2 First-year Survey Response Rate

Similar to the process taken with the fourth-year students, the first-year students received a brief presentation regarding the purpose of the study. The primary difference in timing was that the fourth-year students were given the survey towards the beginning of their semester, whereas the first-year students were given the survey towards the end of the semester. For the former, the survey was given towards the beginning of the semester so as not to conflict with major assessments that often occur in the last half of the semester. For the latter, the survey had to be given towards the end of the semester because the survey asks questions related to experiences that happen in the first few months during the transition to university.

Figure 6 summarizes the response rates for the 267 at SFU ENSC and the 44 students at VIU. The definition of the categories of *Started*, *Submit*, *Interview*, and *Interviewed* are the same as those defined for Figure 3. The bar graphs for each category show the number of *Yes* and *No* responses for each institution. The percentage combines the Yes responses for both institutions.

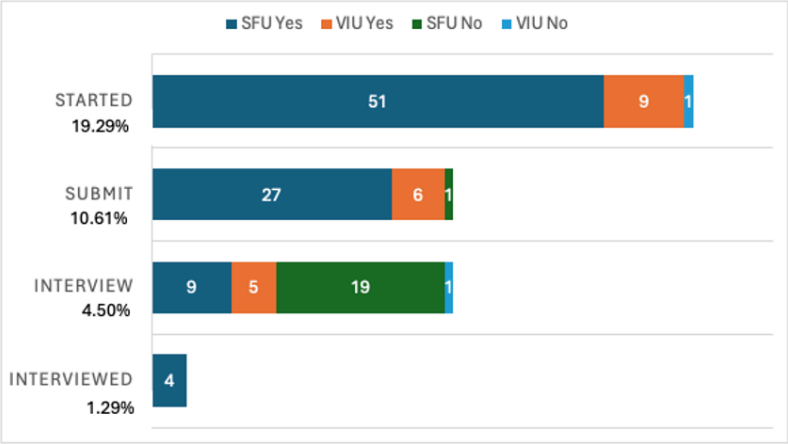

Figure 6: Response rate for first-year students

Table 1 summarizes the participation rates for the four categories for the fourth-year students and the first-year students as a percentage of the cohort (see Figure 3 and 6).

Table 1: Summary of participation between fourth-year and first-year students

	Started	*Submit*	*Interview*	*Interviewed*
Fourth-year	27.50% (22)	21.25% (17)	12.5% (10)	8.75% (7)
First-year	19.29% (60)	10.61% (33)	4.5% (14)	1.29% (4)
$\Delta 4^{th}$ *to* 1^{st}	-8.21% (38)	-10.64% (16)	-8.00% (4)	-7.46% (-3)

The clear trend is a decrease in the percentage of students participating, which ranges from a decrease of 7.46% to 10.64%. The absolute number of those submitting *Yes* to these categories all increased except for those who were interviewed. One difference between the fourth-year and first-year interviews is that the former occurred during the same semester of the survey, whereas the latter occurred the following semester because of the survey was given later in the semester.

Figure 7 shows the overall response rate in terms of engagement. Similar to the construct of Figure 4, branched and open-ended questions were removed. Once again, the *total n* represents all students who started the survey while *consented n* represents only the students who submitted their responses.

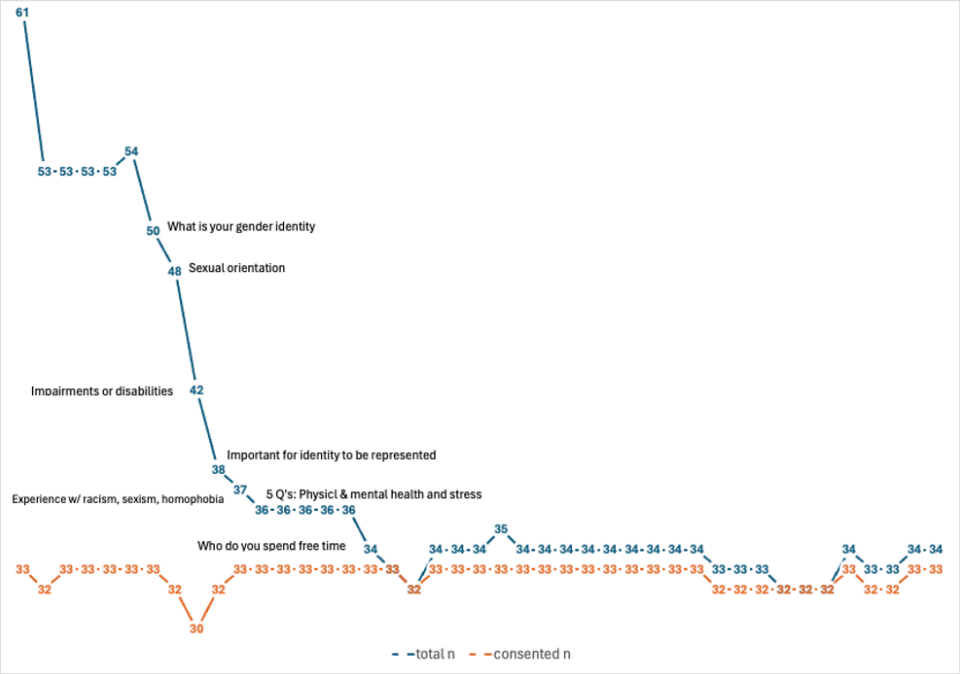

Figure 7: Overall response rates for questions from first-year students

The overall trend is similar to the fourth-year students: students click on the survey link and then many do not complete the survey by providing final consent. Given that just under three times the students clicked on the survey link compared to the first survey (61 fourth-year students versus 23 first-year students), the drop off is more prominent. Again, the number of participants drops off significantly once questions are asked related to sexual orientation, to experiences involving racism, sexism, and homophobia, and to physical and mental health.

With regards to time spent engaging with the survey, Figure 8 similar trends as Figure 5. Given the increased sample size for those marked as *Skip*, a boxplot for these data is included. Only one student explicitly said no to submitting their data. Once again, some outliers have been omitted for visual clarity: one outlier for *Skip* (123.9 min [2h:03mm:55s]) and three outliers for *Yes* (166.3 min [2h:46mm:20s], 204.8 min [3h:24mm:27s], 1314.4 min [21h:54mm:23s])

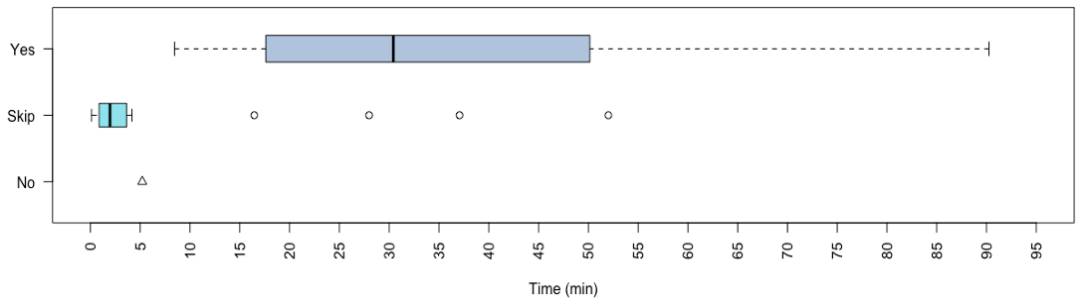

Figure 8: Time active in first-year student survey

Only one student made it to the end of the survey and selected *No* to submit their responses. This student was active in the survey for 5 min and 12 sec. If the student were to have seen all 86 questions (includes the consent question at beginning and end as well as all the branching questions), then the average time per question was 3.6 seconds. The inference can be made that the student simply clicked through questions quickly without answering. Because the student did not consent for their answers to be included in the dataset, further analysis on any responses is not possible.

Students marked as *Skip* spent a median time of ~2 min active in the survey, which corresponds with the early drop off shown in Figure 7. The outliers answered questions up to those asking about sexual orientation or having any impairments. Perhaps these students intended to come back to the survey to complete it but never did.

For those consenting to submit their responses (*Yes*), the median time for completion was 30 min and 25 sec, which corresponds to the amount of time (30 mins) we told students the survey would take. For this boxplot, Q1 = 17.6 min and Q3 = 50.15. Students requiring more time than those in the interquartile range may have needed to come back to the survey. This would certainly be the case for the outliers, who had the survey "active" for over a couple of hours. And a comment from one of the participants who was interviewed (as reported later) corroborates this interpretation. The increase in median completion time from the fourth-year survey to the first-year survey is not a surprise given the increase in the number of questions.

Students completing the first-year survey were also asked to respond to statements about the clarity of instructions and the length of the survey. Using a diverging stacked bar chart for the responses of *Strongly disagree* (SD), *Disagree* (D), *Neither agree nor disagree* (N), *Agree* (A), and *Strongly agree* (SD), Figure 9 summarizes the responses of the first-year students.

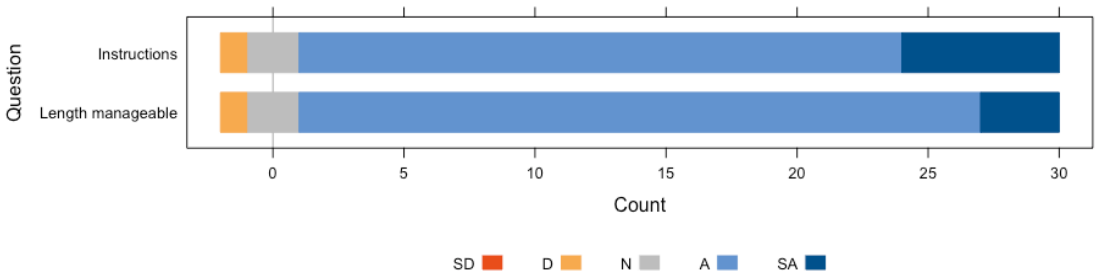

Figure 9: Response for questions regarding the first-year survey

Recall that the responses to these same statements by the fourth-year students only had answers in the category of *Agree* and *Strongly agree*. The majority of responses for the first-year survey fall within these two categories; however, the responses have shifted more towards only agreeing with the statement, and a few students selected *Disagree* of *Neither agree nor disagree.*

3.3 First-year Survey Responses and Interviews

A general analysis of survey responses displayed an overall increase in discussion over the students' engineering education experience through an EDIA lens. Respondents provided more information regarding their personal characteristics, values and perspectives on the concept of diversity and inclusion in the academic space ("*I think that representation can help me to not feel as alone, and it is encouraging to see others like you …*"), the significance (or insignificance) of their identity in engineering ("*It molds who I am here. As I deal with people who have different identities, it keeps me grounded to have this identity and see which peers I can talk to.*"), and their perceived struggles of certain minority groups in the engineering field, such as those with physical disabilities ("*Everything is going to be harder when your body doesn't function as well as others.*"). Underrepresentation and stigma were discussed, particularly pertaining to gender and sexuality ("*The types of characters that the engineering program attracts are quite egotistic with a lot of underlying prejudice against all minority groups, more specifically women, and the LGBTQ community.*"). Respondents also recommended more questions on self-expression, perceived engineering traits, and preparedness, particularly during the period of transition between high school and university.

Of the 10 first-year students that indicated interest for the subsequent in-person interviews (nine from SFU, one from VIU), four SFU students completed the interview process. Therefore, a limitation of these interviews is that these respondents may not be representative of the cohort at large, and certainly did not match it demographically. Regardless, their responses provided a deeper insight into how the survey questions were perceived and what impact survey questions may have had, particularly by and on individuals within minority groups who may incur an additional emotion burden when responding to experiential questions [30] and/or are increasingly asked to contribute to EDIA efforts [31]. Interview questions involved a mix of new and previously used questions (from the online survey and the script used for the fourth-year students). These questions included direct prompts about demographic characteristics (i.e., *"What is your race/gender/sexual identity?"* and *"What can you say about your experiences in engineering education with respect to your race/gender/sexual identity?"*), and self-expression (i.e., *"What does self-expression within engineering education look like to you?"* and, *"Do you think self-expression is important in engineering education specifically?"*).

During the interviews, first-year respondents were also asked to provide feedback regarding their thoughts about the online survey to determine which questions students were less likely to answer. Of all that was discussed, there were four main criticisms that were most prominent: survey length, repetition of certain types of questions, density of questions, and relatability to some questions. Individuals noted that the length of the survey (86 questions, ~30 minutes) could be a potential deterrent to completion and may explain why some students drop out midway, though they themselves did not think it was a major issue. Repetition was another concern, as some respondents noted encountering redundant questions throughout the survey. Respondents also pointed out the unexpected *density* of the questions provided, stating that what they believed would be a "simple" survey about their academic experiences actually required more thoughtful and time-consuming replies, which led to taking the survey in intervals (i.e., continuing every few hours or days, if they remembered to do so) as opposed to completing it in one go, or dropping out. The boxplot in Figure 8 and its associated outliers suggests other students completed the survey in a piecemeal fashion. Lastly, respondents recalled a lack of relatability in some questions, which inhibited a reflective and elaborate response as they did not believe they could speak about experiences they had not personally encountered. For instance, a White, heterosexual, male respondent may have had difficulties responding to questions regarding their perception of the engineering student experience for those who are part of a visible minority group, the LGBTQ+ community, or who identify as female.

4.0 CONCLUSION AND FUTURE WORK

This paper has discussed the iterative process underwent to develop a survey instrument that intends to seek broad demographic details for students in their first and last year of engineering studies. The resulting survey instrument is informed by the Self-Determination Theory as a framework, and the survey has evolved through reflective in-person interviews intended to elaborate on students' nuanced experiences in engineering education as well as their perception of engaging with the survey questions. The resulting instrument, despite being broader and directive with respect to EDIA content, saw limited change in how the participation rate of students drops off when questions related to gender identity, sexual orientation, and or experience of sexism are posed. These questions are seen to act as gatekeepers, and students who persist through them typically would continue and complete the entire survey. Further, some students simply skipped most if not all questions in the survey, providing a completion but few results. These and other factors suggest that the demographic data may not be indicative of the first or final year cohort.

To improve engagement of each cohort, several changes to the survey are envisioned including requiring all questions to be answered (i.e., including only a *Prefer not to say* option instead of also allowing students to skip a question), and inclusion of "attention check" questions to measure student engagement. Evaluating the order of questions may verify that some types of questions inhibit students continuing with the survey, while providing an incentive to complete the survey (e.g., entry into a prize draw, or a token payment) may improve both the participant and completion rate. Considering when the survey instrument is offered to students, particularly those in first year, may also be of value. In the pilot study, the survey was offered towards the end of the first term of study; it is unclear if students have developed sufficiency to respond to the rigors of academic studies to find time to respond to the survey. Offering the survey instrument early in the second term of the first year may address this concern.

Engineering education faces significant challenges related to addressing student persistence and retention within engineering programs. Moving forward, the goal is to expand the survey instrument to include other post-secondary institutions within British Columbia to provide a tool that can be used to help ensure that students of all backgrounds, identities, and demographics are provided an opportunity to thrive without compromise.

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