Bridging Between High School and University: Assessment of Students' Readiness to First-Year Engineering Programs

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This descriptive case study uses self-assessment tools to explore 26 prospective students' preparedness regarding their knowledge and competencies for entering the first year of engineering programs at a large, research-intensive Canadian university. We aim to provide insight for developing the Brigde2Engg (B2E) Program to empower and support students in their transition to university. Applying Conley's college readiness model as a theoretical framework, findings from this study reveal that most students appear confident about their knowledge and skill preparedness for the first-year engineering programs, including their critical thinking abilities, problem-solving skills, and understanding of engineering professions. However, they are less confident in physics and the use of engineering tools. Therefore, we suggest that, when they choose to participate in the bridging program, these students should focus mainly on the subject they deem inadequate. Results also show that an introduction to engineering tools is essential to familiarize students with the programming and spreadsheet software they will use throughout their university programs.

Keywords: bridging program, high school, transition, engineering programs, self-assessment, college readiness

INTRODUCTION

The admission requirements of engineering programs in Canadian universities solely focus on academic credentials (i.e., grade point average) instead of other essential skills and competencies. High school students need competitive average scores in specific required courses to be admitted to the engineering programs. For example, to be admitted into the engineering programs at the University of Alberta (U of A), high school graduates need competitive average scores on the following five courses: Math 30-1, Math 31, Chemistry 30, Physics 30, and English 30-1. However, meeting high school graduation requirements and basic eligibility requirements for university programs may not necessarily lead to being prepared for university-level work (Conley, 2007, 2010).

University readiness refers to "the level of preparation a student needs to enroll and succeed in a credit-bearing course at a post-secondary institution" (Conley, 2008, p. 24). Most students enter university without the basic content knowledge, skills, or academic habits needed to succeed in university-level work (Venezia & Jaeger, 2013), such as the foundational knowledge in subject-matters, problem-solving and critical thinking skills, independent study, and time management skills (Jansen & Suhre, 2010; Kowalchuk et al., 2010; Lane et al., 2020). Transition into engineering education can be extremely challenging because of demanding academic expectations and different academic environment. Students are underprepared for this because of misalignment and disconnect between high school graduation standards and university admission/entrance academic expectations (Conley, 2007; Venezia & Jaeger, 2013). Furthermore, the academic environments of high school and university are completely different. While the former is more structured and guided by teachers, the latter requires independent, less-structured learning (Smith et al., 2013). In addition, the expectations for engagement and intellectual development differ (Conley, 2007). Students who transition to engineering programs tend to lack independent study skills and are unprepared for university-level courses, regardless of their background and previous educational experience (Kopparla et al., 2022). Additionally, several studies reveal that prospective first-year engineering students tend to be underprepared in academic subjects, including math, chemistry, and physics (Casanova et al., 2021; Raines, 2012). Additionally, many students entering the university lack time management and skills such as problem-solving and information literacy (Jansen & Suhre, 2010; Kowalchuk et al., 2010; Lane et al., 2020). Underprepared students tend to feel ineffective and distressed and lack a sense of belonging within the engineering programs (Kopparla et al., 2022; Salas-Morera et al., 2019). As a result, unprepared STEM students will likely drop out of their programs or leave university entirely (Cámara- Zapata & Morales, 2019; Chen & Soldner, 2013). Most importantly, many students may not know that they lack these skills until they enter the university (Conley, 2010). Consequently, high school graduates need guidance and support services to be equipped with the academic knowledge and suitable learning strategies to better transition to and succeed in their first-year engineering programs.

Many Canadian post-secondary institutions such as the University of British Columbia (UBC), the University of Saskatchewan (USASK), and the University of Alberta (U of A) have developed bridging programs, to address the issues of underprepared students and support their transition with the goal to increase their resilience to succeed in their first-year engineering programs (Chen & Soldner, 2013; Sablan, 2014). At the University of Alberta, the bridging program, namely Bridge 2ENGG (B2E) is designed to reduce the gaps between high school graduation requirements and university expectations and ensure prospective students are prepared and confident in their abilities to adapt to university-level subject matters and university learning environments (Matanin et al., 2007). However, students' needs will likely differ and require more targeted and individualized support. Hence, self-assessment can inform faculty members of the students' needs and provide guidance to the B2E Program to empower and support students in their transition to university. Further, practicing self-assessment allows prospective engineering students to understand the expectations of engineering programs, including the competencies and knowledge required to be better prepared for first-year engineering programs. The self-assessment surveys also allow students to reflect on their performance, understand their strength and weaknesses, see the gaps in their learning and helps them to be more critical and reflective towards their learning process and outcomes (Liang, 2006; Van Hattum-Janssen & Lourenço, 2008).

Yet, little attention has been paid to prospective engineering students' perceptions of their competencies and knowledge. Therefore, this study fills the gaps in exploring prospective students' self-assessments of their preparedness for entering engineering programs at a Canadian university. Applying Conley's college (university) readiness model as a theoretical framework, we consider the knowledge and competencies required to succeed in first-year engineering programs (Conley, 2007, 2008, 2010). This study investigates two research questions:

1. How do high school graduates perceive their knowledge preparedness in entering first-year engineering programs?
2. How do high school graduates perceive their competencies in entering first-year engineering programs?

Students' Self-Assessment in Engineering Programs

Self-assessment refers to "the involvement of learners in making judgements about their own learning, particularly about their achievements and the outcomes of their learning" (Boud & Falchikov, 1989, p. 529). Banta & Palomba (2014) note that self-assessment allows students to reflect on their own learning and development. Further, as a key component of formative assessment and life-long learning, self-assessment enhances students' learning by helping them identify their strengths and weaknesses and reflect on their learning process, see gaps in their learning and set their learning goals (Basnet et al., 2011; Brown et al., 2015; Sloan & Scharff, 2022). It also provides teachers with a different lens to view students' performance and informs teachers of students' needs (Blanche, 1988).

Self-assessment has been applied in engineering programs for various purposes. For example, Nielsen et al. (2015) used self-assessment tools to pre- and post-test in a first-semester engineering course and concluded that the assessment allowed students to identify the gap between their current knowledge and the course expectation. The faculty members in this study also noted that the post-assessment guided in developing the course (Nielsen et al., 2015). Moreover, Kyoung et al. (2017) used self-assessment tools to explore how mathematical ability and other "soft" engineering skills (leadership and teamwork) influence students' persistence in engineering graduate programs and related careers. Their findings indicate that students who reported more confidence in "soft" skills tend to enter engineering industries. El-Maaddawy (2017) implemented a self-assessment paradigm in a civil engineering design course and found that the self-assessment improved students' understanding of the course content, developed their self-regulated learning skills, and enhanced their academic results. Lastly, Sloan and Scharff (2022) used Knowledge surveys (respondents rate their ability to answer a question or perform a skill) to examine the accuracy of student self-assessment. Their findings demonstrate that students' self-assessment is reasonably accurate, and self-assessment can be a powerful and potential tool for "achieving the Accreditation Board for Engineering and Technology (ABET) student outcome for acquiring and applying new knowledge, both in academic and professional settings" (Sloan & Scharff, 2022, p.1).

Summer Bridge Programs for First-Year Engineering Students

Summer bridge programs usually occur before a student's first year at university. To promote academic success and improve student retention, summer bridge programs are designed to familiarize prospective students with the campus environment and prepare them with the skills required for academic coursework (Cairncross et al., 2015; Raines, 2012). The bridging programs typically include academic content and workshops on social and study skills (Sablan, 2014). Bridging programs can help students adjust to university life, ensure their choice of major, set realistic academic expectations, and provide opportunities to meet with peers, faculty members, and administrative staff (Harkins, 2016). Specifically, Cairncross et al. (2015) note that bridging programs can "enhance students' interest in and commitment to the engineering field" (p. 5). The related literature on summer bridge programs focuses on the programs' development, implementation, and evaluation.

Many Canadian universities have developed summer bridge programs to facilitate students' transition into university and improve their academic success. For example, the UBC Summer Transition to Engineering Bridge Program (STEP) aims to provide "important engineering themes and concepts to enhance the experience of incoming first-year students" through introductory engineering courses (UBC, n.d.). The USask Summer Bridging Program offers a list of options for students, such as introductory engineering courses, study skills, and health and wellness information (USask, n.d.). The U of A Bridge2EnGG provides opportunities for students to build connections within the engineering community, learn about the engineering field, master basic learning skills and other competencies, refresh physics and calculus skills and knowledge, and build excitement about engineering (U of A, n.d.).

Based on specific program goals, Barnett et al. (2012) categorized bridging programs into academic-focused and university knowledge-focused programs. Matanin et al. (2007) outlined three essential components of engineering bridging programs: “academic enrichment in math, chemistry, and engineering fundamentals, social development within the university community, and professional/personal development” (p. 12). Ashley et al. (2017) reviewed 14 engineering bridging programs and found that both quantitative (surveys and tests) and qualitative methodologies (interview and focus group) can be applied to evaluate the bridging programs. For example, pre-post surveys or comparison groups assess students’ academic success, while interviews or focus groups allow us to understand students’ thoughts and experiences (Ashley et al., 2017). Similarly, Nazempour et al. (2019) used formative and summative assessments to evaluate the summer bridge program.

THEORETICAL FRAMEWORK

This study applies David Conley’s college (or university) readiness framework (2007, 2008, 2010) to understand students’ perceptions of their competencies and knowledge readiness as they enter their first-year engineering programs. According to Conley (2007, 2010), students need non-cognitive and cognitive attributes to persist in post-secondary education. Conley’s college readiness model consists of four components that students should possess to succeed in credit-bearing coursework: key cognitive strategies, key content knowledge, academic behaviors, and contextual skills (Conley, 2008). Key cognitive strategies are intellectual capabilities critical for university-level work, including critical thinking and analysis, problem-solving, precision and accuracy, research, reasoning, and interpretation (Conley). Key content knowledge is academic knowledge, such as understanding the fundamental concepts, skills, and structures in core academic disciplines, such as math, English, physics, science (Conley, 2008, 2010). Writing is also critical to college success (Conley, 2008).

Academic behaviors encompass study skills and educationally purposeful self-management behaviors (Conley, 2008). Self-management behaviors mainly represent students’ ability to understand their current mastery of a subject, self-reflect on their learning process, perseverance, work ethic, and the capability to transfer learning to similar contexts. Essential study skills include time management, information literacy, note-taking, independent learning, and exam preparation. Finally, contextual skills are also called college knowledge, which is associated with applying to the university, getting financial aid, and understanding the university culture and organizational structure. Contextual skills also include building relationships with peers and faculty, through teamwork, and interacting with professors and administrators, as well as leadership skills, and communicating with people from different backgrounds (Conley 2007, 2008, 2010; Geiser & Santelices, 2007).

The college readiness model has been applied to evaluate the effectiveness of intervention programs and develop summer bridge programs. For example, Castro (2013) evaluated an intervention program developed by an Illinois college for high school students by mapping the program activities onto Conley’s framework. Sablan (2014) suggests that the four dimensions of the college readiness framework help understand the activities of summer bridge programs. Lane et al. (2020) also applied this framework to examine how STEM intervention programs equip underserved students with academic and context-specific knowledge to be better prepared for the STEM curriculum and university expectations.

METHOD

This research uses a descriptive case study approach. According to Yin (2009), case study is a methodology that is employed to gain an in-depth, multi-perspective understanding of issues or phenomena in their real-life context. This research approach is useful for collecting, formatting, and processing information that aims to capture the evolving and complex nature of phenomena related to a social system that is imbued with its own dynamics (Karsenti & Savoie-Zajc, 2011). Case study is a flexible methodology that allows the researcher to use a qualitative, quantitative, or mixed methods design, depending on the epistemological standpoint in which his research question is situated (Merriam,1989).

In this study, our research questions were situated within a postpositivist worldview. A descriptive quantitative case study was employed to gain insight into the prospective students' self-assessment of their knowledge and competencies at the U of A. Surveys were used as the data collection technique (Appendix 1). The survey was designed based on the Alberta K-12 competencies (Alberta Education, 2016) and the University of Alberta engineering entry-level Graduate attributes (GAs) (Canadian Engineering Accreditation Board (CEAB), 2014). The CEAB published 12 GAs in 2008 to specify the competencies students should acquire when completing an accredited program in engineering. The 12 GAs are as follows: a knowledge base for engineering; problem analysis; investigation; design; use of engineering tools; individual and teamwork communication skills; professionalism; the impact of engineering on society and the environment; ethics and equity; economics and project management; and lifelong learning. The U of A Faculty of Engineering developed Aspects and Indicators for these 12 GAs, to evaluate the competencies engineering students need to possess after taking specific courses (Dew et al., 2014). Combining the K-12 competencies and Engineering GAs, this survey focuses on eleven aspects: knowledge-based skills; critical thinking; problem-solving; creative thinking; the impact of engineering on society and the environment; professionalism; ethics and equity; individual and teamwork; communication; the use of engineering tools; and lifelong learning.

Self-Assessment Surveys

Surveys were sent to prospective engineering students who registered for the Bridge2ENGG (B2E) program in spring and summer of 2022 at the U of A. B2E consists of three levels: foundations; academic essentials; and ENGG camp (U of A, n. d.). The potential participants for our survey are Alberta high school graduates who registered in the B2E program in July 2022. 427 students registered in the B2E Moodle platform (free programming, Foundations, Level 2 programming Academic Essentials, and Level 3 ENGG Camp), and 326 accounts registered in the B2E Discord Server (some of them are also registered on the eClass page, but not necessarily all). The Moodle platform was used to provide formal program information while the Discord server was initiated to allow direct communication between the program team and the participants and allow participants to discuss among themselves and create a network and a support community to undertake various challenges.

However, we could only collect location information for the students who paid for either Academic Essentials and/or ENGG Camp. By collecting their location information, we found that the total number of high school graduates from Alberta who paid for academic Essentials and/or ENGG Camp is 115. First, we sent out surveys to all Academic Essentials and ENGG Camp participants three times. The B2E program coordinator also requested that participants complete the survey by the end of the ENGG Camp. Secondly, the coordinator emailed the survey to the 326 students on the Discord Server. Lastly, the survey link was posted on the B2E Moodle platform to be accessible to the 427 participants. We received 26 responses, including 23 domestic and 3 international students. A 50% or higher response rate was anticipated, but the actual response rate was low (6%). While surveys can be employed to efficiently and effectively collect data about a large group of people, a low response rate is problematic, as it raises the possibility that the results may be misleading and only representative of those who take the survey. Therefore, the research findings may not reflect elements of the target population with the breadth and depth that would be expected. Consequently, our results cannot be generalized to all the students.

In the sample (n = 26), 22 respondents (84.6 %) completed high school in 2022, two graduated from high school in 2021 or earlier, one had a college diploma, and one with an International Baccalaureate (IB) diploma. The survey comprised 52 items and two extra items assessing students' level of education and identity (international or domestic). The 52 questions asked about students' perceptions of their competencies and skills in five areas: (1) knowledge-based skills; (2) key cognitive strategies; (3) engineering-related knowledge and skills; (4) academic behavior; and (5) contextual skills.

Data Analysis

The data were analyzed with SPSS software, using descriptive and inferential statistics methods. On the one hand, for the descriptive analysis, all the items measuring the same construct with the 5-point and

3-point Likert-type scale were subjected to reliability analysis using Cronbach's alpha method and then combined by their mean into single variables. Then, bar graphs were used to illustrate the proportions of each response of these variables. On the other hand, the choices of the nature of the inferential statistics (parametric vs. non-parametric tests) were made after verifying the normality of the variables using the Shapiro-wilk (W) test, which is adequate for sample sizes less than 50 (Larson- Hall, 2009).

RESULTS

Following the theoretical framework, we analyzed the data from five aspects: key content knowledge; key cognitive strategies; engineering-related knowledge and skills; academic behavior; and contextual skills.

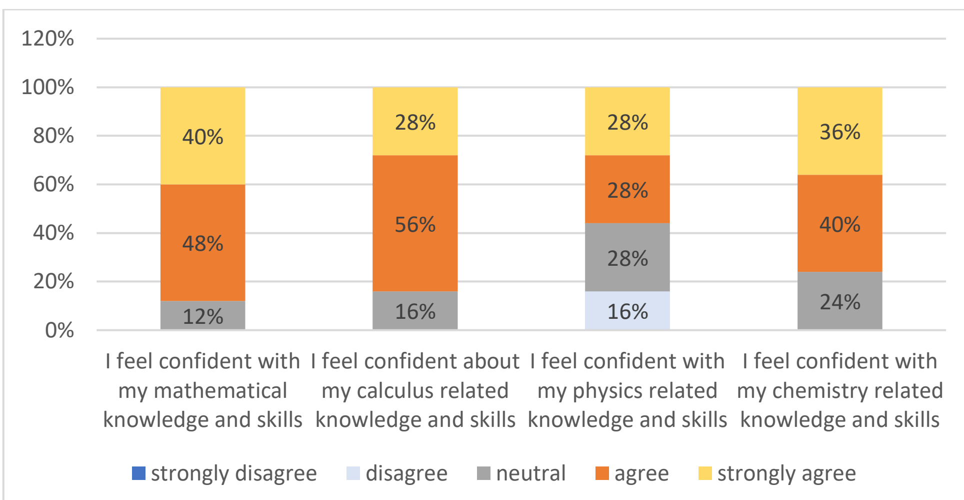
Key Content Knowledge

Key content knowledge is also referred as knowledge-based skills, which were measured by four questions about students' confidence in mathematics, physics, chemistry, and calculus.

Insufficiency in Physics

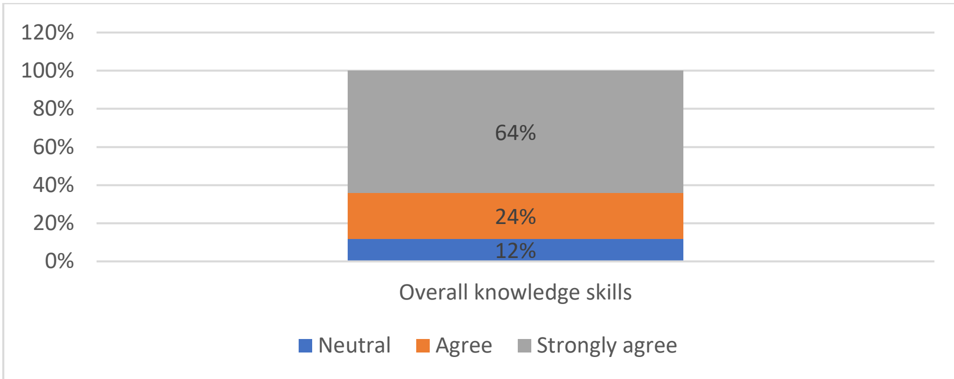
When entering the bridge program, 8 out of 10 students seemed confident in their mathematics, calculus, and chemistry skills. However, when it came to physics, only 6 out of 10 appeared to be confident (Figure 1).

FIGURE 1
PARTICIPANTS' SELF-ASSESSMENT OF THEIR KNOWLEDGE-BASED SKILLS



To understand students' overall perspectives regarding their knowledge-based skills, the four items that measure (question 3 in Appendix 1) that variable have been subjected to a reliability analysis using Cronbach's alpha (α) method. The result $\alpha = 0.74$ enables us to combine the 4 items into one single variable. By using this approach, we found that 88 % of the students agree to be confident in their abilities in knowledge-based skills (Figure 2).

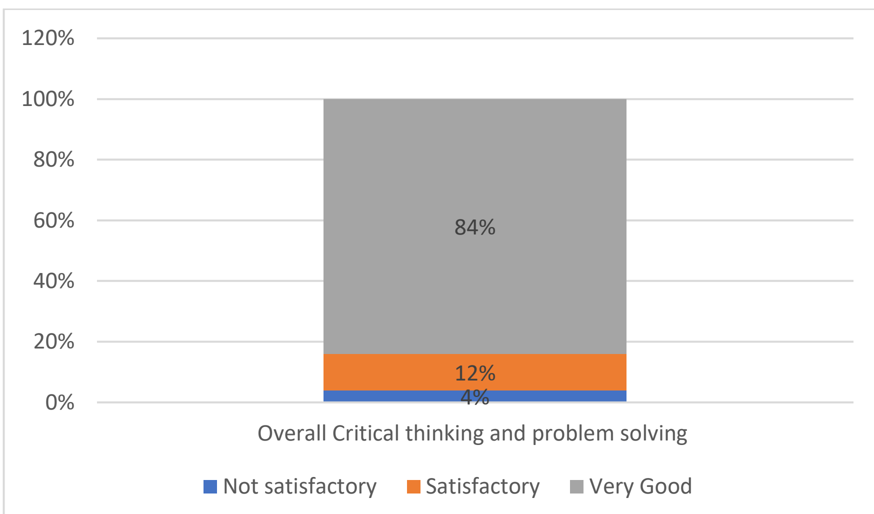
FIGURE 2
PARTICIPANTS' SELF-ASSESSMENT OF THEIR OVERALL KNOWLEDGE SKILLS



Key Cognitive Strategies

Key cognitive strategies were assessed by questions about their critical and creative thinking, as well as problem-solving abilities. The 6 items (α = *0.867*) (question 4 in *Appendix 1*) that measured all the competencies of this component were combined into a single variable. Data shows that 84 % of students perceive their critical thinking and problem-solving skills as being at least satisfactory (Figure 3).

FIGURE 3
PARTICIPANTS' SELF-ASSESSMENT OF THEIR KEY COGNITIVE STRATEGIES



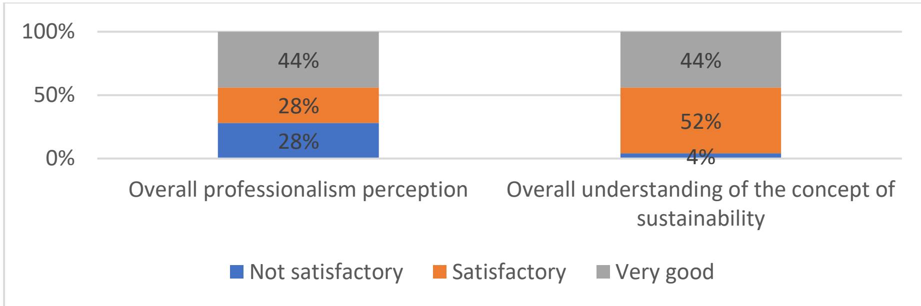
Engineering-Related Knowledge and Skills

Engineering-related knowledge and skills is measured by questions about understanding engineering as a profession, the impact of engineering, ethics and equity issues, and the use of engineering tools.

Understanding Engineering as a Profession

The 3 items that measured this competency were combined into a single variable ($\alpha = 0.703$) (question 6 in **Appendix 1**). The data shows that 7 out of 10 students have at least a satisfactory understanding of engineers' roles and responsibilities in society and the safety measures in conducting experiments and projects. Further, 96% of students have at least a satisfactory understanding of sustainability (Figure 4).

FIGURE 4
PARTICIPANTS' SELF-ASSESSMENT OF THEIR PROFESSIONALISM AND THEIR UNDERSTANDING OF THE CONCEPT OF SUSTAINABILITY

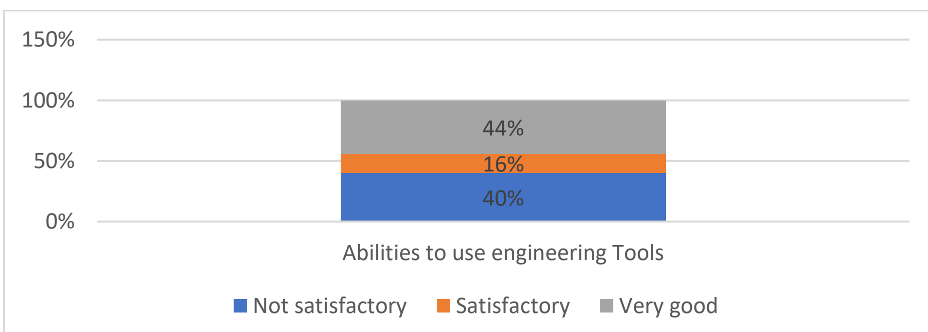


Additionally, we found that students' understanding of engineering professionalism (roles and responsibilities of engineers) is moderately and positively correlated with their understanding of the concept of sustainability ($rs(25) = 0.450, p < 0.05$), the ethical and fairness issues (e.g., integrity, fairness, morality) that underlie engineers' actions and decisions ($rs(25) = 0.438, p < 0.05$), and the environmental impact of the engineering as a profession ($rs(25) = 0.428, p < 0.05$).

Inadequacy in the Use of Engineering Tools

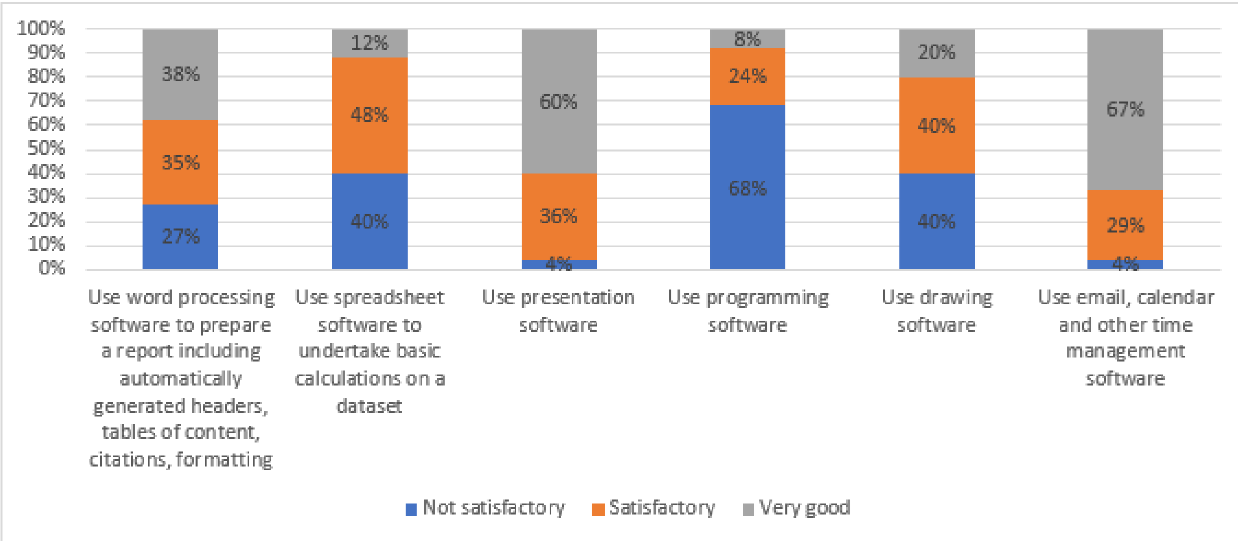
Six items that measured students' abilities to use engineering tools (question 11 in *Appendix 1*), including software and technologies for design projects, assignments, and subject-related work ($\alpha = 0.657$), were combined to create one variable named "abilities to use engineering tools". A high proportion (40%) of students reported not being proficient in use of engineering tools (Figure 5).

FIGURE 5
PARTICIPANTS' SELF-ASSESSMENT OF THEIR SKILLS IN THE USE OF ENGINEERING TOOLS



An in depth look in participants' responses to each item of this competency show that they are satisfied most with using presentation, email and other time management software. However, they are least confident in their abilities to use programming software as well as spreadsheet and drawing software. (Figure 6).

FIGURE 6
STUDENTS' PERCEPTIONS OF THEIR ABILITIES IN THE USE OF ENGINEERING TOOLS

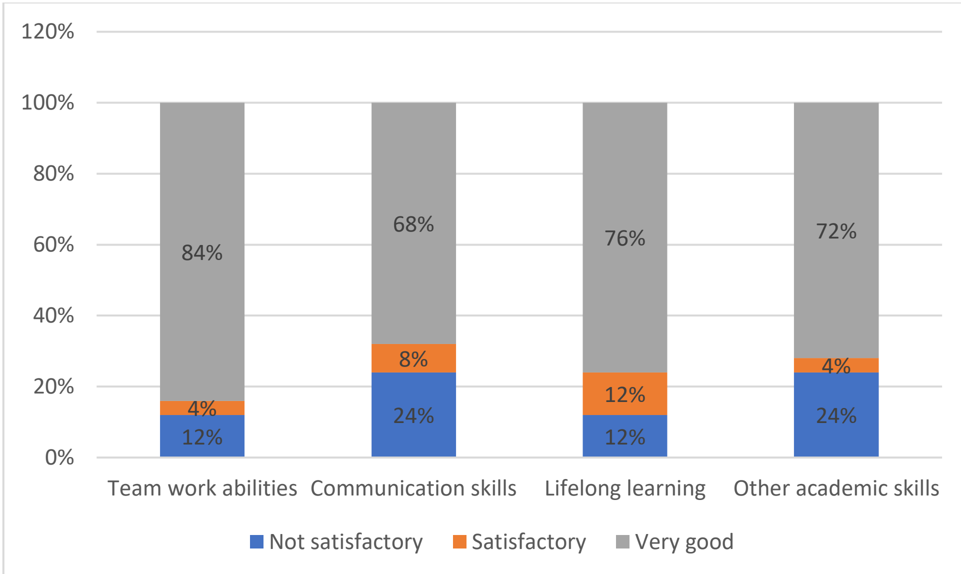


Academic Behaviours and Contextual Skills

Academic behavior includes study skills, time management skills, and lifelong learning abilities. Contextual skills are measured by questions regarding their communication and teamwork skills. Three items (question 13 in *Appendix 1*) that measured students' abilities to identify, select or adapt strategies and resources to address their educational needs, learning goals or career pathways *($\alpha = 0.805$)* were combined into a single variable named "Lifelong Learning". Seven items (questions 14 and 15 in *Appendix 1*) that measured students' abilities to finish assignments and projects on time, cite sources, and take notes *($\alpha = 0.871$)* were combined into one variable named "Other academic skills". Seven items (questions 12 in *Appendix 1*) that measured reading, writing, speaking, and listening abilities, such as the ability to comprehend and write effective reports, express ideas effectively towards a specific audience, demonstrate respect when communicating ideas, and deliver oral presentations ($\alpha = 0.860$) were combined into a single variable named "Communication skills". Eight items (questions 10 in *Appendix 1*) that measured students' abilities to work effectively in a group, such as contributing actively, sharing responsibilities, leading the teams, and respecting diversity ($\alpha = 0.882$) were combined to create a single variable named "Teamwork abilities".

The overall results show that more than 7 in 10 students reported at least satisfactory teamwork abilities, lifelong learning abilities, communication skills, and other academic skills (Figure 7).

FIGURE 7
PARTICIPANTS' SELF-ASSESSMENT OF THEIR TEAMWORK AND COMMUNICATION SKILLS, LIFELONG LEARNING, AND OTHER ACADEMIC SKILLS



DISCUSSION

This study contributes to an understanding of students' self-assessment of their preparedness for engineering programs, allowing administrators, educators, and faculty members to develop targeted bridging programs, curricula, and workshops to help them better transition to first-year engineering studies.

Most students in our survey reported confidence in their mathematics, calculus, and chemistry knowledge and skills, whereas fewer students appeared to be confident in physics. Ultimately, we suggest that pre-assessment or tests should be provided to examine students' academic proficiency so that these students can focus mainly on the subject they deem inadequate due to the short duration of the bridging program. Further, because Matanin et al. (2007) argue that students might have forgotten the fundamental information of the subject-mattered content, we compared the knowledge of students based on their highest level of education using the Kruskall Wallis test. Most participants in our study graduated from high school in 2022, with 16% graduating in 2021 or earlier. We found that there was no significant difference [$\chi 2$ (2, N = 25) = 0.053, $p > 0.05$] in the perceived knowledge skills between students who graduated from high school in 2022 (*Md = 4.25, Mean Rank = 13.02*), those who graduated in 2021 or earlier (*Md = 4.00, Mean Rank = 13.50*), and those who had a college diploma or high school and IB diploma (*Md = 4.00, Mean Rank = 11.50*) (See Table 1 and 2 in Appendix 2). This result might be affected by the small sample size.

Secondly, understanding engineering as a profession is critical for engineering students' success and persistence. Our findings reveal that students' understanding of engineering professionalism is moderately and positively correlated with their understanding of the concept of sustainability, the values of ethics and fairness, and the environmental impacts of their profession. Many studies suggest that potential and first-year engineering students lack an understanding of the engineering profession. For example, students and faculty members at the University of British Columbia reported feeling disconnected from the engineering profession and lacking an understanding of what engineers do or their societal roles (Ostafichuk et al., 2016). High school students in Ontario and Alberta have the least understanding of engineering among other professions (Compeau & Strong, 2015; Spencer & Strong, 2011). However, our results suggest that 7 out of 10 participants are at least confident about their understanding of engineering as a profession and career.

Most importantly, a high proportion (40%) of our participants reported not being proficient in using engineering tools, specifically with programming, spreadsheet, and drawing software. Therefore, it is essential for the bridging program to familiarize students with the engineering tools, and provide students opportunities to develop skills, such as data analysis in Excel, coding in Python, reporting writing in Word, and presentations in PowerPoint.

Finally, from the theoretical perspective, the current U of A B2E program fits into the four components of Conley's college readiness framework, which indicates that Conley's college readiness framework can serve as guidance when developing bridging programs. First, regarding contextual skills, the Foundations familiarize students with the university environment, such as getting involved in the engineering community, class registration, and seeking help. Second, academic Essentials represent the key content knowledge, allowing students to be academically prepared. Third, the ENGG Camps consist of Engineering Challenges, Skills and Wellness Sessions, and Guest Speaker Sessions, which resonate with developing academic behaviour and key cognitive strategies. For example, the Wellness Session provides workshops in developing important academic habits and skills, like time management, effective notetaking, and goal setting.

CONCLUSION

This study explores prospective students' perceptions of their preparedness for first-year engineering programs. Specifically, it focuses on Alberta high school graduates' self-assessment of the knowledge and skills needed to succeed in engineering programs. The participants were recruited from the registrant lists of the B2E programs. Using online surveys with 26 participants and Conley's college readiness framework, the results demonstrate that, in general, students appear to be confident about their knowledge and skill preparedness for the first-year engineering programs, including their critical thinking abilities, problem-solving skills and understanding of engineering professions, except for the use of engineering tools. In terms of the subject matter, students seem less confident in their physics abilities than math, chemistry, and calculus. Indeed, several studies suggest that students need more support with math and calculus and have a poor understanding of engineering as a career. Therefore, pre-tests on the subject matter can help students focus on their most inadequate subjects during the bridging program.

This study has some limitations. First, this is a study of students' perceptions of their abilities; thus, their actual abilities or competencies might be different from their perceptions. The second limitation is that the participants only include Alberta high school graduates entering first-year engineering programs at the U of A. The result will likely differ if students who finished high school in other countries and other Canadian provinces are included (Honken & Ralston, 2013; Li et al., 2009). Most importantly, the small number of participants (N = 26) indicates that our results may not be statistically reliable. Considering the limitations, future research can include international students and high school graduates from other Canadian provinces to identify the differences and make the results more generalizable. Moreover, conducting post-surveys after the B2E program and interviews after their first year in engineering programs will allow us to explore if students' perceptions about their abilities are accurate if the self-assessment help them to reflect on their weaknesses and strength, evaluate the effectiveness of the B2E program, and validate the effectiveness of our survey as a self-assessment tool.

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APPENDIX 1

Bridge2ENGG (Full) Pre-Program Survey

You are invited to complete this survey because you have enrolled in the Bridge2ENGG (B2E) Full Program at the University of Alberta. This survey explores prospective students' preparedness and readiness to transition to engineering programs at the University of Alberta (U of A). Understanding students' knowledge and competencies will allow us to develop targeted programs, curricula, and workshops.

The survey was designed based on the Alberta K-12 competencies and the U of A entry-level graduate attributes (GAs). Comparing the similarities and differences betweenthe K-12 competencies and Engg GAs, this survey focuses on eleven aspects that are essential for students to successfully transition to engineering programs and university academic environment.

1. Knowledge-based skills focus on evaluating students' competencies on the five required subjects to enter the engineering programs: English 30-1, Mathematics 30-1, Mathematics 31, Chemistry 30, and Physics 30.

2. Critical thinking involves your ability to observe, analyze, synthesize, interpret, and evaluate ideas.
3. Problem-solving skills require you to identify what is known and needed to clarify a problem and explore problem-solving strategies to using relevant information and resources.
4. Creative thinking refers to your willingness to play with ideas and ability to generate and apply ideas to create something.
5. The impact of engineering on society and the environment aims to assess your awareness of how their action/behaviour affects the community, environmental, cultural, economic, and political systems.
6. Professionalism refers to your understanding of the roles and responsibilities of professional engineers.
7. Ethics and equity aim to assess your ability to understand and evaluate ethics and equity issues (e.g., integrity, fairness, morals) behind their actions and decisions.
8. Individual and teamwork prioritize students' ability to work effectively in a group, such as contributing actively, sharing responsibilities, leading the teams, and respecting diversity.
9. Communication skills include reading, writing, speaking and listening abilities, such as the ability to comprehend and write effective reports, express ideas effectively towards a specific audience, demonstrate respect when communicating ideas, and deliver oral presentations.
10. The use of tools includes using software and technologies for design projects, assignments, and subject-related work.
11. Lifelong learning means your ability to identify, select or adapt strategies and resources to address your own educational needs, learning goals or career pathways

If you wish to participate in this study, please complete the following survey. By completing the survey you consent to participate in this study. The survey should take you approximately 20 minutes to complete. You do not have to answer any questions that you do not want to answer. You can stop anytime during the survey. However, once you submit the survey answers, we are not able to withdraw your survey result as there is no way for us to identify participants.

We thank you for taking the time for this survey. Your input will benefit you and your future colleagues.

About You

1. Indicate your highest level of completed education from the list below
   High school (graduated in 2022)
   High school (graduated in 2021 or earlier)
   Some college
   Some university
   College Diploma
   Undergraduate University Degree
   Other
2. Are you enrolled as a domestic or international student?
   Domestic
   International

Self-Assessment of Knowledge and Competencies

This section explores your self-assessment of the knowledge and skills that are essential for successfully transition to engineering programs.

Knowledge-Based Skills

<u>Strongly disagree, disagree, neutral, agree, strongly agree</u>

3. When you applied to the engineering program, there are five core courses to be admitted, including CHEM 30, PHYS 30, MATH 30-1, MATH 31, ENGL 30. Indicate your level of agreement with each statement as they are related to four courses

- I feel confident with my mathematical knowledge and skills.
- I feel confident about my calculus related knowledge and skills
- I feel confident with my physics related knowledge and skills.
- I feel confident with my chemistry related knowledge and skills.

Critical Thinking and Problem Solving

Critical thinking involves your ability to observe, analyze, synthesize, interpret, and evaluate ideas. Problem-solving skills require you to identify what is known and needed to clarify a problem and explore problem-solving strategies to using relevant information and resources.

Very good, satisfactory, not satisfactory

4. How would you rate your ability
    - to identify and address questions and problems?
    - to explore problem-solving strategies using relevant information, resources or criteria?
    - to access and evaluate information legally and ethically?
    - to use and evaluate different tools and strategies to solve the problem?
    - to analyze and interpret data?
    - to reason inductively and deductively to form and test hypotheses?

Creative Thinking

Creative thinking refers to your willingness to play with ideas and ability to generate and apply ideas to create something.

Very good, satisfactory, not satisfactory,

5. How would you rate your ability
    - to explore or experiment with ideas to create something new?
    - to evaluate and adapt ideas in response to feedback or emerging conditions?
    - to recognize opportunities and possibilities to apply ideas in new ways?

Professionalism

Professionalism refers to your understanding of the roles and responsibilities of professional engineers.

Very good, satisfactory, not satisfactory,

6. How would you rate your
    - understanding of engineering as a profession?
    - understanding of the roles and responsibilities of engineers in society?
    - understanding of the safety measures in conducting experiments and other projects?

Impact of Engineering on Society and Environment

The impact of engineering on society and the environment aims to assess your awareness of how their action/behaviour affects the community, environmental, cultural, economic, and political systems.

Very often, quite often, sometimes, seldom, never

7. Have you ever considered
    - the impact of your action on our society and environment?
    - the consequences (benefits, hazards, dangers) of new applications of science and technology on our society and environment?

Very good, satisfactory, not satisfactory,

8. How would you rate your
    - understanding of the concept of sustainability?

Ethics and Equity

Ethics and equity aim to assess your ability to understand and evaluate ethics and equity issues (e.g., integrity, fairness, morals) behind their actions and decisions.

Very good, satisfactory, not satisfactory

9. How would you rate your ability to
    - recognize situations containing ethical and equity issues?
    - Evaluate the ethical and equity issues behind your decisions and actions?

Individual and Teamwork

Individual and teamwork prioritize students' ability to work effectively in a group, such as contributing actively, sharing responsibilities, leading the teams, and respecting diversity

Very good, satisfactory, not satisfactory

10. How would you rate your ability
    - to lead a group project or discussion?
    - to actively contribute to team discussion and planning?
    - to respect the contributions of other team members?
    - to meet expected responsibilities and tasks?
    - to support others to achieve a common goal?
    - to exhibit reciprocity and trust when sharing ideas or roles?
    - to demonstrate sensitivity to diverse cultures, audiences or contexts when working with others?
    - to share responsibilities and supporting others to achieve a common goal?

Use of Engineering Tools

The use of engineering tools includes using software and technologies for design projects, assignments, and subject-related work.

Very good, satisfactory, not satisfactory

11. How would you rate your ability
    - to use word processing software to prepare a report including automatically generated headers, tables of content, citations, formatting?
    - to use spreadsheet software to undertake basic calculations on a dataset?
    - to use presentation software?
    - to use programming software?
    - to use drawing software?
    - to use email, calendar and other time management software?

Communication skills

Communication skills include reading, writing, speaking and listening abilities, such as the ability to comprehend and write effective reports, express ideas effectively towards a specific audience, demonstrate respect when communicating ideas, and deliver oral presentations.

Very good, satisfactory, not satisfactory

12. How would you rate your ability
    - to use proper grammar, punctuation, and properly constructed sentences in writing to communicate your ideas clearly?
    - to identify the correct means of communication for a specific audience?
    - to comprehend written documents and scholarly work?
    - to prepare and deliver an effective oral presentation?
    - to select oral, written, graphical or symbolic representations to effectively convey mathematical/physics/chemistry ideas or patterns?
    - to demonstrate respect and responsibility when communicating with others?
    - to effectively use graphical elements to support message?

Lifelong Learning

Lifelong learning means your ability to identify, select or adapt strategies and resources to address your own educational needs, learning goals or career pathways.

Very good, satisfactory, not satisfactory

13. How would you rate your ability
    - to learn effectively on your own and find information and resources that you need?
    - to identify your interests, values or skills to set learning or career goals?
    - to explore and select strategies and resources that support your academic or career pathways?

Other academic skills

Very good, satisfactory, not satisfactory

14. How would you rate your
    - ability to finish your assignments and projects on time?
    - ability to cite sources?
    - note-taking abilities?

15. How would you rate your
    - willingness to ask help?
    - optimism when adapting to new situations and transitions?
    - flexibility when adapting to new situations and transitions?
    - resilience when adapting to new situations and transitions?

Please note that once you submit your results, it is no longer possible to withdraw it. If you do not want to participate, do not submit it.

Thank you for completing the survey. Your feedback and opinion are valuable to us.

If you have any questions or want further information about this survey, you can reach us at jpcarey@ualberta.ca, selatia@ualberta.ca or syu9@ualberta.ca

APPENDIX 2

TABLE 1
KNOWLEDGE SKILLS RANKS COMPARISONS BY HIGHEST LEVEL OF COMPLETED EDUCATION

Highest level of completed education		N	Mean Rank
Knowledge Skills	High school (graduated in 2022)	22	13.02
	High school (graduated in 2021 or earlier)	2	13.50
	College Diploma or high school and IB diploma	1	11.50
	Total	25	

TABLE 2
KRUSKALL WALLIS TEST BETWEEN KNOWLEDGE SKILLS AND HIGHEST LEVEL OF COMPLETED EDUCATION

	Knowledge Skills
Kruskal-Wallis H	0.053
df	2
Asymp. Sig.	0.974
a. Kruskal Wallis Test	
b. Grouping Variable: highest level of completed education	