Bidirectional Transfer Pathway for Ontario's Engineering and Technology Programs

Project 2018-06

Final Report

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Contents

Executive Summary

The viability of a multi-institutional transfer pathway between engineering technology advanced diploma and engineering degree programs in Ontario has been an ongoing discussion for decades. Several recent ONCAT studies have moved this discourse forward substantively. This study combined previous findings with extensive additional research to produce a viable advanced diploma to degree transfer pathway model. The study also yielded the finding that, given the low volume and highly individualized circumstances of students transferring in other direction, pathway bi-directionality is not warranted at this time.

The study reached these results through investigation of the following key research questions:

1) What is the current landscape of engineering and engineering technology transfer in Canada?
    a. What current practices exist for engineering transfer?
    b. What bridging programs or transfer agreements are in place, and how were they created? What are the experiences of students who have followed those paths?
    c. What risks and pitfalls are concomitant with engineering transfer?
2) How much commonality is there between engineering and engineering technology curricula, from the perspectives of course content, learning outcomes, and accreditation criteria?
3) How can these findings contribute to the development of a large-scale, bi-directional engineering transfer pathway?

Due to the range and complexity of the research questions, multiple research methods were employed. In-depth interviews with key stakeholders in extant and attempted transfer pathway programs were conducted. Students and graduates of existing transfer programs were interviewed. Discussions with content specialists, and both regulator and accreditor consultants were had. Previous study findings, literature, and publicly available information were reviewed carefully to ensure that the assessment had been comprehensive.

In addition to these qualitative techniques, a quantitative, detailed gap analysis was conducted for Civil, Mechanical and Electrical engineering programs between institutions whose programs were determined to be a potentially good fit for a future pilot program. The analysis involved comparisons of program course descriptions, learning outcomes (LOs), and assigned accreditation units (AUs).

Key research results can be summarized as follows:

1) Analysis confirmed that the advanced diploma to degree pathway meets an identified need and has growth potential. It was also confirmed that increasing access to engineering degrees in this manner offers the potential to diversify engineering program student populations, as college pathways to engineering degrees have been demonstrated to disproportionately benefit visible minorities. Transfer pathways have been established successfully in other provinces such as British Columbia and Alberta but, due to the Ontario college system having been established independently of the universities, infrastructure differences preclude directly adopting any of

these. There are successful institution-specific pathways in Ontario as well and it would be expedient to develop any multi-institutional model with the flexibility to include them. There is much to be learned from all extant and attempted pathway models. It was also confirmed that students transferring from engineering degree to engineering technology advanced diplomas are doing so overwhelmingly in response to academic failure. This leads to highly individualized transcripts, which in combination with the low numbers, preclude investment in a bi-directional pathway at this time.

2) A detailed gap analysis of the commonality between engineering and engineering technology curricula for three disciplines revealed that the missing coursework could not be contained to a single bridge term, but that there were a number of possibilities for integrating additional courses prior to transfer and during program completion at the receiving institution. Interview findings highlighted the importance of student supports being offered in transfer success.
3) Analysis of the combined research findings made it possible to develop a three-phase engineering advanced diploma to engineering degree transfer pathway model, designed with the flexibility to incorporate extant institution specific transfer pathways, while also providing a solid foundation for development of a pilot multi-institutional transfer pathway:

Phase 1 (Transfer Preparation) is completed while the student is still enrolled in their advanced diploma program. Qualifying students are supported in incorporating additional courses that have been identified as filling engineering program gaps and being feasible to undertake in addition to the advanced diploma workload. There are three possible delivery mechanisms for such courses: in house, on-line, or at geographically convenient institutions. Students may also decide to take courses during or outside of term, depending on availability.

Phase 2 (Bridge Term) is completed at a designated Bridge Institution prior to entering the receiving degree granting Institution. A block of missing courses is delivered as a cohesive session.

Phase 3 (Program Completion) is completed while attending the receiving degree granting Institution. Students are supported in creating a plan to incorporate all remaining missing courses. Courses may be taken in house or on-line. In some instances, courses that might otherwise be designated as electives will be requisite for transfer students in order to ensure that they meet the missing AU requirements.

The pathway model was reviewed with study partners and institutions that would be interested in such a multi-institutional pilot were identified for future reference. The response was positive. A review by regulator and accreditor consultants was also favourable.

The study's success in developing a viable transfer pathway model paves the way for the development of a pilot program. This could be initially implemented in stages with the subset of identified interested institutions and then expanded province wide.

1 Background

Unlike other provinces such as British Columbia, Ontario's engineering technology advanced diploma and degree granting institutions were established as completely distinct entities, without any view to facilitating transfer between them. This has made the process of determining what are appropriate transfer credits a complicated and frustrating experience for transfer student, as well as a labour-intensive effort for the receiving institution. Engineering degree program accreditation requirements present additional complications for students moving from advanced diploma to degree programs. The receiving institution must ensure that all transfer credits can be defended from the perspective of not only course content, but Accreditation Unit (AU) count based on the Canadian Engineering Accreditation Board (CEAB) requirements.

Fortunately, the relatively recent shift in the university sector towards defining course and program level learning outcomes in addition to course descriptions have provided an additional mechanism for program comparison. This has made it feasible to explore developing a multi-institutional pathway model. The study builds on the results of several recent ONCAT studies (2015-29, 2016-11, 2017-39), incorporating extensive additional research to develop a viable transfer pathway model that would be a solid foundation on which to build a pilot program.

2 Literature Review

The relevant literature is briefly reviewed below in three key areas: a) the benefits of engineering transfer; b) current challenges within engineering transfer; and c) current practices for transfer between engineering technology and engineering programs. Limited documentation in a Canadian context is available; thus, some inferences must be drawn from a North American perspective.

2.1 Benefits of Transfer

Research done in Ontario suggests that college programs tend to enrol higher numbers of learners who are traditionally disadvantaged (Deller & Oldford, 2011; Trick, 2013). Pathways from diploma-granting to degree-granting programs are seen as a way to increase access to marginalized or underrepresented students, including low-income, adult, or Indigenous learners. These pathways also increase opportunity for individuals with weak academic history (Kerr, McCloy, & Liu, 2010; Lennon, Zhao, & Gluszynski, 2011).

Internationally, Ogilvie (2014) suggested that college programs could act as a smooth transition between high school and degree programs, allowing students to build confidence in their academic abilities. This would be particularly useful for students who were warier of their ability in a university lifestyle. College pathways to engineering programs disproportionately improve access to engineering degrees for visible minorities, with some students relying on transfer as a pathway to a baccalaureate degree (Lattuca, Terenzini, Ro, & Knight, 2014; Sullivan et al., 2012).

Zhang and Ozuna (2015) conducted a qualitative study to explore engineering students' academic and interpersonal experiences of transfer, both prior to and following successful transfer. They found that many of the successful transfer students believed that it was beneficial to learn fundamental concepts in college courses, as their professors were more accessible and dedicated to teaching. College as a pathway gave confidence to students who were otherwise afraid of the university experience.

2.2 Transfer Challenges

Although the benefits of increasing representation in the engineering student body are tangible, transfer remains challenging for many reasons, from course content to administrative challenges. Much of the existing research focuses on challenges from a student perspective.

Zhang and Ozuna (2015) concluded that mathematics in particular was difficult for transferring students, often resulting in low mathematical identity. In a math-heavy program like engineering, this presents challenges for incoming students. Laugerman, Rover, Shelley, and Mickelson (2015) estimated retention rates in engineering programs for a group of approximately 1200 transfer students, using grades from Calculus I and II, and Physics I. They found that high grades in the introductory calculus courses seemed to be a higher predictor of retention than physics, suggesting that high achievers in mathematics are more likely to overcome the initial difficulty identified by Zhang and Ozuna.

In their 2015 paper, Zhang and Ozuna also found that many students are unaware of college pathways to engineering degrees until late in their college career. This can make achieving requirements for transfer difficult, often resulting in reduced credit for courses taken.

Engineering programs would greatly benefit from increased diversity of the student population, which would result from increasing the transfer opportunities between engineering technology and engineering programs in Ontario. However, the large variation in Ontario's higher education transfer policies, engineering and engineering technology syllabi, and course delivery and focus present a problem for the development of a large-scale transfer system in the engineering sector (Zakani, Frank, Turner, & Kaupp, 2016).

2.3 Current Transfer Practices

Little documentation was found on current methods of engineering transfer. It is common practice for institutions to engage in 'articulation agreements' whereby certain criteria are met by the sending institution, and the receiving institution allocates certain spaces for incoming transfer students.

Mattis and Sislin (2005) argued that the articulation agreement model is not sufficient for sustainable, successful transfer pathways. They identified areas for improvement in transfer practices, largely centered around cooperation and resource sharing between diploma and degree granting institutions. Further suggestions were made for increased student support at the institutional level, particularly for student counselling, connections between students and staff, learning communities of transfer students, and workshops or training modules for college advisors.

3 Methods

Given the above literature search, it was evident that more investigation in a Canadian context was warranted. Perspectives of engineering transfer from the institutional level would add valuable context to the necessary components of successful Canadian engineering transfer. Key research questions were defined as follows:

1) What is the current landscape of engineering and engineering technology transfer in Canada?
    a. What current practices exist for engineering transfer?
    b. What bridging programs or transfer agreements are in place, and how were they created? What are the experiences of students who have followed those paths?
    c. What risks and pitfalls are concomitant with engineering transfer?
2) How much commonality is there between engineering and engineering technology curricula, from the perspectives of course content, learning outcomes, and accreditation criteria?
3) How can these findings contribute to the development of a large-scale, bi-directional engineering transfer pathway?

The research team employed a range of methods in obtaining the requisite information for this project, as warranted by the range of associated tasks:

3.1 Analysis of Extant and Attempted Transfer Pathways

In-depth interviews with key stakeholders in extant and attempted transfer pathway programs (out of province and by individual institution) were conducted, where possible. Interviews with current and previous engineering transfer students were also conducted to allow for consideration of the student transfer experience. Discussions with content specialists were had. Previous project findings, literature, and publicly available information were reviewed as warranted. The methodology utilized for each for interview varied as appropriate for the research questions.

Qualitative research was best suited for information gathering, as the diverse understanding, practices, and experiences within the Canadian engineering transfer landscape renders quantitative study inefficient and limiting. A phenomenographical framework was used for analysis of data from institutions, as we focus on differences in understanding of a group of individuals; here, the experiences and processes of engineering transfer of across Canada (Marton, 1981). For the student interviews, a phenomenological framework and analysis was deemed more appropriate, as we attempted to dive into common experiences, themes, and opinions of those with first hand experience of the transfer process (Creswell, 2013).

Ethical clearance for the study was granted by the Queen's University General Research Ethics Board (GREB) prior to data collection. Approval documentation is available in Appendix A: Ethics Documentation. The data collection and analysis methods for each set of interviews is detailed below.

3.1.1 Interviews with Institutions

Though there are significant differences between provincial delivery of higher education, the national accreditation requirements present one of the largest challenges to transfer pathway development, so a national study was deemed to be most applicable. Semi-structured interviews were undertaken with institutions with existing or attempted transfer pathways into accredited Engineering or unaccredited Bachelor of Technology programs. This was useful for adjusting to the nuances of each interview and allowed for probing questions when necessary.

The interview questions themselves were structured to elicit detailed responses describing a) existing or attempted transfer pathways or bridging programs and their formation; b) current use of and demand for the pathway; c) lessons learned; d) risks or pitfalls; and e) advice for a province-wide program. These questions are available in Appendix B: Institutional Interview Questions.

Interviews were conducted via telephone. When possible, recordings were made to assist in data analysis.

A combination of convenience and snowball sampling was used. Convenience sampling was first used to establish contact with those interested in speaking about transfer practices at their institutions, and snowball sampling was also included to ensure that both well-established and unique perspectives were heard. Participant roles varied at every institution; the only required criterion was that the participant was knowledgeable and comfortable speaking about the transfer practices at their institution. An attempt was made to stratify by location to gain a full perspective of Canadian transfer, but institutional availability made this difficult. Speaking to all institutions with transfer pathways in Canada was not feasible given the timeline of the project, so efforts were concentrated in Ontario and known successful pathways in British Columbia and Alberta.

A total of 14 interviews were completed with representatives from 15 different institutions or groups. The interview sample by province and type of institution is seen in Table 1. When possible, one-on-one interviews were conducted; however, in a few cases small focus groups were held to invite many perspectives.

Table 1. Sample by province and institution type. Note that some institutions were both diploma and degree granting – they have been counted dependent on the program affiliation of the interviewee.

Independent Variable	**Group**	***n***
Province	Ontario	8
	Alberta	3
	British Columbia	4
Type of Program/Group	Degree Granting	7
	Advanced Diploma Granting	7
	Transfer Council	1

3.1.2 Interviews with Students and Graduates

Interviews were further conducted with graduates and students currently enrolled in Ontario engineering transfer programs. Analysis was focused on Ontario students, as their experiences would be more relevant for the region of interest. As with the above methods, semi-structured interviews were used.

Interview questions were developed, focusing on: a) rationale for student transfer; b) experiences while studying; and c) experiences or plans post-graduation. These questions were designed to obtain an understanding of the strengths and weaknesses of the pathways from a student perspective and are available in Appendix C: Student and Graduate Interview Questions. Interviews were conducted by phone or in person, as applicable, and were recorded when possible.

Convenience sampling was used to select interview participants. Student and/or graduate contact information was obtained from institutional interview participants, and individuals who were available and willing to participate were interviewed. Contact information was only received for vertical transfer students who had transferred from an engineering technology to an engineering program, due to the relatively small number of reverse transfers.

A total of 8 interviews were conducted with students and graduates of 4 engineering technology to engineering transfer pathways in Ontario. Two participants were still completing their undergraduate degrees, while 6 had graduated and moved on to full-time employment or further studies. Following the completion of 8 interviews, saturation was observed in the themes and perspectives observed and, as such, interviews were halted.

3.1.3 Interview Data Analysis

A similar approach to analysis was employed for both institutional and student interviews. Detailed notes were used for the analysis rather than transcripts, as recordings were not available for all conducted interviews.

Inductive coding was undertaken on these detailed notes. For institutional interviews, the general approach of a phenomenographic analysis was followed; that is, to study both the “what aspect” and the “how aspect” of the phenomenon in question (Larsson & Holmström, 2007). For student interviews, a phenomenological method was employed, where small “codes” were grouped into larger themes, representative of the essence of the data set.

The inherent bias of the researcher as the instrument in qualitative research was limited as much as possible by “bracketing out” experiences and attempting to view the data from as fresh a perspective as possible.

3.2 Curriculum Gap Analysis

To determine the ‘goodness of fit’ of engineering technology programs for transfer into a given engineering degree programs, a detailed curriculum gap analysis was undertaken.

3.2.1 Engineering Advanced Diploma to Engineering Degree Transfer

The CEAB has defined Accreditation Units (AUs) to ensure content and quality of engineering curricula. AUs are categorized in seven groups, namely: mathematics, natural sciences, mathematics and natural sciences, engineering science, engineering design, engineering science and engineering design, and complementary studies. An AU is defined on an hourly basis and represents the actual time that students spend on a particular activity with faculty or faculty representatives (Teaching Assistants as an example). Accordingly, one hour of lecture and one hour of laboratory/tutorial are equivalent to 1 AU and 0.5 AU respectively.

All engineering students must meet the minimum AU requirements for a successful graduation. Table 2 presents AU categories and associated minimum AUs required (CEAB, 2018). AUs are separated into specified and unspecified, with specified AUs representing specific program content (Mathematics, Engineering Science, etc.) and unspecified adding to the total required AU count for graduation.

Table 2.-AU category and associated minimum specified and unspecified AU's required (CEAB, 2018).

AU category	**Minimum AU's required**
Mathematics	195
Natural Sciences	195
Mathematics and Natural Sciences	420
Engineering Science	225
Engineering Design	225
Engineering Science and Engineering Design	900
Complementary Studies	225
Sub-Total	1545
Total AUs	**1950**

For the engineering technology advanced diploma to engineering degree program pathway model, a gap analysis was conducted for the Civil, Mechanical and Electrical engineering programs between institutions whose programs were determined to be a good fit for a future pilot program, based on results of a broad, high level program analysis of current programs, and drawing on work done in ONCAT project #2016-11 (Zakani et al., 2016). Expressed institutional interest was also considered.

To achieve this, Learning Outcomes (LOs) and course descriptions (content) of these disciplines at Queen's and interested institutions were carefully reviewed. Due to the existence of the Queen's-SLC transfer in Civil Engineering program, the gap analysis conducted was confirmed through discussions and emails with those parties involved in the original transfer.

As part of the gap analysis process, the equivalency threshold for granting credit to a given course was assigned as 75%. As a result, courses with more than 75% equivalency received both credit and the associated AUs. These courses are shown as "yes" in gap analysis tables in Section 4.3.1.

The following list highlights the key items considered during the gap analysis process:

- A course from a given year at the college may not necessarily be equivalent to the same course at the given year. For example, a 3rd-year college course may be equivalent to a 2nd-year university course.
- In some instances, two or three college courses were equivalent to one course at the university level (Queen's).
- Given the fact that college students finish their third year before starting an engineering program at the university, the summation of credited AUs from the 1st year and the 2nd year were deducted from the total AUs being offered at Queen's in order to determine the number of AUs required to be developed/covered in the pathway model.
- Complementary studies are mandatory at Queen's, although the number of each is variable across the disciplines. In most cases, general education courses from the college met the complementary studies requirement at Queen's.
- Similar to the complementary studies courses, students are required to take a certain number of technical electives (variable among different engineering programs) in order to successfully graduate from their program. If a given college course had more than 75% equivalency with a given technical course at Queen's, both the credit and the associated AUs were granted. However, a unique scenario was found for Civil Engineering program in which students are required to take 8 technical elective courses. Since the Queen's Civil Engineering program meets the minimum specified AU requirements by the end of the third year, transfer students from the SLC college received credit for the technical courses taken at the college even if those courses are not being offered at Queen's, as these specific

courses were counted as unspecified AU's, which could include any relevant engineering content.

- A few college courses from each discipline were identified with 50% equivalency with the counterpart courses at Queen's. These courses were identified as "Maybe" in gap analysis tables and are open for further discussion with colleges. Potentially, the maybe courses could be offered as a module (instead of a whole course), or two maybe courses could be merged into a one course, where the contents are relevant.
- The college courses with less than 50% equivalency were identified as "no" in gap analysis tables.

4 Results

4.1 Identification and Analysis of Extant and Attempted Pathways

Extant and attempted pathways were identified by reaching out through discussions and emails with the relevant personnel and review of publicly available information. Interviews were then conducted to gather information about them.

4.1.1 Interviews with Institutions

Results from the institutional interviews were grouped into three main areas: a) factors of Canadian engineering transfer; b) success strategies; and c) risks and pitfalls of transfer in engineering.

4.1.1.1 Factors of Canadian Engineering Transfer

Interview participants were asked to describe the transfer pathways and programs in which their institutions participated. The overwhelming result from this portion of the analysis was that pathways and programs are remarkably varied between institutions. There were common factors, however, which differed dependent on the pathway: a) timeline; b) structure; c) development; and d) scale. These factors are highlighted in Figure 1.

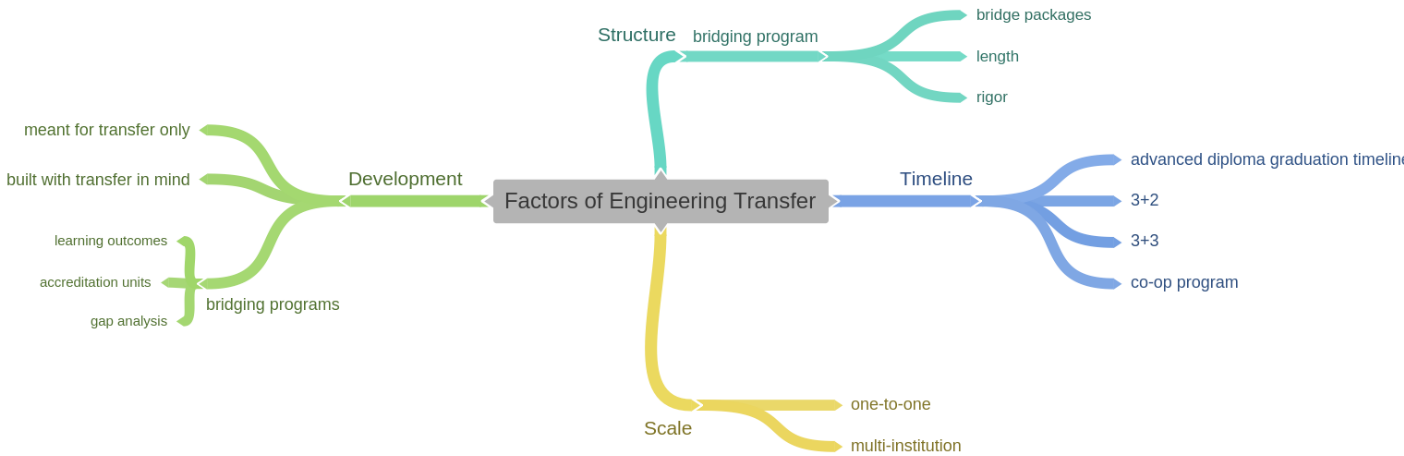

Figure 1. Map showing the breakdown of categories present in the "Factors of Engineering Transfer" theme.

The timeline of the pathways refers mainly to the year at which the transferring student enters the degree program. It was common for students to enter engineering degree programs at a 2nd or 3rd year level, dependent on many factors, such as course equivalencies, work terms, and student success in engineering technology courses.

In Ontario, the timeline of existing transfer pathways was also influenced by graduation schedules for advanced diploma programs. With differing graduation times, entry into fall-entry engineering degrees was sometimes challenging. Similarly, engineering programs with work terms had challenges accepting students from engineering technology programs when the timeline did not align directly. Thus, some programs required an additional 3 years of study from transferring students following the completion of their advanced diploma, while some required 2-2.5 years.

The structure of the transfer pathways also influenced the timeline. Commonly pathways include a transitionary program or set of courses to bridge the gaps present between the skill-set and knowledge base developed in the advanced diploma and that required upon entry into a given year of an engineering program. These programs were referred to as "bridging programs" or simply "bridges".

These bridges were generally developed by detailed course matching between programs by course content and learning outcomes. This allowed as much credit as possible to be given to incoming students for previously covered material, while indicating what content would need to be "topped up" to allow entry at a specified point in the final program of study. The bridges must also consider the minimum requirements for accreditation units (AUs) necessary to meet accreditation requirements.

The wide range of college engineering technology curricula was a common theme through the interview process. Thus, any bridge meant to service more than one sending institution would need to be flexible enough to meet the requirements of students from multiple programs. In a unique case, a large group of institutions have shifted towards the standardization of first year curriculum – an attempt to reduce the difficulty of transfer due to disparate programs.

The length and rigor of bridges were, again, dependent on the individual institutions being bridged. An engineering technology program with most curricula 'equivalent' to first-year engineering would require fewer courses to enable transfer into the second year of the program. For larger scale transfer pathways, then, it was common to have bridging "packages" dependent on the sending institution which dictated the required bridge for the transitioning student.

The development of the transfer pathways in their entirety differed from institution to institution. In a few cases, engineering programs were built to cater specifically to transfer students. This approach allows the engineering program to be structured "from-the-ground-up", considering the type of learning that students would likely do in engineering technology. These programs were then built with possible pathways in mind, making them more streamlined and efficient for transferring students.

In extreme cases, programs have been developed at the university level for which an advanced diploma in engineering technology is an entry requirement. However, not all of these "transfer only" programs are accredited by the Canadian Engineering Accreditation Board (CEAB), limiting interest from students.

Finally, the scale of the transfer pathways varied across Canada. Often, institutions followed the articulation agreement model – a one-to-one pathway for student mobility. Some cases operated on a larger scale, with one engineering program receiving students from engineering technology programs at multiple colleges. The scalability of the transfer pathways investigated seemed to be dictated by the previous factors identified; that is, the timeline, structure, and development of the pathway itself.

4.1.1.2 Success Strategies

Part of the qualitative analysis uncovered strategies and requirements for transfer pathway success. Thematic analysis grouped these results into four main themes: a) communication; b) collaboration; c) consideration; and d) accreditation. The breakdown of these themes can be seen in Figure 2.

Figure 2. Map showing the breakdown of categories present in the "Success Strategies" theme.

Communication and collaboration were often spoken of in conjunction by interview participants. Not only was open communication between sending and receiving institutions paramount in the successful development of a transfer pathway, but both institutions also needed to be willing to collaborate on programs and requirements to meet student needs.

Sending institutions made it clear that they were beholden to the receivers – they must meet certain requirements to initiate or uphold a transfer pathway. The more clearly those requirements (GPA, course content, timelines) were articulated by the receivers, the more easily those demands could be met by their partners. The credit-granting process is individual to each institution, making transparency of expectations more difficult. Institutions also often spoke of the importance of clear, open communication to build trust and foster a culture of growth. This could be done through frequent close contact of involved parties, or a larger scale annual meeting of all institutions to foster new connections and ensure goodwill.

A strong theme that emerged from analysis was that of broad consideration of transfer. This generally focused on the student experience, in terms of both knowledge requirements and support.

A high proportion of interviews noted that meeting incoming students at their current level of knowledge was paramount to transfer pathway success. College technology graduates will often have a lower level academic transcript from their high school education, as they may have been guided into primarily University/College M-level or College C-level courses. The focus, then, must on be bridging these students into post-technology university program courses. It can be difficult to reconcile those differences in an engineering degree program with common curricula, particularly without the support of instructors and faculty at the receiving institution. Thus, it was determined to be essential to have flexibility in curricula to meet the needs to incoming students.

Many participants noted that, although some knowledge gaps must be addressed, there were other aspects in which incoming students excelled and should be given credit. Practical, hands-on components were often areas of excellence in transfer students. Opportunities to reward students for their achievements should be regarded as highly as areas for improvement. Some sending institutions identified reluctance to grant advanced standing on the part of receiving institutions, which (anecdotally) students were often discouraged by.

Consideration of the student experience was a key theme throughout the interviews. Interviewees recommended that the timeline and workload of any proposed bridge be carefully considered, and that student academic supports be provided when necessary. Although few institutions mentioned successfully implemented support programs, student guidance was often seen as beneficial in helping students to realize their educational and career goals. Anecdotally, many institutions were adamant that students were looking for a straight pathway to professional practice, making the accreditation of engineering programs a key component to transfer.

Accreditation requirements were identified as a significant challenge to development of successful engineering transfer pathways in Canada. To receive accredited status by the CEAB, engineering programs must meet certain minimums in terms of accreditation unit counts for various categories of course content (math, natural science, engineering science, engineering design, and complementary studies). Transfer programs have had to consider the AUs necessary to meet these minimums, as well as how transfer credits will impact the AU count for transferring students. These requirements have often necessitated case-by-case analysis of applicants – a time consuming and costly process. To minimize accreditation risk, it was fairly common practice among interviewees to ensure that all AU minimums were met by courses taken at the degree-granting institution. This, however, increased the required time-to-completion for transfer students, as they had to complete all necessary AUs in house.

4.1.1.3 Risks and Pitfalls

Participating institutions also identified areas of risk, where promising pathways might fail before or after implementation, shown in Figure 3. These included the lack of any of the success characteristics above, but also addressed key features not addressed previously.

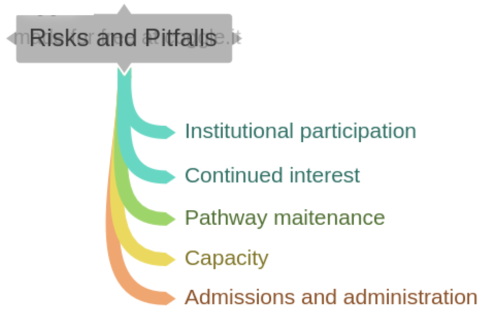

Figure 3. Map showing the categories present in the “Factors of Engineering Transfer” theme.

The willingness (or lack thereof) of institutions to participate in such programs was mentioned by participants. Several college programs voiced a desire for more interest in transfer on the part of accredited engineering programs. It was acknowledged that strong partnerships and collaboration require effort from both receiving and sending institutions, and yet without them pathways tended to fail.

Participation and interest also had to be maintained in order to develop sustainable pathways. With changing curricula and programs, constant reassessment of transfer pathways was necessary to ensure their success. A lack of continued maintenance was highlighted as an area of failure for several pathways. Maintenance was also hindered by a lack of knowledge dissemination; it was highly recommended that participant institutions avoid the situation where one individual or institution is harboring transfer knowledge and specifics. Proper documentation and dissemination of all approaches, pathways, and agreements was deemed to be essential.

Consideration of the capacity of receiving engineering programs was also consistently mentioned throughout the interviews. It was viewed as imperative that students not only complete any required bridge courses, but that there be a spot in an engineering program made available for them to occupy upon bridge completion. Although it was acknowledged that demand is never certain, it was also made clear that engineering programs must actively set aside seats for transfer students and communicate with college partners about availability for pathway success

Finally, as mentioned in the accreditation section above, complex admissions and administration have been a barrier to successful pathway implementation. Applications were identified as being very time consuming, as they often behave been assessed on a case by case basis, sometimes by more than one individual. Participants suggested that admissions cannot generally be managed successfully by a centralized university admissions structure, but rather would be best implemented within the engineering academic unit. This, of course, requires a considerable investment of time and resources, particularly as curriculum is subject to frequent revisions, restructuring, and improvement. An admission process, therefore, was suggested to be more feasible than a fixed admission template.

4.1.2 Interviews with Students and Graduates

The transfer process is intended to be for the benefit of students, and thus is student focused. To gain an understanding of student rationale for transfer, benefits, and challenges of current transfer systems, student interviews were completed. Results are detailed below.

4.1.2.1 Transfer Student Rationale

Students discussed their rationale for transfer in two capacities, one being the rationale for not entering an engineering degree directly out of high school, the other being the rationale for transferring into an engineering program following the completion of their advanced diploma. Key messages are highlighted in Figure 4. These areas were important to explore to fully understand the stories and perspectives of transferring students within the engineering landscape.

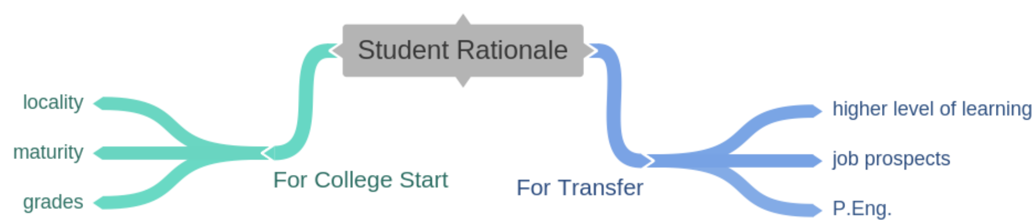

Figure 4. Map showing the categories present in the “Student Rationale” theme.

Participants spoke about their entry into engineering technology programs as generally being the result of “not being ready” – not ready to move away, not emotionally mature enough to commit to a degree program, or not ready academically. Each participant had a unique story about their entry into a college program and subsequent enrollment in an engineering degree. This highlights the diversity of student experience in these pathways, and the importance of unbiased consideration when developing transfer opportunities.

The rationale students had for vertical transfer into engineering was generally focused on career growth; participants believed that having both diploma and degree would result in better opportunities and more room for advancement in the workplace. Participants often came to this conclusion following a co-op or work placement in their diploma program. They spoke of how they felt that work done in engineering technology could be repetitive and lacked opportunity for advancement, whereas variety and advancement opportunities would be more likely in an engineering position. Some also spoke of experiences in which they saw engineering technologists and engineers doing much the same work, but for very different pay. This motivated students to pursue further education.

Eligibility for designation as a professional engineer (P.Eng.) was also very appealing to students and motivated them to pursue transfer into engineering programs. Many participants spoke of the P.Eng. designation as a mark of pride in their work, and important to their identity as engineers and professionals. Thus, retaining accredited status of transfer programs is essential in engineering.

Several students also remarked that they were interested in transfer because it presented opportunities for a higher level of learning, often on theoretical and abstract concepts, or more open-ended creative design. These participants spoke of their natural affinity for engineering, which they only uncovered through participation in an engineering technology program. Many of the participants had gone on to pursue graduate degrees.

4.1.2.2 Transfer Benefits

The students extolled several virtues of their transfer experience, developed from the rigorous program and the variation in curricula. A summary of benefits as identified by students is seen in Figure 5.

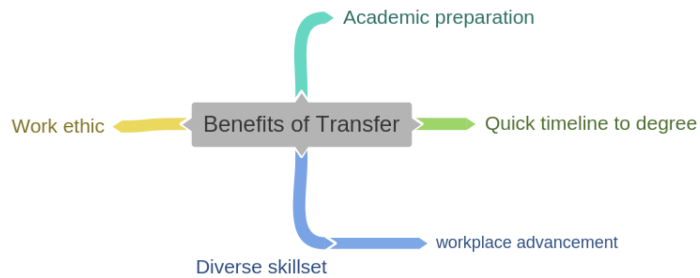

Figure 5. Map showing the categories present in the “Benefits of Transfer” theme.

On the whole, students felt well academically prepared for entry into their engineering degree programs. They spoke about their skillset for certain practical components (often software modelling or drawing, and lab skills) as more highly developed than their peers who had entered the program from year 1.

The combination of engineering technology and engineering was beneficial in developing a diverse skillset amongst students. The interviewees discussed how having both the practicality and “real-world” grounding of the engineering technology diploma strongly complimented the more abstract and theoretical learning in engineering degree programs. Several participants discussed how a foundation of practical knowledge was helpful to them in learning complex theoretical concepts; often these concepts came more naturally to them than to their ‘direct-entry’ counterparts, as they had the foundational knowledge of how these theories were applied in a real world context.

Graduates also strongly believed that having an engineering technology diploma was a benefit to them in the workplace. They discussed how they often advanced more quickly than their colleagues who possessed just an engineering degree, as they were able to think more critically and practically about projects, and had more experience building and designing.

The rigor of intermediary bridging programs was challenging, as will be further explored in Section 4.1.2.3, but benefitted students through their development of sound work ethic and time management skills. Many participants discussed how, if they could get through the bridge, they were confident that they could handle anything an engineering degree might throw their way. They felt their work ethic and time management skills also gave them an edge over direct-entry students; they were entering upper years of the program with good study habits and skills, giving them a means to succeed early on.

The rigor of the program also resulted in an expedient path to degree completion, something appreciated by all the participants. Most discussed how they were interested in the shortest pathway possible, and sometimes chose pathways purposefully based on time-to-completion. Although an intense bridging program has many challenges, students were willing to forgive those to graduate sooner.

4.1.2.3 Transfer Challenges

Although the transfer experience did result in a number of benefits to students, they were also presented with challenges as they completed their programs. Some of these challenges highlighted a lack of support network for transferring students, while others focused more on difficulty in the pace of the program. All identified challenges are summarized in Figure 6.

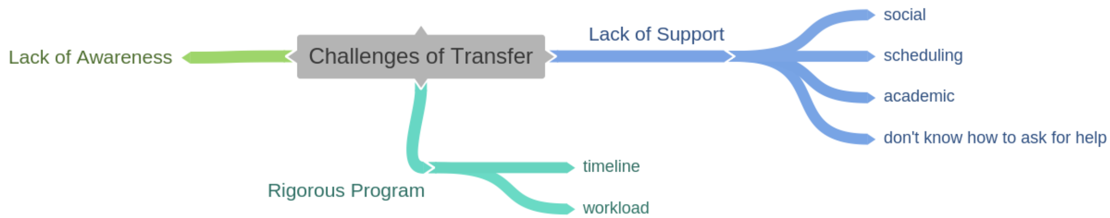

Figure 7. Map showing the categories present in the "Challenges of Transfer" theme.

Some students mentioned the fact that they were unaware of the possibility of transfer until late in their college career. One student also discussed how he believed that others would have benefitted from knowing about the opportunity earlier, as it would help them to make course and program decisions that would support transfer. The students did appreciate the flexibility of the transfer programs, however, which allowed them to enroll even after late discovery. Pathway awareness, they said, should be promoted without sacrificing the ease of access for students who choose transfer toward the end of their advanced diploma program.

Not only did the awareness of the program itself present challenges for students, but rigorous bridging programs presented academic difficulties. Students reported that these programs were incredibly challenging, not generally due to difficult academic content, but because they were often condensed into a short time-frame and had a tremendous workload. Many students referred to their bridge program as containing upwards of eight courses, presented over a four-month period – which would be challenging for any student. Interviewees discussed the benefits of this approach as investigated in the previous section – it prepared them well to succeed in their university degrees and was an excellent introduction to the expectation of a higher level of learning. However, these students did discuss the very negative impact that this workload had upon their personal and emotional lives, with one student joking that he “nearly got divorced”.

Both of the previous factors were referenced to support the largest theme arising from student data collection; there is a lack of support available for transfer students, particularly in the midst of their transfer between institutions. This support ranges from academic to social and seemed a particularly prevalent need for students transferring into entirely new institutions. These students spoke of the expectation of faculty and staff that they would be familiar with the university, as they were technically upper year students upon arrival. However, these students were unable to locate buildings or classes, or find necessary student resources.

Academic support was also lacking for students in these programs, particularly as they were not used to larger class sizes associated with the engineering degree experience. Many interviewees spoke about not knowing how to ask for help in an academic context. These students also found the transfer experience isolating at first – their cohort was small, and had difficulty adjusting to the university setting.

Student support, therefore, must play a critical role in the development of any new engineering transfer pathway.

Students also mentioned a sense of frustration with repetitive course content. They felt that certain required courses for transfer were redundant, as they had covered very similar material at the engineering technology level. This, they said, was demotivating to complete homework and assignments, as they felt their previous knowledge was being overlooked. A rigorous gap analysis is thus key to both confidence in student knowledge base, and student satisfaction.

4.2 Identification of Interested Partner Institutions

Interested institutions were identified by reaching out through discussions and emails with the relevant personnel. Those interested in future pilot program participation were then considered for discipline-specific program comparisons, with selections made based on proportion of program similarities identified in ONCAT Project #2016-11and additional analysis for Civil Engineering programs.

Table 3 shows institutions who responded with interest to an enquiry made to all Ontario colleges and universities with engineering or engineering technology programs. Colleges selected for partnership in initial program development phases have been flagged.

Table 3. Institutions interested in inclusion in the project over the long term, with checkmarks indicating those selected as partners for any potential pilot program.

Institution	Current Partner
Queen's University	✓
Laurentian University	
UOIT	
University of Windsor	
York University	
Conestoga College	✓
Sheridan College	✓
Seneca College	✓
Mohawk College	✓
St. Lawrence College	✓
Cambrian College	
Niagara College	
Fleming College	
Centennial College	
Collège La Cité	

4.3 Curriculum Analysis of Select Partner Institution Programs

4.3.1 Gap Analysis for Transfer from Engineering Technology Advanced Diploma to Engineering Degree Program

Using the Methods outlined in 3.2.1, a detailed gap analysis was conducted of sample programs in Civil, Mechanical and Electrical engineering technology and engineering. Note that all programs were mapped for eligibility to Queen's University programs; however, ONCAT Project #2016-11 suggested that Queen's University had representative programs for Ontario institutions in both Mechanical and

Electrical engineering (Zakani et al., 2016). Thus we posit that these maps would likely be similar for many engineering degree programs in Ontario.

All mapping was done by the research team and is indicative of an initial attempt to determine program eligibility. Since mapping was done in house, these are not necessarily representative of what final program maps would look like. College names have been redacted to ensure anonymity.

The results of the gap analysis are shown in the Tables 4(A-E), 5(A-E), 6(A-E), and 7(A-E):

Tables 4A-4E. Transfer to Civil Engineering Program Summary; transferrable courses by year, and AU analysis

A) First Year

Civil Engineering Courses												
Degree Course Number	Degree Course title	Diploma Course Equivalency	Diploma Course Title(s)	Degree Course AU Total	Degree Course AU by CEAB Category							Diploma Course AU Equivalency Total
					Math	NS	M+NS	CS	ES	ED	ES+ED	
APSC 101	Engineering Problem Solving and Modelling	Yes	CIVL 32 Introduction to Physics and Effective Teamwork & CIVL 43 Workplace Safety & COMP 75 Computer Applications in Excel	35	0	0	0	18	0	17	17	35
APSC 102	Experimentation and Design	No		34	0	16	16	0	18	0	18	-
APSC 103	Engineering Design Project	Yes	CIVL 64 Water and Wastewater Technology & CIVL 74 Water and Wastewater Tech Lab &	40	0	0	0	18	6	16	22	40
APSC 111	Physics I	Yes	CIVL 11 Applied Physics	40	0	40	40	0	0	0	0	40
APSC 112	Physics II	No		40	0	30	30	0	10	0	10	-
APSC 131	Chemistry and Materials	No		40	0	40	40	0	0	0	0	-
APSC 132	Chemistry and its Applications	No		40	0	30	30	0	10	0	10	-
APSC 143	Introduction to Computer Programming for Engineers	No		40	0	0	0	0	40	0	40	-
APSC 151	Earth Systems and Engineering	Yes	CIVL 01 The subsurface Environment	40	0	17	17	8	15	0	15	40
APSC 162	Engineering Graphics	Yes	CIVL 38 Technical Drafting & CIVL 39 Computer Assisted Drafting Design 1 & CIVL 40 Computer Assisted Design II	30	0	0	0	0	20	10	30	30
APSC 171	Calculus I	Yes	MATH 18 Intermediate Math & MATH 20 Basic Calculus	40	40	0	40	0	0	0	0	40
APSC 172	Calculus II	No		40	40	0	40	0	0	0	0	-
APSC 174	Introduction to Linear Algebra	No		40	40	0	40	0	0	0	0	-
APSC 182	Applied Engineering Mechanics	Yes	CIVL 46 Mechanics & CIVL 56 Mechanics of Materials Laboratory	20	0	0	0	0	15	5	20	20

B) Second Year

Civil Engineering Courses													
Degree Course Number	Degree Course title	Diploma Course Equivalency	Diploma Course Title(s)	Degree Course AU Total	Degree Course AU by CEAB Category								Diploma Course AU Equivalency Total
					Math	NS	M+NS	CS	ES	ED	ES+ED		
APSC 200	Engineering Design and Practice II	No		48	0	0	0	12	0	36	36	-	
APSC 221	Economics and Business Practices in Engineering	No		36	0	0	0	36	0	0	0	-	
APSC 293	Engineering Communications I	No		12	0	0	0	12	0	0	0	-	
CIVL 200	Professional Skills I	Yes	CIVL 61 Work Placement & COMM 110 Communication for College	28	0	0	0	8	0	20	20	28	
CIVL 210	Chemistry for Civil Engineers	No		55	0	20	20	0	20	15	35	-	
CIVL 215	Materials for Civil Engineers	Yes	CIVL 23 Construction Materials	54	0	12	12	0	32	10	42	54	
CIVL 222	Numerical Methods for Civil Engineers	No		60	45	0	45	0	15	0	15	-	
CIVL 230	Solid Mechanics I	Yes	CIVL 14 Mechanics of Materials	50	0	0	0	0	50	0	50	50	
CIVL 231	Solid Mechanics II	No		54	0	0	0	0	54	0	54	-	
CIVL 250	Hydraulics I	Yes	CIVL 13 Mechanics of Fluids & CIVL 18 Fluid Mechanics Lab	48	0	4	4	0	22	22	44	48	
MTHE 224	Applied Mathematics for Civil Engineers	No		50	50	0	50	0	0	0	0	-	
2nd Year	1st Complementary Studies Course (List A)	No		36	0	0	0	36	0	0	0	-	
2nd Year	2nd Complementary Studies Course (List A)	No		36	0	0	0	36	0	0	0	-	

C) Third and Fourth Years

Civil Engineering Courses												
Degree Course Number	Degree Course title	Diploma Course Equivalency	Diploma Course Title(s)	Degree Course AU Total	Degree Course AU by CEAB Category							Diploma Course AU Equivalency Total
					Math	NS	M+NS	CS	ES	ED	ES+ED	
CIVL 300	Professional Skills II	No		28	0	0	0	28	0	0	0	-
CIVL 330	Structural Analysis	No		44	0	0	0	0	44	0	44	22
CIVL 331	Structural Steel Design	No		48	0	0	0	0	12	36	48	-
CIVL 340	Geotechnical Engineering I	Yes	CIVL 50 Soil Mechanics	44	0	0	0	0	32	12	44	44
CIVL 341	Geotechnical Engineering II	No		48	0	0	0	0	12	36	48	-
CIVL 350	Hydraulics II	No		44	0	0	0	0	14	30	44	-
CIVL 360	Civil Engineering Design and Practice III	No		48	0	0	0	12	0	36	36	-
CIVL 371	Groundwater Engineering	No		44	0	0	0	0	30	14	44	-
CIVL 372	Water and Wastewater Engineering	No		48	0	12	12	0	20	16	36	48
3rd Year	1st Complementary Studies Course (List A)	Yes	(i)	36	0	0	0	36	0	0	0	36
3rd Year	2nd Complementary Studies Course (List A)	Yes	(i)	36	0	0	0	36	0	0	0	36
3rd Year	1 Management Elective Course	Yes	CIVL 26 Environmental Management	24	0	0	0	24	0	0	0	24
CIVL 400	Professional Skills	No		28	0	0	0	28	0	0	0	-
CIVL 460	*Civil Engineering Design and Practice*	No		44	0	0	0	12	0	60	60	-
4th Year	8 Technical Electives from List 1 & 2 (ii)	See Table below		309								
4th Year	1 Complementary Studies Course (from List A, B, C, or D)	Yes	CIVL 05 Technical Report (List B)	36	0	0	0	36	0	0	0	36
	Program Total			1995	215	221	436	396	491	391	882	671
(i) Variable (General Education Courses)												
(ii) At least 6 of which must be from List 1												

D) Technical Electives

Degree Course title	Diploma Course Title(s)
Tehnical Elective 1	CIVL 25 Hydrology
Technical Elective 2	CIVL 02 Introduction to GIS & CIVL 24 Construction Management
Technical Elective 3	CIVL 22 Highway Technology & CIVL 58 Highway Technology Lab
Technical Elective 4	CIVIL 12 Surveying

E) Required AUs for Graduation

Academic Year	Degree Course AU Total	Degree Course AU by CEAB Category							Certificate Course AU Equivalency Total	Certificate Course AU Equivalency by CEAB Category						
		Math	NS	M+NS	CS	ES	ED	ES+ED		Math	NS	M+NS	CS	ES	ED	ES+ED
1st Year	519	120	173	293	44	134	48	182	245	40	57	97	44	56	48	104
2nd Year	567	95	36	131	140	193	103	296	180	0	16	16	8	104	52	156
3rd Year	492	0	12	12	136	164	180	344	210	0	12	12	24	74	28	102
4th Year	417	0	0	0	76	0	60	60	36	0	0	0	36	0	0	0
TRANSFER	AU Total	Math	NS	M+NS	CS	ES	ED	ES+ED								
TRANSFER YEAR 1	245	40	57	97	44	56	48	104								
TRANSFER YEAR 2	180	0	16	16	8	104	52	156								
REQUIRED AU TO MAKE UP	**661**	**175**	**136**	**311**	**132**	**167**	**51**	**218**								

Tables 5A-5E. Transfer to Mechanical Engineering Program Summary from Diploma Program A; transferrable courses by year, and AU analysis

A) First Year

Mechanical Engineering Courses												
Degree Course Number	Degree Course title	Diploma Course Equivalency	Diploma Course Title(s)	Degree Course AU Total	Degree Course AU by CEAB Category							Diploma Course AU Equivalency Total
					Math	NS	M+NS	CS	ES	ED	ES+ED	
APSC 101	Problem Analysis and Modelling	No		35	0	0	0	18	0	17	17	-
APSC 102	Experimentation and Measurement	No		34	16	0	16	0	18	0	18	-
APSC 103	Engineering Design	No		40	0	0	0	18	6	16	22	-
APSC 111	Mechanics	No		40	0	40	40	0	0	0	0	-
APSC 112	Electricity and Magnetism	No		40	0	30	30	0	10	0	10	-
APSC 131	Chemistry and Materials	Maybe	PHYS10009 - Physical Science	40	0	40	40	0	0	0	0	-
APSC 132	Chemistry and its Applications	No		40	0	30	30	0	10	0	10	-
APSC 143	Introduction to Computer Programming for Engineers	No		40	0	0	0	0	40	0	40	-
APSC 151	Earth Systems and Engineering	No		40	0	16	16	10	14	0	14	-
APSC 162	Engineering Graphics	Yes	CADM10045 - Engineering Drawing 1 Lecture & CADM10046 - Engineering Drawing 1 Lab & CADM10047 Engineering Drawing 2 Lab & CADM10048 - Introduction to Solid Modelling	30	0	0	0	0	20	10	30	30
APSC 171	Calculus I	Yes	MATHMA383 - Differential Calculus & MATHMA483 - Integral Calculus	40	40	0	40	0	0	0	0	40
APSC 172	Calculus II	No		40	40	0	40	0	0	0	0	-
APSC 174	Introduction to Linear Algebra	No		40	40	0	40	0	0		0	-
APSC 182	Applied Engineering Mechanics	Yes	MECHMC322 - Statics	20		0	0	0	15	5	20	20

B) Second Year

Mechanical Engineering Courses												
Degree Course Number	Degree Course title	Diploma Course Equivalency	Diploma Course Title(s)	Degree Course AU Total	Degree Course AU by CEAB Category							Diploma Course AU Equivalency Total
					Math	NS	M+NS	CS	ES	ED	ES+ED	
MECH 221	Statics and Solid Mechanics	Yes	MECHMC364 - Strength of Materials	48		0	0	0	48	0	48	48
MTHE 225	Ordinary Differential Equations	No		42	42	0	42	0	0	0	0	-
MECH 213	Manufacturing Methods	Maybe	MANU10042 - Materials and Processes in Manufacturing	54	0	0	0	0	36	18	54	-
MECH 217	Measurement in Mechatronics	Yes	METR10005 - Metrology Lecture & METR10006 - Metrology Lab & METR10007 - Measurement Systems Lecture & METR10008 - Measurement Systems Lab	51	0	0	0	0	36	15	51	51
MECH 230	Thermodynamics I	Yes	MECHMC491 - Thermodynamics	42	0	30	30	0	12	0	12	42
MECH 270	Materials Science and Engineering	Yes	MATL10110 - Properties of Materials Lecture & MATL10111 - Properties of Materials Lab	45	0	12	12	0	33	0	33	45
APSC 200	Engineering Design and Practice II	Maybe	IENG10113 - Capstone Project	48	0	0	0	12	0	36	36	-
APSC 293	Engineering Communications I	Yes	COMM11040 - Communication D	12	0	0	0	12	0	0	0	12
ELEC 210	Introductory Electric Circuits and Machines	Yes	ELEC10085 - Electricity Lecture & ELEC10086 - Electricity Lab	51	0	0	0	0	51	0	51	51
MTHE 272	Application of Numerical Methods	No		42	20	0	20	0	11	11	22	-
MECH 228	Kinematics and Dynamics	Yes	MECHMC422 - Dynamics	42	0	11	11	0	31	0	31	42
MECH 241	Fluid Mechanics I	Yes	MECH10018 - Fluid Mechanics	42	0	24	24	0	18	0	18	42
APSC 221	Economics and Business Practices in Engineering	No		36	0	0	0	36	0	0	0	-

C) Third and Fourth Years

Mechanical Engineering Courses												
Degree Course Number	Degree Course title	Diploma Course Equivalency	Diploma Course Title(s)	Degree Course AU Total	Degree Course AU by CEAB Category							Diploma Course AU Equivalency Total
					Math	NS	M+NS	CS	ES	ED	ES+ED	
MECH 321	Solid Mechanics II	No		42	0	0	0	0	30	12	42	-
MECH 328	Dynamics and Vibration	No		42	0	11	11		17	14	31	-
MECH 396 or	Mechanical and Materials Engineering Laboratory I	No		36	0	0	0	12	24		24	-
MECH 398	Mechanical Engineering Laboratory I	No		0	0	0	0	0	0	0	0	-
MECH 323	Machine Design	Yes	MECHMC512 - Machine Design 1 & MECHMC614 - Machine Design 2	54	0	0	0	0	27	27	54	54
MECH 346	Heat Transfer	Maybe	MECH10019 - Heat Transfer	42	0	0	0	0	42		42	-
MECH 350	Automatic Control	No		42	0	0	0	0	23	19	42	-
MTHE 367	Engineering Data Analysis	No		42	31	0	31	0	11	0	11	-
MECH 397	Mechanical and Materials Engineering Laboratory II	No		24	0	0	0	0	24	0	24	-
MECH 399	Mechanical Engineering Laboratory II	No		0	0	0	0	0	0	0	0	-
MECH 330	Applied Thermodynamics II	No		42	0	0	0	0	42	0	42	-
MECH 341	Fluid Mechanics II	No		42	11	0	11	0	31	0	31	-
3rd Year	Technical Elective OR Complementary Studies	No		36	0	0	0	0	0	0	0	-
MECH 460	Team Project - Conceive and Design	No		48	0	0	0	0	0	48	48	-
MECH 464	Communications and Project Management	Yes	IENG10005 - Project Management	18	0	0	0	18	0	0	0	18
4th Year	*1 Complementary Studies Course (from List A)*	Yes	(i)	36	0	0	0	36	0	0	0	36
4th Year	*1 Complementary Studies Course (from List A , B, C, or D)*	Yes	(i)	36	0	0	0	36	0	0	0	36
4th Year	8 Technical Electives	See Table below		324			0	0	0	0	0	
	Total Program			**1980**	**240**	**244**	**484**	**208**	**680**	**248**	**928**	**567**
(i) Variable (General Education Courses)												

D) Technical Electives

Degree Course title	Diploma Course Title(s)
Technical Elective 1	CADMMC634 - CIM and CNC
Technical Elective 2	STENMC400 - Automation 1 & STENMC500 - Automation 2

E) Required AUs for Graduation

Academic Year	Degree Course AU Total	Degree Course AU by CEAB Category							Diploma Course AU Equivalency Total	Diploma Course AU Equivalency by CEAB Category						
		Math	NS	M+NS	CS	ES	ED	ES+ED		Math	NS	M+NS	CS	ES	ED	ES+ED
1st Year	519	136	156	292	46	133	48	181	90	40	0	40	0	35	15	50
2nd Year	555	62	77	139	60	276	80	356	333	0	77	77	12	229	15	244
3rd Year	444	42	11	53	12	271	72	343	54	0	0	0	0	27	27	54
4th Year	504	0	0	0	90	21	69	90	90	0	0	0	90	0	0	0
TRANSFER	AU Total	NS	NS	M+NS	CS	ES	ED	ES+ED								
TRANSFER YEAR 1	90	40	0	40	0	35	15	50								
TRANSFER YEAR 2	333	0	77	77	12	229	15	244								
REQUIRED AU TO MAKE UP	**651**	**158**	**156**	**314**	**94**	**145**	**98**	**243**								

Tables 6A-6E. Transfer to Mechanical Engineering Program Summary from Diploma Program B; transferrable courses by year, and AU analysis

A) First Year

Mechanical Engineering Courses													
Degree Course Number	Degree Course title	Diploma Course Equivalency	Diploma Course Title(s)	Degree Course AU Total	Degree Course AU by CEAB Category								Diploma Course AU Equivalency Total
					Math	NS	M+NS	CS	ES	ED	ES+ED		
APSC 101	Problem Analysis and Modelling	Maybe	PROG 1395 - Visual Basic for Application for Engineering	35	0	0	0	18	0	17	17		-
APSC 102	Experimentation and Measurement	No		34	16	0	16	0	18	0	18		-
APSC 103	Engineering Design	No		40	0	0	0	18	6	16	22		-
APSC 111	Mechanics	No		40	0	40	40	0	0	0	0		-
APSC 112	Electricity and Magnetism	No		40	0	30	30	0	10	0	10		-
APSC 131	Chemistry and Materials	No		40	0	40	40	0	0	0	0		-
APSC 132	Chemistry and its Applications	No		40	0	30	30	0	10	0	10		-
APSC 143	Introduction to Computer Programming for Engineers	No		40	0	0	0	0	40	0	40		-
APSC 151	Earth Systems and Engineering	No		40	0	16	16	10	14	0	14		-
APSC 162	Engineering Graphics	Yes	MECH1065 - Engineering Drawing II & DRWG2220 - Advanced Solid Modeling	30	0	0	0		20	10	30		30
APSC 171	Calculus I	Yes	MATH2130 - Calculus	40	40	0	40	0	0	0	0		40
APSC 172	Calculus II	No		40	40	0	40	0	0	0	0		-
APSC 174	Introduction to Linear Algebra	No		40	40	0	40	0	0	0	0		-
APSC 182	Applied Engineering Mechanics	Yes	MECH1220 - Applied Mechanics	20	0	0	0	0	15	5	20		20

B) Second Year

Mechanical Engineering Courses													
Degree Course Number	Degree Course title	Diploma Course Equivalency	Diploma Course Title(s)	Degree Course AU Total	Degree Course AU by CEAB Category								Diploma Course AU Equivalency Total
					Math	NS	M+NS	CS	ES	ED	ES+ED		
MECH 221	Statics and Solid Mechanics	Yes	MECH2030 - Mechanics of Materials	48	0	0	0	0	48	0	48	48
MTHE 225	Ordinary Differential Equations	No		42	42	0	42	0	0	0	0	-
MECH 213	Manufacturing Methods	Yes	MACH1010 - Conventional Machining Processes & MANU2000 - Manufacturing	54	0	0	0	0	36	18	54	54
MECH 217	Measurement in Mechatronics	Maybe	DIMM2010 - Dimensional Metrology and Coordinate Measuring Machines	51	0	0	0	0	36	15	51	-
MECH 230	Thermodynamics I	Yes	MECH3070 - Thermodynamics 1	42	0	30	30	0	12	0	12	42
MECH 270	Materials Science and Engineering	Yes	MECH 1130 - Engineering Materials	45	0	12	12		33	0	33	45
APSC 200	Engineering Design and Practice II	Maybe	MECH 3190 - Engineering Project and Report A & MECH3200 - Engineering Project and Report B & CEPR1020 - Co-op and Career	48	0	0	0	12	0	36	36	-
APSC 293	Engineering Communications I	Yes	COMM1085 - College Reading & Writing Skills	12	0	0	0	12	0	0	0	12
ELEC 210	Introductory Electric Circuits and Machines	Yes	EECE1475 - Electrical Fundamentals & CNTR3061 - Electrical Machines and Controls	51	0	0	0	0	51	0	51	51
MTHE 272	Application of Numerical Methods	No		42	20	0	20	0	11	11	22	-
MECH 228	Kinematics and Dynamics	No		42	0	11	11	0	31	0	31	-
MECH 241	Fluid Mechanics I	Maybe	IFME3010 - Mechanics and Dynamics of Fluids	42	0	24	24	0	18	0	18	-
APSC 221	Economics and Business Practices in Engineering	Maybe	ECON1041 - Engineering Economics	36	0	0	0	36	0	0	0	-

C) Third and Fourth Years

Mechanical Engineering Courses												
Degree Course Number	Degree Course title	Diploma Course Equivalency	Diploma Course Title(s)	Degree Course AU Total	Degree Course AU by CEAB Category							Diploma Course AU Equivalency Total
					Math	NS	M+NS	CS	ES	ED	ES+ED	
MECH 321	Solid Mechanics II	Yes	MECH2110 - Applied Mechanics (Advanced) & MECH 2090 -Mechanics of Materials (Advanced)	42	0	0	0	0	30	12	42	42
MECH 328	Dynamics and Vibration	No		42	0	11	11	0	17	14	31	-
MECH 396 or	Mechanical and Materials Engineering Laboratory I	No		36	0	0	0	12	24	0	24	-
MECH 398	Mechanical Engineering Laboratory I	No		0	0	0	0	0	0	0	0	-
MECH 323	Machine Design	Yes	MECH2070 - Engineering Design I & MECH3065 - Mechanics of Machines	54	0	0	0	0	27	27	54	54
MECH 346	Heat Transfer	No		42	0	0	0	0	42	0	42	-
MECH 350	Automatic Control	No		42	0	0	0	0	23	19	42	-
MTHE 367	Engineering Data Analysis	Maybe	QUAL2010 - Quality Assurance and Systems	42	31	0	31	0	11	0	11	-
MECH 397	Mechanical and Materials Engineering Laboratory II	No		24	0	0	0	0	24	0	24	-
MECH 399	Mechanical Engineering Laboratory	No		0	0	0	0	0	0	0	0	-
MECH 330	Applied Thermodynamics II	Yes	MECH3080- Thermodynamics II	42	0	0	0	0	42	0	42	42
MECH 341	Fluid Mechanics II	No		42	11	0	11	0	31	0	31	-
3rd Year	Technical Elective OR Complementary Studies	Maybe	(i)	36								-
MECH 460	Team Project - Conceive and Design	No		48	0	0	0	0	0	48	48	-
MECH 464	Communications and Project Management	No		18	0	0	0	18	0	0	0	-
4th Year	*1 Complementary Studies Course (from List A)*	Yes	(i)	36	0	0	0	36	0	0	0	36
4th Year	*1 Complementary Studies Course (from List A , B, C, or D)*	Yes	(i)	36	0	0	0	36	0	0	0	36
4th Year	8 Technical Electives	See Table below		324								
	Program Total			**1980**	**240**	**244**	**484**	**208**	**680**	**248**	**928**	**552**
(i) Variable (General Education Courses)												

D) Technical Electives

Degree Course title	Diploma Course Title(s)
Technical Elective 1	MECH3050 - Computer Aided Stress Analysis

E) Required AUs for Graduation

Academic Year	Degree Course AU Total	Degree Course AU by CEAB Category							Diploma Course AU Equivalency Total							
		Math	NS	M+NS	CS	ES	ED	ES+ED		Math	NS	M+NS	CS	ES	ED	ES+ED
1st Year	519	136	156	292	46	133	48	181	90	40	0	40	0	35	15	50
2nd Year	555	62	77	139	60	276	80	356	252	0	42	42	12	180	18	198
3rd Year	444	42	11	53	12	271	72	343	138	0	0	0	0	99	39	138
4th Year	504	0	0	0	90	21	69	90	72	0	0	0	72	0	0	0

TRANSFER	AU Total	Math	NS	M+NS	CS	ES	ED	ES+ED
TRANSFER YEAR 1	90	40	0	40	0	35	15	50
TRANSFER YEAR 2	252	0	42	42	12	180	18	198
REQUIRED AU TO MAKE UP	**732**	**158**	**191**	**349**	**94**	**194**	**95**	**289**

Tables 7A-7E. Transfer to Electrical Engineering Program Summary; transferrable courses by year, and AU analysis

A) First Year

Electrical Engineering Courses												
Degree Course Number	Degree Course title	Diploma Course Equivalency	Diploma Course Title(s)	Degree Course AU Total	Degree Course AU by CEAB Category							Diploma Course AU Equivalency Total
					Math	NS	M+NS	CS	ES	ED	ES+ED	
APSC 101	Engineering Problem Solving and Modelling	No		35	0	0	0	18	0	17	17	
APSC 102	Experimentation and Design	Yes	LIN 155 Electronic Lab Instrumentation and Techniques	34	0	16	16	0	18	0	18	34
APSC 103	Engineering Design Project	Yes	ETD 555 Engineering Technology and Design	40	0	0	0	18	6	16	22	40
APSC 111	Physics I	Yes	PHY 354 Physics for Electronics	40	0	40	40	0	0	0	0	40
APSC 112	Physics II	No		40	0	30	30	0	10	0	10	-
APSC 131	Chemistry and Materials	No		40	0	40	40	0	0	0	0	-
APSC 132	Chemistry and its Applications	No		40	0	30	30	0	10	0	10	-
APSC 143	Introduction to Computer Programming for Engineers	Yes	PRG 155 Programming Fundamentals Using "C" & PRG 255 Advanced Programming Using "C"	40	0	0	0	0	40	0	40	40
APSC 151	Earth Systems and Engineering	No		40	0	17	17	8	15	0	15	-
APSC 162	Engineering Graphics	No		30	0	0	0	0	20	10	30	-
APSC 171	Calculus I	Maybe	MTH 356 Mathematics - Introductory Calculus and Statistics & AMT 453 Advanced Mathematics	40	40	0	40	0	0	0	0	-
APSC 172	Calculus II	No		40	40	0	40	0	0	0	0	-
APSC 174	Introduction to Linear Algebra	Maybe	MTH147 Mathematics with Foundations or MTH155 - Mathematics	40	40	0	40	0	0	0	0	-
APSC 182	Applied Engineering Mechanics	No		20	0	0	0	0	15	5	20	-

B) Second Year

Electrical Engineering Courses												
Degree Course Number	Degree Course title	Diploma Course Equivalency	Diploma Course Title(s)	Degree Course AU Total	Degree Course AU by CEAB Category							Diploma Course AU Equivalency Total
					Math	NS	M+NS	CS	ES	ED	ES+ED	
ELEC 221	Electric Circuits	Yes	ECR 255 AC Circuit Principles	51	0	0	0	0	51		51	51
ELEC 252	Electronics I	Yes	ELD 255 Electronics: Semiconductor Devices	51	0	0	0	0	36	15	51	51
ELEC 271	Digital Systems	Yes	DGS 255 Digital Systems	51	0	0	0	0	23	28	51	51
ELEC 273	Numerical Methods and Optimization	No		42	21	0	21	0	21	0	21	-
ELEC 274	Computer Architecture	No		48	0	0	0	0	26	22	48	-
ELEC 278	Fundamentals of Information Structures	No		48	12	0	12	0	24	12	36	-
ELEC 280	Fundamentals of Electromagnetics	Yes	TRN 553 Transmission Theory	55	10	27	37		18		18	55
APSC 200	Engineering Design and Practice II	Yes	TPJ 655 Technical Project	48	0	0	0	12	0	36	36	48
APSC 293	Engineering Communications I	Yes	COM 101 Communicating Across Contexts & TEC 400 Technical Communications	12	0	0	0	12	0	0	0	12
ELEC 299	Mechatronics Project	Maybe	MEC 300 Introduction to Mechatronics & MEC 400 Mechatronics, Pneumatics, and Hydraulics	18	0	0	0	0	0	18	18	-
MTHE 228	Complex Analysis	No		42	42	0	42	0	0	18	18	-
MTHE 235	Differential Equations for Electrical and Computer Engineers	No		36	27	0	27	0	9	0	0	-
2nd Year	1 Complementary Studies Course (from List A)	Yes	(i)	36	0	0	0	36	0	0	0	0

C) Third and Fourth Years

Electrical Engineering Courses												
Degree Course Number	Degree Course title	Diploma Course Equivalency	Diploma Course Title(s)	Degree Course AU Total	Degree Course AU by CEAB Category							Diploma Course AU Equivalency Total
					Math	NS	M+NS	CS	ES	ED	ES+ED	
ELEC 323	Continuous-Time Signals and Systems	No		45	12	0	12	0	33		33	-
ELEC 324	Discrete-Time Signals and Systems	No		48	12	0	12	0	36		36	-
ELEC 326	Probability and Random Processes	No		42	31	0	31	0	11		11	-
ELEC 353	Electronics II	No		54	0	0	0	0	27	27	54	-
ELEC 371	Microprocessor Interfacing and Embedded Systems	No		48	0	0	0	0	36	12	48	-
ELEC 381	Applications of Electromagnetics	No		42	0	0	0	0	24	18	42	-
ELEC 390	Electrical and Computer Engineering Design	No		27	0	0	0	7	0	20	20	-
APSC 221	*Economics and Business Practices in Engineering*	No		36	0	0		36	0	0	0	-
ENPH 336	*Solid State Devices*	No		39	0	18	18	0	21	0	21	-
3rd Year	*1 Complementary Studies Course (from List A)*	Yes	(i)	36	0	0	0	36	0	0	0	0
3rd Year	*1st Elective Course (from List A or B)*	No		42								-
3rd Year	*2nd Elective Course (from List A or B)*	No		42								-
ELEC 490	*Electrical Engineering Project*	No		84	0	0	0	21	0	63	0	-
4th Year	*1 Complementary Studies Course (from List A , B, C, or D)*	Yes	(i)	36	0	0	0	36	0	0	0	36
4th Year	8 Technical Electives	See Table below		298	31	0	31	0	11	0	11	-
	Program Total			**1976**	**318**	**218**	**536**	**240**	**541**	**337**	**806**	**458**
(i) Variable	(General Education Courses)											

D) Technical Electives

Degree Course title	Certificate Course Title(s)
Tehnical Elective 1	ELM 453 Electrical Machines
Technical Elective 2	NET 455 Networking Essentials
Technical Elective 3	CSF 453 Control Systems Fundamentals
Technical Elective 4	COM 455 Communication Fundamentals & COM 556 Wireless & Satellite Communication Systems

E) AUs to make up

Academic Year	Degree Course AU Total	Degree Course AU by CEAB Category							Certificate Course AU Equivalency Total	Certificate Course AU Equivalency by CEAB Category						
		Math	NS	M+NS	CS	ES	ED	ES+ED		Math	NS	M+NS	CS	ES	ED	ES+ED
1st Year	519	120	173	293	44	134	48	182	154	0	56	56	18	64	16	80
2nd Year	538	112	27	139	60	208	149	348	268	10	27	37	60	128	79	207
3rd Year	501	55	18	73	79	188	77	265	0	0	0	0	36	0	0	0
4th Year	418	31	0	31	57	11	63	11	36	0	0	0	36	0	0	0
TRANSFER	AU Total	Math	NS	M+NS	CS	ES	ED	ES+ED								
TRANSFER YEAR 1	154	0	56	56	18	64	16	80								
TRANSFER YEAR 2	268	10	27	37	60	128	79	207								
REQUIRED AU TO MAKE UP	**635**	**222**	**117**	**339**	**26**	**150**	**102**	**243**								

4.3.2 Development of Three Phase Pathway Model

Drawing on the combined study findings the research team defined key characteristics for a viable model. It was determined that our model needed to address the significant challenge of providing the missing courses in a timely manner while respecting the student need for a manageable workload, and also ensuring that accreditation requirements were being met. The student requests for built in support during the transition was also noted. Given these factors, a one term bridge was found to not be feasible for a multi-institutional pathway, given the variability between curricula. The potential options for delivering some of the missing courses to students prior to transition and after they completed their bridge were explored.

This led to development of a three-phase engineering technology advanced diploma to engineering degree transfer pathway model, designed with the flexibility to incorporate extant institution specific transfer pathways, while also providing a solid foundation for development of a pilot multi-institutional bridge program.

- <u>Phase 1 (Transfer Preparation)</u> is completed while the student is still enrolled in their advanced diploma program. Qualifying students are supported in incorporating additional courses that have been identified as filling engineering program gaps and being feasible to undertake in addition to the advanced diploma workload. There are three possible delivery mechanisms for such courses: in house, on-line, or at geographically convenient institutions. Students may decide to take courses during or outside of term, depending on availability. In some instances, institutions may accept a degree course of sufficiently overlapping course content as a substitute for the advanced diploma equivalent, thus reducing repetition.
- <u>Phase 2 (Bridge Term)</u> is completed at a designated Bridge Institution prior to entering the receiving degree granting Institution. A block of missing courses is delivered as a cohesive session.
- <u>Phase 3 (Program Completion)</u> is completed while attending the receiving degree granting Institution. Students are supported in creating a plan to incorporate all remaining missing courses. Courses may be taken in house or on-line. In some instances, courses that might

otherwise be designated as electives will be requisite for transfer students in order to ensure that they meet the missing AU requirements.

A visual depiction of this model is available in Appendix D: Transfer Pathway Infographic. There are successful institution specific pathways in Ontario as well and it would be expedient to develop any multi-institutional model with the flexibility to include them. There is much to be learned from all extant and attempted pathway models.

4.3.3 Three-Phase Transfer Pathway Model Overviews

This three-phase model was applied to sample programs in Civil, Mechanical and Electrical engineering technology and engineering. Tables 8 through 11 show sample mapping for Civil, Mechanical, and Electrical engineering technology to engineering pathways.

All mapping was done by the research team and is indicative of an initial attempt to determine program eligibility. Since mapping was done in house, these are not necessarily representative of what final program maps would look like. College names have been redacted to ensure anonymity.

Table 8. Overview of Three-Phase Transfer Pathway from Civil Engineering Technology Program to Queen's University Civil Engineering.

Bridge Phase	Course Gaps	Method of Delivery
Phase 1	APSC 174 – Linear Algebra	eCampus Ontario
	APSC 171 Calculus I	eCampus Ontario
	APSC 143 – Introduction to Computer Programming for Engineers	eCampus Ontario
Phase 1 OR Phase 2 (depending on the structure of the diploma program and the structure of the bridge)	APSC 112 – Physics 2	eCampus Ontario OR on-site
	APSC 172 – Calculus 2	eCampus Ontario OR on-site
	APSC 162 Engineering Graphics	eCampus Ontario OR on-site
	CIVL 231 – Solid Mechanics II	eCampus Ontario OR on-site
Phase 2	APSC 10X/APSC 200/APSC 293	On-site
	APSC 131 – Chemistry and Materials	On-site
	APSC 132 – Chemistry its Applications	On-site
	CIVL 210 Chemistry for Civil Engineering	On-site
	CIVL 222 – Numerical Methods for Civil Engineers	On-site
	MTHE 224 – Applied Mathematics for Civil Engineers	On-site
Phase 3	APSC 151 – Earth Systems and Engineering	At receiving institution

Table 9. Overview of Three-Phase Transfer Pathway from Mechanical Engineering Technology Program (A) to Queen's University Mechanical Engineering.

Bridge Phase	Course Gaps	Method of Delivery
Phase 1	APSC 174 – Linear Algebra	eCampus Ontario
	APSC 111 – Physics 1	eCampus Ontario
	APSC 143 – Introduction to Computer Programming for Engineers	eCampus Ontario
Phase 1 OR Phase 2 (depending on the structure of the diploma program and the structure of the bridge)	APSC 112 – Physics 2	eCampus Ontario OR on-site
	APSC 172 – Calculus 2	eCampus Ontario OR on-site
	MTHE 225 – Ordinary Differential Equations	eCampus Ontario OR on-site
	MECH 241 – Fluid Mechanics I	eCampus Ontario OR on-site
Phase 2	APSC 10X/APSC 200/APSC 293	On-site
	APSC 131 – Chemistry and Materials	On-site
	APSC 132 – Chemistry its Applications	On-site
	MECH 217 – Measurement in Mechatronics	On-site
	MECH 228 – Kinematics and Dynamics	On-site
	MTHE 272 – Application of Numerical Methods	On-site
Phase 3	APSC 151 – Earth Systems and Engineering	At receiving institution

Table 10. Overview of Three-Phase Transfer Pathway from Mechanical Engineering Technology Program (B) to Queen's University Mechanical Engineering

Bridge Phase	Course Gaps	Method of Delivery
Phase 1	APSC 174 – Linear Algebra	eCampus Ontario
	APSC 111 – Physics 1	eCampus Ontario
	APSC 143 – Introduction to Computer Programming for Engineers	eCampus Ontario
Phase 1 OR Phase 2 (depending on the structure of the diploma program and the structure of the bridge)	APSC 112 – Physics 2	eCampus Ontario OR on-site
	APSC 172 – Calculus 2	eCampus Ontario OR on-site
	MTHE 225 – Ordinary Differential Equations	eCampus Ontario OR on-site
Phase 2	APSC 10X/APSC 200/APSC 293	On-site
	APSC 131 – Chemistry and Materials	On-site
	APSC 132 – Chemistry its Applications	On-site
	MECH 213 – Manufacturing Methods	On-site
	MTHE 272 – Application of Numerical Methods	On-site
Phase 3	APSC 151 – Earth Systems and Engineering	At receiving institution

Table 11. Overview of Three-Phase Transfer Pathway from Electrical Engineering Technology Program to Queen's Electrical Engineering

Bridge Phase	Course Gaps	Method of Delivery
Phase 1	APSC 174 – Linear Algebra	eCampus Ontario
	APSC 111 – Physics 1	eCampus Ontario
	APSC 143 – Introduction to Computer Programming for Engineers	eCampus Ontario
	APSC 182 – Applied Engineering Mechanics	eCampus Ontario
Phase 1 OR Phase 2 (depending on the structure of the diploma program and the structure of the bridge)	APSC 112 – Physics 2	eCampus Ontario OR on-site
	APSC 172 – Calculus 2	eCampus Ontario OR on-site
	MTHE 235 – Differential Equations for Electrical and Computer Engineers	eCampus Ontario OR on-site
	MTHE 299 – Complex Analysis	eCampus Ontario OR on-site
Phase 2	APSC 10X	On-site
	ELEC 273 – Numerical Methods and Optimization	On-site
	ELEC 274 – Computer Architecture	On-site
	ELEC 278 – Fundamentals of Computer Structures	On-site
	ELEC 299 – Mechatronics Project	On-site
Phase 3	APSC 151 – Earth Systems and Engineering	eCampus Ontario or at receiving institution
	APSC 131 – Chemistry and Materials	At receiving institution
	APSC 132 – Chemistry and Applications	At receiving institution

4.3.3.1 Consultation with PEO and CEAB regarding Pathway Model

At intervals throughout the study, designated PEO and CEAB consultants were provided with updates on study progress, and well as content to review for feedback. This consultation with PEO and CEAB guided analysis of course mapping to focus on equivalent courses from engineering technology to engineering, with a focus on the transferable AUs for each course. In a teleconference the draft pathway model was discussed, and they provided the following feedback:

- Any bridging program developed would not be applicable to be accredited by CEAB in its own right, only as a part of a full engineering program
- It is imperative that any transfer program provide evidence of all courses done in the advanced diploma and/or bridging program that are receiving credit, as well as all program AUs, specific AUs, Graduate Attributes, and other gaps
- Consideration and documentation will be required of the P.Eng. status of instructors for courses involving Engineering Science and Engineering Design content. A bridging program would be an ideal place to introduce content requiring instruction by a P.Eng.
- Any transfer program must take into consideration that 50% of the AUs for the program must be taken at the degree granting institution.
- Thorough documentation specifying courses, AUs, specific AUs, and Graduate Attributes of the transfer program, signed by all participating parties and institutions would be extremely beneficial to include in any submission made by a participating university for accreditation of an engineering program.

4.3.3.2 Consultation with College and University Partners regarding Pathway Model

The pathway model was also shared with college and university contacts for review and discussion, resulting in key messages as follows:

- College programs did not have interest in developing new course material to ease transfer for the benefit of a limited number of students, particularly as engineering technology programs are already content heavy.
    - They were, however, amenable to the idea that certain courses be offered at a higher level which could replace core engineering technology courses to make transfer more expedient. For example, the replacement of an engineering technology calculus course with one more aligned with engineering program content.
- The three-phase model was well-regarded by all institutions, and the flexibility it offers was deemed beneficial.
- Institutions with existing engineering transfer pathways expressed interest in inclusion of Phase 1 courses in their program, to ease the transition into a rigorous bridge. This emphasized the willingness of inclusion in the program on behalf of some extant pathways.

4.3.4 Process Analysis for Transfer from Engineering Degree to Engineering Technology Advanced Diploma Program

Discussions were held with advanced diploma institutions personnel, who provided insights into the present process. Anonymized individual student transfer documentation was reviewed in detail with personnel with assigned transfer responsibilities, resulting in the identification of two overarching methods of transfer, of which some institutions use one or the other, or a combination of both. Description of the methods is available in Table 11.

Table 11. Description of required information and equivalency determination process for two methods used for transfer into Engineering Technology programs.

Method 1	**Information Provided to Advanced Diploma Granting Institution**	• transcript and course outlines for all courses is received. • all information assessed by receiving institution to determine which credits will be offered.
	Process for Determining Equivalency	• conditional credits are often offered and granted only after a Prior Learning Assessment and Recognition (PLAR), depending on the common practice at any given institution. Often these are 50% theory, 50% practical lab skills. • These might also be used to assess whether student is up to speed on some components of courses, without which these credits are not equivalent (probability in a mathematics course, for example).
Method 2	**Information Provided to Advanced Diploma Granting Institution**	• transfer credit requests selected by the student are received, along with grades and course outlines in the relevant subjects. Some institutions require a transcript, but others are not permitted to request it. • course outlines for the course in the year completed by the student are requested, if at all possible. If not available, most current available outline is accepted.
	Process for Determining Equivalency	• generally, even a small but significant missing element will result in denial of credit. Some institutions, however, require only a 75-80% equivalency. • some institutions are developing internal data bases of transfer credit information for recognized equivalencies to increase assessment efficiency.

Transfer students into Engineering Technology programs consistently lack the hands-on practical lab skills of their peers in the advanced diploma programs. This often impacts initial student confidence and success rates, but supplemental lab skills support has been found to be effective. Findings from this research were then discussed with a larger group comprised of stakeholders, including both university and college representatives. The overwhelming majority of those consulted was that, given the low volume of students transferring and the highly individualized nature of their transfer circumstances (due to transfers overwhelmingly being in response to academic failure), a bi-directional pathway model is not required at this time.

5 Recommendations

The following section details recommendations for further pursuit of a large-scale engineering transfer system, with both short- and long-term objectives and considerations.

5.1 Advanced Diploma to Degree Transfer Pathway Pilot Program

A detailed gap analysis of the commonality between engineering and engineering technology curricula for three disciplines revealed that the missing coursework could not be contained to a single bridge program. The three-phase transfer pathway model developed in this study addresses this by integrating additional courses prior to transfer and during program completion at the receiving institution. It provides a solid foundation on which to build a pilot program. The scale and pace of the pilot program, in terms of number of participant institutions and disciplines, will be determined by available funding and resources.

The Pilot Program Coordinator (PPC) will share findings with all partner institutions, as well as those who express interest in becoming involved in future at regular intervals throughout.
Given the associated development costs and complexities, it is reasonable to assume that the pilot program will be implemented in multiple Stages:

- Stage 1: development of an initial offering of three-phase pathway(s), based on this study's findings and the available budget.
- Stage 2: delivery of the Stage 1 pathway(s).
- Stage 3: expansion of the Stage 1 pathway(s) to include the remaining institutions and disciplines included in this study.

- Stage 4: analysis of Stage 1 and Stage 3 pathway(s) delivery experience in order to develop plan for increasing the scale to the provincial level.

This study's program gap analyses (Civil, Mechanical, and Electrical Engineering) between potential participant institutions will be reviewed carefully by the PPC to determine the best fit program matches for each Stage of the pilot program. Once this has been confirmed the following steps will be taken:

5.1.1 Confirmation of Participant Institutions

Once the budget has been confirmed, partner institutions for the identified best fit program matches for Stages 1 and 3 will be contacted by the PPC to ascertain their continued interest in participation. Once all participants have confirmed interest, then a memorandum of understanding would be drafted to ensure clear delegation of responsibilities.

There will be two overlapping but not identical groups participating in the pilot program:

- Sending and Receiving Institutions: as per the study analysis, there will be one "Sending" (Engineering Technology Advanced Diploma) Institution and one "Receiving" Institution (Engineering Degree Program) for each discipline pathway.
- Bridging Institutions: the limited number of discipline pathways in the pilot program warrants one host institution developing the Phase 2 bridge program. Extant bridge program institutions will also be encouraged to be involved: their expertise is valued, and they may find some of the pilot program pathway Phase 1 and Phase 3 course options of interest for their institutions to consider.

5.1.2 Ongoing Development of Pathway Model

The pilot program will provide additional information and experience required to refine the three-phase model. This will help to address existent and arising challenges.

As explained in Section 4, the identified program AU gaps are filled by transfer students taking additional courses, which are slotted in to the phase that is the best fit in terms of both program flow and student success.

5.1.2.1 Initial Model

Phase 1: Transfer Preparation

This phase is completed by the student while still enrolled in their advanced diploma program. The interested student receives support in developing a plan to incorporate those missing courses identified as being feasible to undertake in addition to regular program work load, and accessible from their institution.

There are three potential delivery mechanisms, for the Phase 1 courses:

- On-site (courses already being offered for other programs at the participant institution).
- Online (eCampus Ontario).
- Off-site (geographically close institutions offering necessary courses).

It is important that the student have access to support while adjusting to the increased academic workload. This introductory phase offers the student the opportunity to test their capability to complete the transfer before incurring the associated costs of Phase 2 and 3 of their pathway.

Phase 2: Bridge Term

This phase is completed on site at a designated Bridge Institution prior to entering the receiving degree granting Institution. A block of missing courses (those common to most disciplines and pre-requisite for year of entry) is delivered as a cohesive session. Customized courses could potentially fill a combination of missing AU categories.

Phase 3: Program Completion

This phase is completed while attending the receiving degree granting Institution. The student receives support in developing a plan that will ensure that they incorporate the remaining missing courses in such as a way as to optimize their program work load.

There are three potential delivery mechanisms (maximises student options such that they could take some during regular term, and others during breaks):

- On-site (elective courses that ensure the missing credits being designated as requisite for the transfer student - if demand sufficient, there is potential to add courses).
- Online (eCampus Ontario).
- Off-site (geographically close institutions offering necessary courses).

5.1.2.2 Development Possibilities

Some potential developments for the pathway that have been discussed are:

- (Phase 1) – Partner colleges have expressed a willingness to consider counting Phase 1 courses in place of an Advanced Diploma course where there is sufficient course content commonality. This would reduce student workload and repetition of material.

- (Phase 2) The experience of living on campus and attending courses with peers who are making the same transition could be morale and confidence building for incoming students.
- (Phase 3) - As the pathways become more established, some courses may be adjusted to address the AU count issue, such that the elective lists for transfer students don't have to be constricted.

5.1.2.3 Associated Challenges

Some challenges associated with the pathway are:

- Developing some discipline pathways may not be cost effective if there is not sufficient student demand.
- Keeping student costs down will be a challenge.
- Considering student needs as well as institutional convenience in developing pathway timelines can be difficult.
- The accreditation unit count for receiving institution will likely present a challenge, particularly with respect to ensuring that 50% AUs are granted within the degree program. This will require maintenance and detailed analysis on behalf of all participating parties.

5.1.3 Development of Student Supports

The inclusion of student support networks was a key component of the qualitative analysis, both from an institutional and a student perspective. The housing of student advisors or support staff, however, presents a challenge with a large-scale system. There is thus a need for a small number of centralized "Bridge Institutions" that are able to provide student support as the transfer occurs.
In Stage 1 of the Pilot Program, it will be important to identify what supports are available at all participant institutions and accessed as needed by students. The experience of students in Stage 2 will inform further analysis of how these existing supports can be either leveraged or expanded to include the transfer program, both at the university and college level most efficiently. Possible areas of student support include: administration, scheduling, academic support, and orientation and introduction to new institutions to encourage a sense of belonging.

5.1.3.1 Supporting Under-Represented Learners

One of the goals of the pathway is to increase access to engineering for underrepresented groups. In order to maximize retention rates it will be important to ensure that any population specific challenges that might be faced by incoming students are addressed discretely and expediently. These may include language support, more readily available and targeted academic support, and community building within programs to encourage a sense of fit.

5.2 Long Term Possibilities

5.2.1 Promotion of Pathway Option to Students

An established Engineering Technology Advanced Diploma to Engineering Degree Pathway would be well worth promoting to students. Participant colleges could benefit from an increased student intake, and engineering programs would benefit from the addition of a qualified, diverse addition to their student population in the upper years of their programs.

5.2.2 Expansion of the number of Participant Institutions and Discipline Pathways

Successful completion of the Pilot Program will offer the possibility of building on existing agreements to increase both the number of participant institutions and the available discipline pathways.

5.2.3 Exploration of Value of Introducing More Consistency Within Engineering Technology and Engineering Degree Programs

As students move around more fluidly the institutions start to share practices and consider whether there should be more commonality within AD programs and within engineering programs in Ontario. E.g. BC has been working on an agreement about some principles for what a common first year includes, allowing more fluid transfer.

5.2.4 Exploration of Establishing Pathways with Other Provinces

Should a province wide system be successfully implemented, thought may be given to expansion on a national scale. A similar development process would be applicable for transfer between institutions in different provinces, given the national level of engineering accreditation in Canada. Here, communication would be paramount to account for increased distance.

5.3 Engineering Technology Lab Skills Module

Although the demand for reverse transfer does not warrant the development of a full multi-institution pathway at this time, the lack of practical labs skills was a challenge to students entering engineering technology programs with advanced standing. Student could benefit from the development of a short-term lab skills module to be taken prior to starting their courses at the college level. Due to the variation in college curriculum, these modules should be developed unique to the engineering technology program in question, at this time. Should more demand for transfer of this kind present itself in the future, these modules can serve as the starting point for an intermediary bridging program.

6 Conclusion

The study's pathway model paves the way for the development of a pilot program. A successful method for determining equivalency has been documented and explored for several proof of concept pathways. Information regarding institutional and student experience of transfer was collected. These analyses resulted in the development of a three-phase model of transfer for engineering technology to engineering programs. This could be initially implemented with the subset of identified interested institutions and then expanded systematically province wide, following the equivalency determining process. Implementation of a pilot for this model of engineering transfer is necessary to test the validity and feasibility of this model, while increasing trust and partnerships between engineering and engineering technology programs, providing increased access to diverse learners, and pushing for increased student support through non-traditional learning pathways.

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8 Appendices

8.1 Appendix A: Ethics Documentation

August 21, 2018

Dr. Brian Frank
Professor
Department of Electrical and Computer Engineering
Queen's University
Beamish-Munro Hall
Kingston, ON, K7L 3N6

GREB Ref #: GELEC-126-18; TRAQ # 6024278
Title: "GELEC-126-18 Bidirectional transfer pathway for Ontario's engineering and technology programs"

Dear Dr. Frank:

The General Research Ethics Board (GREB), by means of a delegated board review, has cleared your proposal entitled **"GELEC-126-18 Bidirectional transfer pathway for Ontario's engineering and technology programs"** for ethical compliance with the Tri-Council Guidelines (TCPS 2 (2014)) and Queen's ethics policies. In accordance with the Tri-Council Guidelines (Article 6.14) and Standard Operating Procedures (405.001), your project has been cleared for one year. You are reminded of your obligation to submit an annual renewal form prior to the annual renewal due date (access this form at http://www.queensu.ca/traq/signon.html/; click on "Events;" under "Create New Event" click on "General Research Ethics Board Annual Renewal/Closure Form for Cleared Studies"). Please note that when your research project is completed, you need to submit an Annual Renewal/Closure Form in Romeo/traq indicating that the project is 'completed' so that the file can be closed. This should be submitted at the time of completion; there is no need to wait until the annual renewal due date.

You are reminded of your obligation to advise the GREB of any adverse event(s) that occur during this one-year period (access this form at http://www.queensu.ca/traq/signon.html/; click on "Events;" under "Create New Event" click on "General Research Ethics Board Adverse Event Form"). An adverse event includes, but is not limited to, a complaint, a change or unexpected event that alters the level of risk for the researcher or participants or situation that requires a substantial change in approach to a participant(s). You are also advised that all adverse events must be reported to the GREB within 48 hours.

You are also reminded that all changes that might affect human participants must be cleared by the GREB. For example, you must report changes to the level of risk, applicant characteristics, and implementation of new procedures. To submit an amendment form, access the application by at http://www.queensu.ca/traq/signon.html; click on "Events;" under "Create New Event" click on "General Research Ethics Board Request for the Amendment of Approved Studies." Once submitted, these changes will automatically be sent to the Ethics Coordinator, Ms. Gail Irving, at University Research Services for further review and clearance by the GREB or Chair, GREB.

On behalf of the General Research Ethics Board, I wish you continued success in your research.

Sincerely,

Dean Tripp, Ph.D.
Chair
General Research Ethics Board

c: Ms. Nerissa Mulligan and Dr. James Kaupp, Co-investigators

December 20, 2018

Dr. Brian Frank
Professor
Department of Electrical and Computer Engineering
Queen's University
Beamish-Munro Hall
Kingston, ON, K7L 3N6

Dear Dr. Frank:

RE: Amendment for your study entitled**: GELEC-126-18 Bidirectional transfer pathway for Ontario's engineering and technology programs;** TRAQ **# 6024278**

Thank you for submitting your amendment requesting the following changes:

1) To conduct interviews with current undergraduate student [redacted]

2) To conduct interviews with graduates of engineering programs who have completed bridging programs across Canada;

3) To increase the sample size to a maximum of 15 participants to be interviewed;

4) Revised Letter of Information/Consent Form (v. 2018/12/19);

5) Student/Graduate Interview Questions (v. 2018/12/03);

6) Recruitment Email for Graduate/Student Interviews (v. 2018/12/03);

7) Email to Institutional Contacts for Graduate/Student Interviews (v. 2018/12/03).

By this letter, you have ethics approval for these changes.

Good luck with your research.

Sincerely,

Dean Tripp, Ph. D.
Chair
General Research Ethics Board

c.: Ms. Nerissa Mulligan, Dr. James Kaupp, and Ms. Hannah Smith, Co-investigators

8.2 Appendix B: Institutional Interview Questions

1. Please describe your pathway or bridging program
2. What process was used to develop your pathway? (e.g. is it block transfer, were courses compared individually for specific matching outcomes, one-to-one course mapping, etc)
3. What is the demand for this type of pathway?
4. Does your pathway including bridging courses or modules, and if so how were these defined?
5. How effective is the pathway? (i.e. when students transfer via the pathway, how well do they do in their new program?)
6. What have you learned from your experience with this pathway, and how would you change the process/setup if you were to create another one?
7. Are there any limits to transfer that you are aware of (Engineering Technology to Engineering or vice versa)?
8. Are there any risks to be aware of when building a bridging program of pathway, and is so, do you know of a way they can be mitigated?
9. Would a more general (province-wide or broader) bridging process, which takes into account the current contents of source and destination programs, be more effective than developing and maintaining custom pathways between specific institutions?
10. What do you think are the principles for building a province-wide bridge?
11. Are there any other successful examples of bridges or pathways?
12. Is there anyone else we should talk to?

8.3 Appendix C: Student and Graduate Interview Questions

1. Where did you complete your engineering degree?
2. Where did you complete your engineering technology diploma?
3. What is the name of the institution where you completed a bridging program (if applicable)?
4. What discipline of engineering are you studying or did you study?
5. What made you decide to complete an engineering degree after earning an engineering technology diploma?
6. When did you decide you wanted to complete an engineering degree?
7. Did you work as an engineering technologist before returning to complete your engineering degree, or did you go directly from the engineering technology program to the bridge to the engineering degree?
8. How long was your bridging program?
9. Compared to your peers who started in year 1 of the engineering degree program, did you feel the engineering technology diploma + bridging program made you less prepared, just as prepared or more prepared for your courses in the engineering degree program?
10. Were there any course(s) in your engineering program you felt particularly underprepared for? If so, which course(s), and why?
11. Were there any course(s) in your engineering program you felt particularly prepared for? If so, which course(s), and why?
12. If you have already graduated, did you feel your background in both engineering technology and engineering made you less prepared, just as prepared or more prepared than your peers who entered into the engineering degree program directly into year 1?
13. How do you feel you would have done in the engineering program had you gone directly into year 1, instead of engineering technology + bridge?
14. Is certification as a professional engineer important to you? Why?
15. If you have graduated from an engineering program, are you working in an engineering job? Do you think your program(s) have adequately prepared you for the workplace? Why or why not?

8.4 Appendix D: Transfer Pathway Infographic