“MEET THEM WHERE THEY’RE AT”: GATHERING INSTITUTIONAL PERSPECTIVES ON ENGINEERING TECHNOLOGY TO ENGINEERING TRANSFER IN CANADA

Hannah Smith ^{a*}, Nerissa Mulligan ^a, Brian Frank ^a, Alexandra Downie ^a and Roxanna Gholami ^a

^a Queen’s University

*hannah.smith@queensu.ca

Abstract – This paper presents an investigation to determine the state of Canadian engineering transfer pathways and programs, how they were developed, and how to develop future large-scale transfer pathways. Technology to engineering pathways disproportionately improve access to engineering degrees for visible minorities, with some students relying on transfer as a pathway to a baccalaureate degree. However, there is no province-wide pathway in Ontario’s higher education system, so efficient transfer to engineering happens in a very a limited number of programs. To understand the system, a qualitative research study was developed that used semi-structured interviews with 15 institutions or groups with existing or attempted engineering transfer pathways. Results indicate that there are four factors differentiating existing pathways: timeline, structure, development, and scale. New partnerships should consider communication, collaboration, consideration of students and other institutions, and accreditation concerns as paramount in the success of proposed pathways, while lack of sustained institutional commitment, maintenance of programs, knowledge dissemination, and capacity may present challenges.

Keywords: engineering transfer, bridging programs, engineering technology, qualitative research, interviews

1. INTRODUCTION

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[1], [2]. 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 [3].

Several provinces in Canada have established pathways for students wishing to move from an engineering technology diploma to an engineering degree, such as Alberta and British Columbia. There also exist a number of formal “passerelles” between engineering faculties and technical Diplôme d’études collégiales (DEC) programs in CÉGEPs. Successful existing pathways in Ontario do exist, however it is generally the case that transferring students receive minimal credit for courses taken. These students are often required to start an engineering degree from year one, and in many cases to repeat course material in order to meet accreditation requirements and/or learn the theoretical foundations which are part of an engineering degree program.

As part of a larger project on developing a provincial approach to engineering transfer in Ontario, this paper seeks to answer the following questions:

1. What is the current landscape of engineering and engineering technology transfer in Canada?
 - a. What are current transfer systems, and how were they developed?

What factors influence currently existing transfer pathways, both positively and negatively?

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 [4], [5]. 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 [6], [7].

Internationally, Ogilvie 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 [8].

Zhang and Ozuna 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 [9].

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 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 [9]. Laugerman, Rover, and Mickelson 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 [10].

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 [9].

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 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 [11].

3. METHODOLOGY AND METHODS

To understand the current technology-engineering transfer system in Canada, a qualitative research study was developed that used semi-structured interviews of institutions with existing or attempted transfer pathways into accredited Engineering or unaccredited Bachelor of Technology programs. Though there are significant differences between provincial delivery of higher education, the national accreditation requirements present one of the largest challenges, so a national study was deemed to be most applicable. A qualitative methodology was best suited for data collection, as individuals' experiences and knowledge are paramount for a full understanding of the Canadian transfer landscape. A cursory overview of transfer practices revealed a wide variation in the structure and timeline of extant transfer programs, making quantitative data collection inefficient. Qualitative research allowed for the collection of rich data, without limiting the perspectives studied.

A phenomenographic methodology was selected for this research study. The purpose of phenomenographical research is to study how people understand or experience a given phenomenon in the surrounding world; here, the variation of understanding and experiences with engineering transfer in Canada [12]. Contrary to a phenomenological approach, here we are not seeking to understand the *essence* of the phenomenon, but rather the range of understanding and experiences present in a given landscape.

Ethical clearance for the study was granted by the Queen's University General Research Ethics Board prior to data collection.

3.1. Sampling Design

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. Due to the limitations of this sampling method, no interviews were conducted with Quebec pathways.

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. Roles included Deans and Associate Deans of Engineering, department heads, transfer specialists, and pathway managers, facilitators, and support staff.

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
	Degree Granting	7
Type of Program/Group	Advanced Diploma Granting	7
	Transfer Council	1

3.2. Interview Protocol

A semi-structured interview format was utilized for all conducted interviews. Probing questions were used to explore within the structured interview protocol. 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. The guiding questions for the interview are provided in Appendix A: Interview Questions.

Interviews were conducted via telephone. When possible, recordings were taken of the interviews to assist in data analysis.

3.3. Deductive Coding Analysis

Inductive coding was undertaken on detailed notes from the interviews, following the general approach of a phenomenographic analysis; that is, to study both the “what aspect” and the “how aspect” of the phenomenon in question [13].

Detailed notes were used for the analysis rather than transcripts, as recordings were not available for all conducted interviews. Thus, the “how aspect” of the analysis was limited. These notes, however, had sufficient detail for a high quality analysis.

4. RESULTS

Results from the qualitative analysis suggested three main areas of focus: a) models of Canadian transfer; b) success strategies; and c) risks and pitfalls.

4.1.1. 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.

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 transitional 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 minimum requirements for accreditation units (AUs) necessary to maintain

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 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 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.

4.1.2. 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.

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 are 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) can be articulated by the receivers, the more easily those demands can 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 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.

4.1.3. Risks and Pitfalls

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

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.

5. DISCUSSION

The results of this research will help guide the development of future engineering transfer pathways, particularly informing the development of a large-scale engineering transfer pilot project in Ontario.

Knowledge of extant engineering transfer pathways is extremely beneficial for those aiming to develop new pathways. From this research key considerations in pathway development include: conducting a detailed gap analysis that considers course content, outcomes and accreditation units, as part of developing bridge programs; considering student needs as well as institutional convenience in developing pathway timelines; and remaining cognisant of accreditation requirements throughout the development of the pathway to maintain degree granting institutional confidence in the process.

The inclusion of student support networks was a key component of the qualitative analysis, supporting the assertions made by Mattis and Sislin [11] These support networks were not always present or maintained in current programs, however, and is an area of potential improvement for engineering transfer pathways.

An overwhelming result of the present study was the sheer volume of considerations, ideas, and intricacies present within each transfer network. It would be impossible to group transfer pathways into generalized ‘models’ without losing key components and factors present in each. This brings attention to the difficulty of developing and sustaining successful pathways. The identification of key areas for success and failure is helpful in ensuring transfer program sustainability.

5.1. Limitations

As with any piece of qualitative research, some bias is unavoidable. Interview participants were selected based on those available and willing to participate in the research. The sample did not include individuals at all institutions

with extant and attempted transfer pathways, limiting the perspectives collected in the research.

Data was collected highlighting only the perspectives of faculty and staff, not the student experience. All insight into student experiences or motivations was, therefore, anecdotal. This will be remedied through the second phase of the research, examining student experiences of engineering transfer.

The bias of the researcher as the instrument is one inherent in qualitative research. Effort was made to “bracket out” the experiences and perspectives of the researcher, attempting to remain as impartial and unbiased as possible during data collection and analysis.

6. CONCLUSIONS

In conclusion, key factors shaping the formation of engineering technology to engineering transfer pathways have been identified and characterized. Success of these pathways hinges on collaboration, communication, consideration, accreditation, and student support. Risks inherent in the process included lack of institutional buy-in, sustained interest and maintenance, capacity of programs, and administration issues. These factors must be overcome to ensure the longevity of any developed pathway. The collected data can serve as sign-posts to guide and inform those attempting to create further opportunities for engineering transfer in Canada.

Acknowledgements

We would like to thank the faculty and staff at participating institutions for their time and wisdom. We also gratefully acknowledge funding and support from the Ontario Council on Articulation and Transfer (ONCAT).

References

- [1] L. Lattuca, P. Terenzini, H. K. Ro, and D. Knight, “America’s Overlooked Engineers: Community Colleges and Diversity in Engineering Education,” National Science Foundation, Jun. 2014.
- [2] M. D. Sullivan, C. C. de Cohen, M. J. Barna, M. K. Orr, R. A. Long, and M. W. Ohland, “Understanding engineering transfer students: Demographic characteristics and educational outcomes,” in *2012 Frontiers in Education Conference Proceedings*, 2012, pp. 1–6.
- [3] S. Zakani, B. Frank, R. Turner, and J. Kaupp, “Framework for transferability between engineering and technology programs: Project 2015-29,” Ontario Commission on Articulation and Transfer, Toronto, 2016.
- [4] F. Deller and S. Oldford, “Participation of low-income students in Ontario,” Higher Education Quality Council of Ontario, Toronto, Ontario, 2011.
- [5] D. Trick, “College-to-university transfer arrangements and undergraduate education: Ontario in a national and international context,” Higher Education Quality Council of Ontario, Toronto, Ontario, 2013.
- [6] A. Kerr, U. McCloy, and S. Liu, “Forging pathways: Students who transfer between Ontario colleges and universities,” Higher Education Quality Council of Ontario, Toronto, Ontario, 2010.
- [7] M. C. Lennon, H. Zhao, and T. Gluszynski, “Educational pathways of youth in Ontario: Factors impacting educational pathways,” Higher Education Quality Council of Ontario, Toronto, Ontario, 2011.
- [8] A. M. Ogilvie, “A review of the literature on transfer student pathways to engineering degrees,” in *2014 ASEE Annual Conference & Exposition*, 2014, p. 24.101.1-24.101.14.
- [9] Y. (Leaf) Zhang and T. Ozuna, “Pathways to Engineering: The Validation Experiences of Transfer Students,” *Community Coll. J. Res. Pract.*, vol. 39, no. 4, pp. 355–365, Apr. 2015.
- [10] M. Laugerman, D. Rover, M. Shelley, and S. Mickelson, “Determining Graduation Rates in Engineering for Community College Transfer Students Using Data Mining,” *Int. J. Eng. Educ.*, Jan. 2015.
- [11] M. C. Mattis and J. Sislin, Eds., *Enhancing the community college pathway to engineering careers*. National Academies Press, 2005.
- [12] F. Marton, “Phenomenography: Describing conceptions of the world around us,” *Instr. Sci.*, vol. 10, no. 2, pp. 177–200, Jul. 1981.
- [13] J. Larsson and I. Holmström, “Phenomenographic or phenomenological analysis: Does it matter? Examples from a study on anaesthesiologists’ work,” *Int. J. Qual. Stud. Health Well-being*, vol. 2, no. 1, pp. 55–64, 2007.

APPENDIX A: INTERVIEW QUESTIONS

Note that these questions were used as a guide for the interview, but points of investigation naturally emergent from discussion were also followed.

1. Can you describe your bridging pathway or 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. What would you consider the strengths and the limitations of your pathway as it stands?
8. Are there any limits to transfer that you are aware of (Engineering Technology to Engineering or vice versa)?
9. Are there any risks to be aware of when building a bridging program of pathway, and if so, do you know of a way they can be mitigated?
10. 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?
11. What do you think are the principles for building a province-wide bridge?
12. Are there any other successful examples of bridges or pathways?
13. Is there anyone else we should talk to?