BACHELOR OF MINING ENGINEERING TECHNOLOGY

PROJECT #: **2014-21**

QUEEN'S UNIVERSITY

NORTHERN COLLEGE

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Executive Summary

The Robert M. Buchan Department of Mining at Queen's University and Northern College's Haileybury School of Mines (NCHSM) applied to the Ontario Council on Articulation and Transfer (ONCAT) in 2014 for funding to support the development of a diploma-to-degree pathway in mining engineering. ONCAT funded the proposal with a $1,117,005 grant for course development, and the Faculty of Engineering and Applied Science (FEAS) contributed an additional $1,124,816.15 to support program and curriculum development, as well as program coordination and administration, IT infrastructure, and marketing and recruitment initiatives.

The ONCAT and FEAS funds covered an initial three-year pilot of the program (which was extended by one year), with the FEAS funding then used to bridge the pilot program development phase into the program delivery phase until the program was fully developed.

The BTech program is a diploma-to-degree pathway initially designed for the 2-year Mine Engineering Technician program offered at Northern College, but eventually expanded to include graduates of any Engineering Technology program seeking to upgrade their academic credentials. Graduates who maintained a 75% cumulative average in their college program receive block transfer credit for the first two years of study, and start the BTech program enrolling in a customized bridging curriculum designed to close the knowledge gap between college and university. Upon successful completion of the Bridge, students move directly into Year 3, and then Year 4. Each year also includes an on-site field school, an experiential learning module where students complete a series of laboratories necessary to obtain their degree.

The program includes seven bridge courses, twelve Year 3 courses, twelve Year 4 courses, as well as two Field Schools. Course development was achieved through multi-disciplinary course development teams, which included expertise in educational development and instructional design, multimedia technologies, as well as subject matter expertise. The teams broke the development timeline into four phases, designed to break the development cycle into manageable components, starting with scoping the course and identifying learning outcomes, through content development, and finishing with a quality review. Development timelines typically ranged from 8-12 months, with some outliers taking as long as 24 months to complete. The average cost to develop a course was $43k.

Graduates of the program receive a Bachelor's of Mining Engineering Technology (BTech) degree – which is currently unaccredited. Initial discussions with the Professional Engineer's of Ontario (PEO) have highlighted issues with online programming, and additional discussions will be necessary if a pathway to licensure is to be established. While students cannot apply for licensure upon graduation, they are eligible to apply for Master's studies (either in the Masters of Science, or Masters of Engineering programs). However; the issue of accreditation and licensure remains an on-going risk for the program's long-term success.

The BTech program opened enrollment in January 2016. Since that time, we've had 66 applications, made 57 offers of admission, and currently have 34 students active in the program. While this continues to exceed original enrollment forecasts, identifying strategies to improve our retention rate will be an on-going priority as we move from pilot phase into regular operation. Recruitment efforts are driven by a multi-faceted outreach program that includes both targeted digital promotion, and on-campus recruitment visits. Three formal Articulation and Transfer Agreements have been signed with Northern College, Cambrian College, and Saskatchewan Polytechnic – who all have Mining Engineering Technology programs, as well as over a dozen other Engineering Technology programs that can articulate into the BTech program. As the program grows, we hope to add more partnerships with relevant college programs.

Project Purpose and Goals

Queen's University's Robert M. Buchan Department of Mining and Northern College's Haileybury School of Mines (NCHSM) have partnered on a joint collaboration to create a new diploma-to-degree Bachelor of Mining Engineering Technology (BTech) program. The idea for the program was conceived at the college level. Through consultations with their industry advisory committee, Northern College identified a pathway need for their graduates to obtain a university degree. The College approached Queen's University about a potential collaboration. Building on the successful strategy employed by NCHSM's online Mining Engineering Technician program, the foundations of an online BTech program were formed. The program is open to the 2-yr Mine Engineering Technician graduates from Northern College, as well as any 3-yr college Engineering Technology program graduates.

A survey of 500 mining professionals[1] were asked to rate on a scale of 1-10 recent engineering graduates "preparedness to enter the workforce", nearly 56% of respondents ranked 'new hire engineers' as only being between a 5-7 out of 10. Of those respondents, 79% identified graduates as lacking "practical hands-on training", 46% identified "management skills", and 43% identified "communication skills". The detailed results of the survey are shown in Figures 1 and 2.

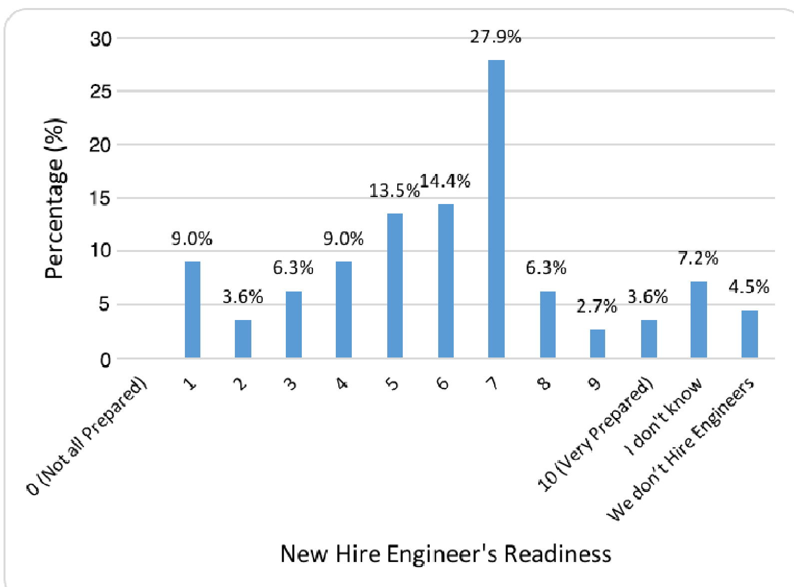

Figure 1: Survey Response to the question: "Thinking about new hire Engineers, how prepared are they to enter your workforce?"

1. 2014 "Bachelor of Technology Industry Survey", Queen's University

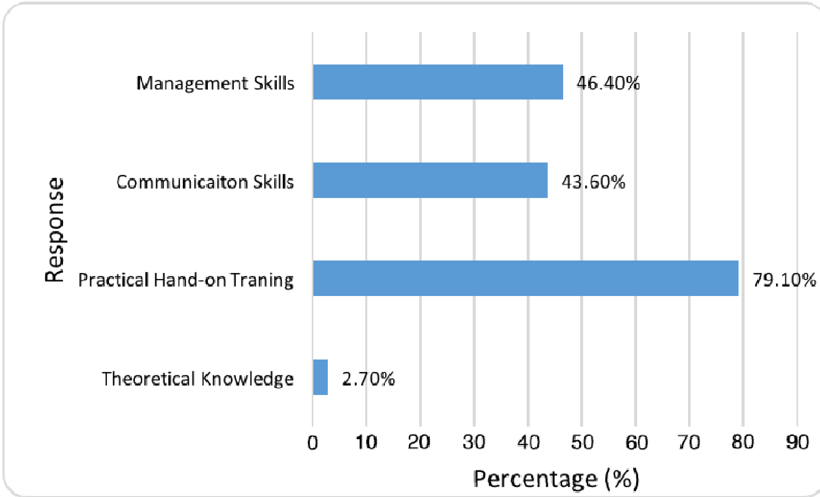

Figure 2: Survey Response to the question: “Thinking about new hire Engineers, what training do they lack upon entering your workforce?”

As a result of the survey information, the BTech program curriculum was designed to provide a balance of technical, managerial, and societal skills. Table 1 shows the Program Learning Outcomes (PLO’s) that were used for the development of the curriculum. Fundamentally, the curriculum provides depth of knowledge and background theory in a broad range of technical mining competencies, while also emphasizing practical application skills through current and emerging trends towards using technologically advanced equipment.

Table 1: Program Learning Outcomes

1. Identify, formulate, analyze, and solve typical mining engineering problems using a balance of mathematics, physics, chemistry, and Earth sciences

2. Conduct experiments, analyze and interpret data

3. Choose and implement sustainable methods for the safe extraction, handling, and processing of mineral resources to meet the technical, economic, and environmental needs of society

4. Employ modern engineering tools effectively for the purpose of mine planning and design, as well as for data visualization, analysis and interpretation

5. Value the mining industry’s unique characteristics in terms of its economic, legal, environmental and societal elements

6. Work professionally and communicate effectively in a team-based multi-disciplinary environment. Articulate and justify technical solutions to diverse audiences

Pathway Development

The BTech diploma-to-degree pathway is shown in Figure 3, with the to date number of applications and offers since inception shown in Figure 4.

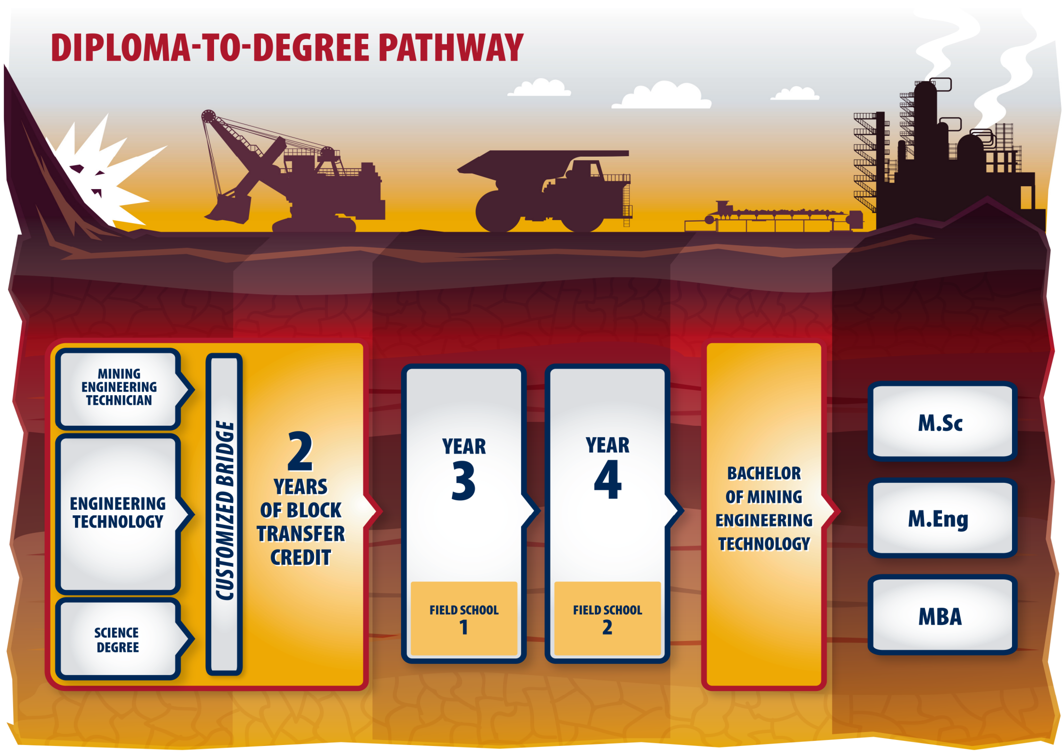

Figure 3: BTech Program Pathway Diagram

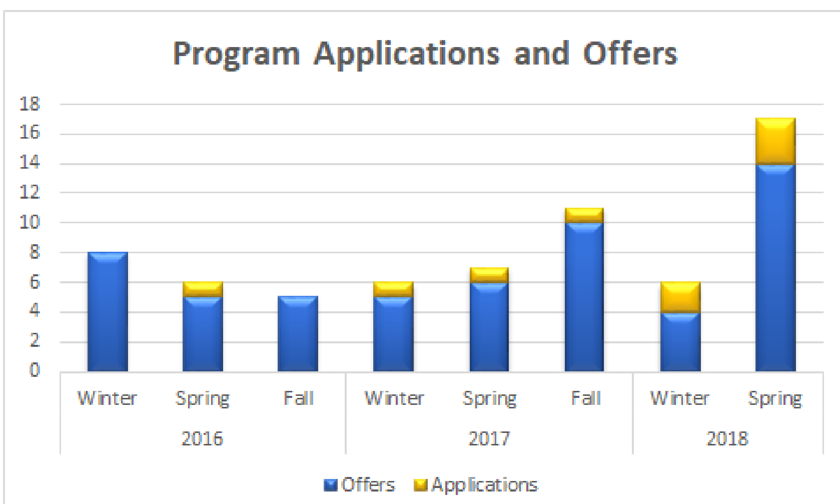

Figure 4: BTech Program Applications and Offers

Methodology

Following the initial consultation process in 2012, Northern College and Queen's University signed a Memorandum of Understanding (MOU) in 2014 (Appendix 2). The MOU agreed to share resources and expertise on the development of a new online degree program. Due to the size and scope of the project, a dedicated Project Manager was hired in the fall of 2014 to oversee the approvals process, development, and pilot delivery of the program.

The approvals process for a new degree program at Queen's University requires extensive thought relating to quality assurance (it's officially called the Queen's University Quality Assurance Process, or QUQAP). Initial development of the program framework occurred at the Mining Department level, and was presented to the Faculty of Engineering and Applied Science Faculty Board for approval in November 2014. Following Faculty Board approval, the program was submitted to the Senate Committee on Academic Development for approval in February 2015, and following that received Queen's Senate approval in March 2015. From there, the program was submitted to the Ministry of Training, Colleges, and Universities (MTCU) for approval, which was received in May 2015.

While not officially a program, course development initiated in January 2015 – starting with the bridging curriculum. Because the program intakes students from any engineering technology background (civil, mechanical, electrical, chemical, etc.) it was necessary to build a set of customizable bridging courses, that various students could take to fill their theoretical gaps, depending on their backgrounds. Additionally, because the various college programs were so diverse in the type of content taught, rather than individually map the college programs to the BTech program, it was decided to map the necessary theory required in Year 4 of the program back to Year 3, and then build the necessary theoretical knowledge taught in the bridge from those requirements (see Appendix 5 for an example of the Math Gap Analysis report). The benefit of this approach was that any college engineering technology graduate could enroll in the program; and their specific bridging requirements would depend on their knowledge. One criteria of the BTech program is a progression rule that requires students exit the Bridge with a minimum 65% cumulative average, which prevents anyone from enrolling in upper year curriculum without the necessary foundational theory.

The BTech program opened enrollment in January 2016. Recruitment efforts initially targeted institutions with multi-disciplinary engineering technology programs. In 2017, three formal Articulation and Transfer Agreements were signed with Northern College, Cambrian College, and Saskatchewan Polytechnic – who all have Mining Engineering Technology programs, as well as over a dozen other Engineering Technology programs that can articulate into the BTech program. An example of the Articulation and Transfer Agreement signed between Queen's University and Northern College is shown in Appendix 3. As the program grows, we hope to add more partnerships with relevant college programs.

As stated previously, the program adopted a multidisciplinary team-based approach to course design and development. Course Development Teams can be comprised of individuals with various roles shown in Figure 5:

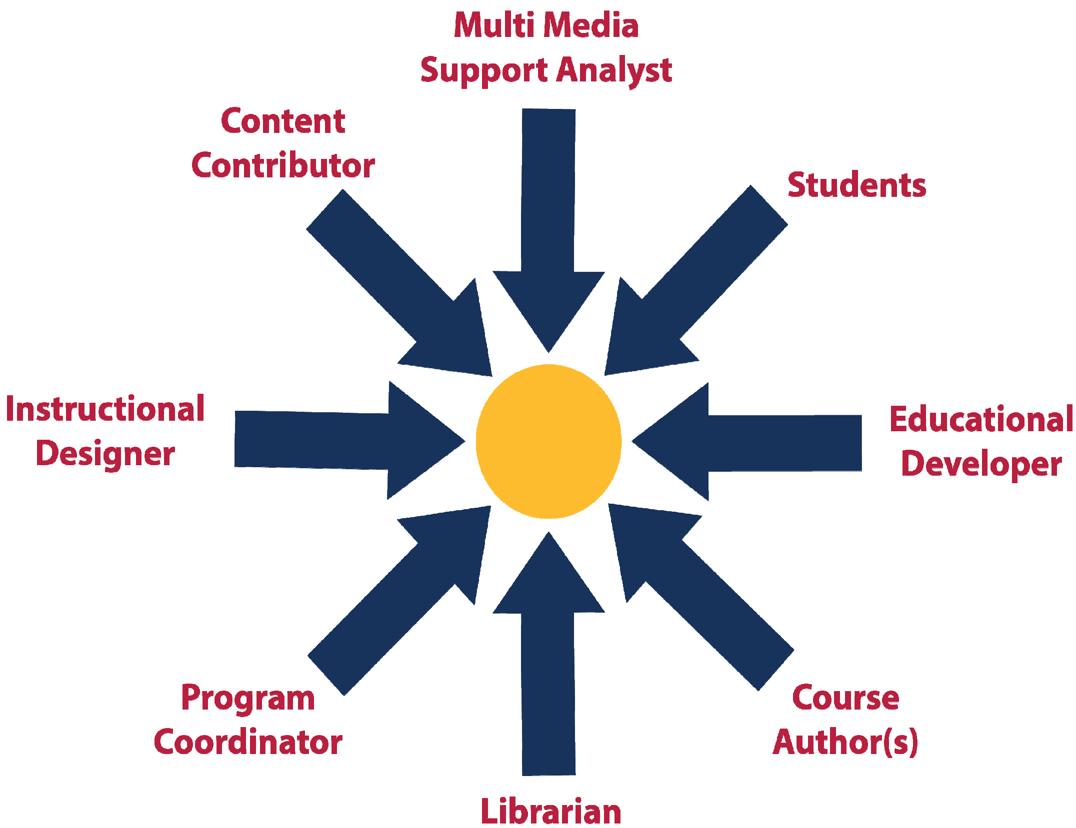

Figure 5: Multi-disciplinary Course Development Team

The diversity of the Course Development Team provides additional strengths through its ability to present a variety of perspectives. Some Course Authors describe the experience as transformational, as for many this was the first time in their careers that they had been supported with experts in the field of learning.

The course development process being employed is a process loosely based on the first three steps in the popular Analysis, Design, Development, Implementation, Evaluation (ADDIE) model of instructional systems design (Branch, 2009)[2], but adapted for the unique needs of engineering learners. In an 8-12 month period, the course design process passes through four phases, shown in Figure 6:

[2] Branch, R. M. (2009). *Instructional Design: The ADDIE Approach*. New York: Springer.

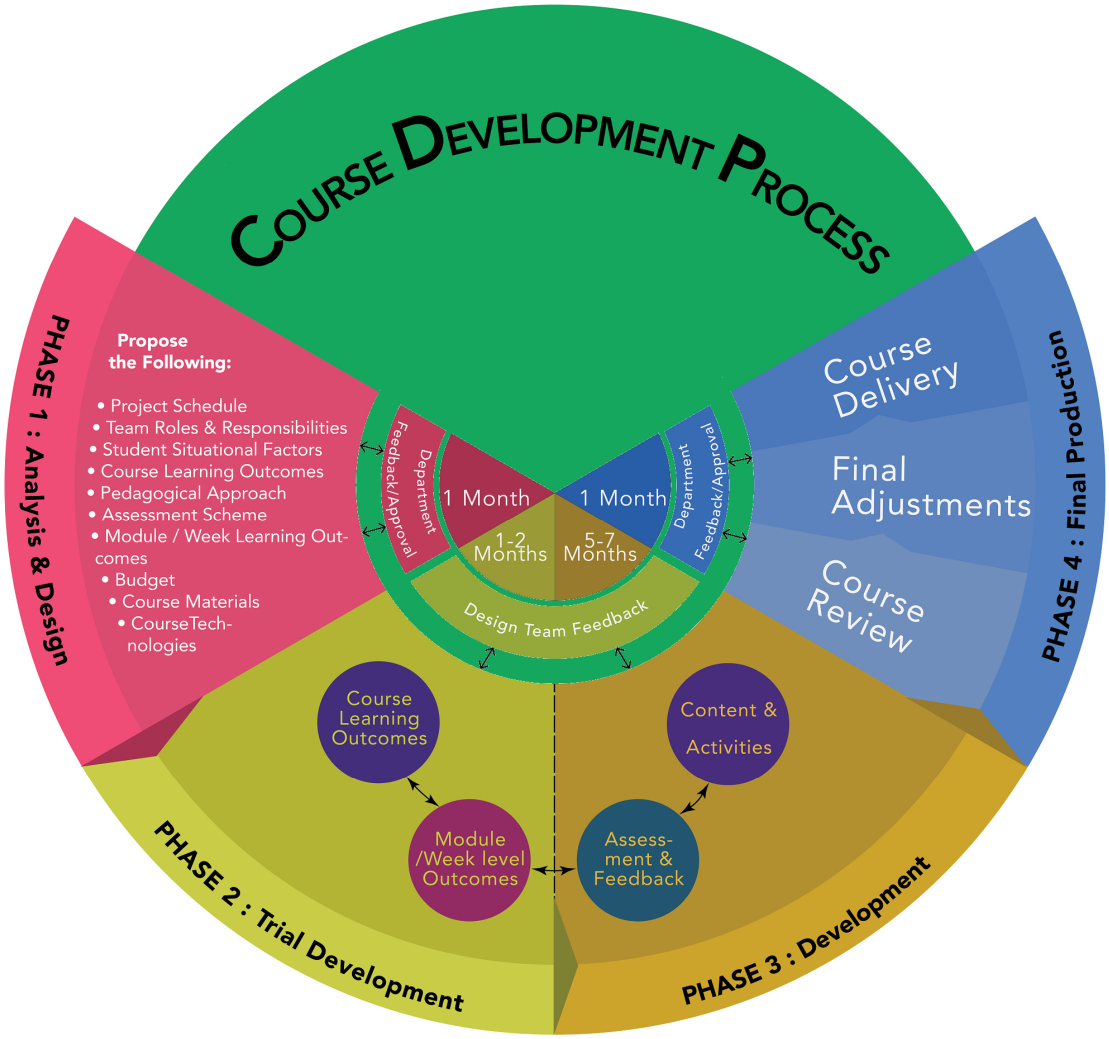

Figure 6: Phased Course Development Process

Phase 1 (~1 month): The Course Development Team assembles to clarify their roles, establish agreed-upon milestones and develop a team-based communication strategy. Their first course-related task is to determine the Course-level, and Week-level Learning Outcomes, and align them with the overarching BTech Program-level Learning Outcomes (PLO's). Next, they continue this alignment into the assessment scheme and design a balance of activities that satisfy the quality standards, while providing opportunities for interaction and active learning. Finally, a Course Design Scoping Report is produced and used to communicate the planned course design with the Mining Department, in order to obtain feedback. This is an important feedback step that allows for any modifications to the course design and development plan early in the process.

Phase 2 (~1 month): The Course Design Team explores and selects technology tools that best fit with the types of content and assessments being planned for the course. During this phase, the Team typically chooses one week of the course to experiment upon. Using a rapid prototyping approach, they create a small number of learning objects, and iterate them into finished products.

Phase 3 (~5 months): Equipped with the lessons-learned from Phase 2, the Team then systematically creates all the course content, learning activities, and assessments for the online course. This activity often requires consultation with other more-transient members of the Team including Content Contributors, Information Technology staff, and members of the local community. Finally, the completed course material is organized on the Learning Management System adopted at Queen's, Brightspace by Desire2Learn[3].

Phase 4 (~1 month): The Team engages in a two-part quality assurance phase. It is important to note that decision-making processes in Phases 1, 2, and 3 are guided by the evidence-based Quality Matter Framework and that Phase 4 represents a different type of "quality" assurance. It includes a review of the course content by the BTech Program Coordinator, who looks for disconnections, ambiguities and errors. Once these deficiencies are repaired, a faculty member (who did not participate on the Course Development Team) conducts a comprehensive review of the course in order to ensure it meets the intended learning outcomes, the assessments are achievable, and that the overall course meets the quality standards of the department. This feedback helps inform either final adjustments to the course material, or future directions for course improvement.

1. **Course Overview and Introduction**
2. **Learning Outcomes**
3. **Assessment & Measurement**
4. **Instructional Materials**
5. **Course Activities & Learner Interaction**
6. **Course Technology**
7. **Learner Support**
8. **Accessibility & Usability**

Figure 7: Quality Matters Framework

Quality is the primary driver in online course design and development in the Faculty of Engineering and Applied Science at Queen's. In order to operationalize this, the FEAS adopted an evidence-based approach when designing and developing curriculum. To help guide decisions at all stages of the course development projects, the FEAS uses the well-established Quality Matters framework[4] for defining quality in online courses (shown in Figure 7). Key staff that work on Course Development Teams have been formally trained in this quality benchmarking system and use its principles to inform their practice.

[3] https://www.d2l.com
[4] www.QualityMatters.org

Program Comparison and Analysis

The program recognizes the value of a student's college diploma (in any 3-yr engineering technology program, or a 2-yr mine engineering technician program), and grants block transfer credits for the first two years of the bachelor's degree. However; it was recognized that a gap in the core sciences exists - specifically in a college graduate's mathematics, physics, and chemistry knowledge. A solid understanding of the foundational theory in these areas is essential for student success in the University curriculum, particularly in the advanced study courses in Year 3 and 4. Initially, the thought was to map specific college programs to university – but it was quickly realized that the differences between programs would make this task difficult. Instead, a Gap Analysis (Appendix 2) was done to map the necessary skills from the program's 4th year curriculum, down to what students would need entering 3rd year, and then to close the gap between college and university, the program created a set of customized bridging courses. Students are required to take specific courses in various math, physics, chemistry, geology, or surveying theory that are identified as lacking in their college education. The Bridge represents a critical component to the program's success. It serves as a 'proving ground' for the BTech program, and prepares them for their University education. Requiring that students pass the Bridge with a minimum 65% average ensures that only students who have the potential to succeed are able to move beyond the foundational theory portion of the program (and saves those students who might otherwise have failed the time and money of making a prolonged attempt).

Overall, the Program, Course-level, and Weekly Learning Outcomes are all constructively aligned, and map to the Undergraduate Degree-Level Expectations (UDLE's). This mapping is shown in Appendix 6.

Another essential element of the program is the online delivery format. Industry continually identifies a need for professional development and continuing an employee's education. However; very few employees are able to relocate to an academic institution to continue their educational career – both professional and personal responsibilities often prevent long-term relocation. Online education presents an incredible opportunity to overcome this geographic obstacle. By offering content online, students can access their instructors and classmates from virtually anywhere in the world (with an internet connection).

The challenge has been to overcome the 'online stigma' in technical disciplines like engineering education. Jones et. Al. (2009)[5] established that, when courses are well designed, with committed instructors who have the appropriate supports, online delivery is not inferior to classroom delivery in a higher education context. However, in technical disciplines where the line between "training" and "education" are often blurred, the quality of online higher education courses has been questioned. In order to overcome this challenge Queen's University adopted a two-pronged approach: first, quality was deemed the primary driver in online course design and development. In 2014, Queen's became an institutional member to the most respected evidence-based standard setting body for quality in online education: Quality Matters. The articulated standards are applied directly to all courses in the BTech program by specially trained personnel. Secondly, Queen's University adopted a multi-disciplinary approach to assembling Course Development Teams who design and

[5] Jones, et. al., (2009) Evaluation of Evidence-Based Practices in Online Learning: A meta-analysis and review of online learning studies. Retrieved from http://files.eric.ed.gov/fulltext/ED505824.pdf

develop online courses. Adopting a team approach meant that the course design and development process takes longer and costs more than the traditional development process; however, quality levels meet or exceed residential program standards.

This approach to creating curriculum has been transformational for the BTech program. Courses have been created that foster an optimum environment for learning, where students have a clear understanding of what is expected of them, and are guided in a student-centric and supportive environment. The program is constructively aligned throughout, from program-level outcomes, to course-level outcomes, to content, through to the assessments. As a result, both students and employers can be certain that graduates of the BTech program at Queen's are well-equipped to immediately make positive impacts in the workplace.

Finally, the 'secret ingredient' that truly differentiates the program has been the involvement of industry in content creation. Naturally, a Bachelor of Mining Engineering Technology degree places an emphasis on the technology. In order to stay relevant, the program consulted industry on which technologies should be showcased; not as a sales tactic, but to educate the student on the tools and technologies being used in the modern mining industry today. In many cases, industry experts contributed to course development, and helped inform the curriculum at the course-level. Having access to mining industry data, training documentation, case studies, simulations, equipment, and technologies, and carefully integrating these into the curriculum where appropriate, has proven to be a clear differentiator for the program.

It is worth mentioning that while most institutions offer support to their students with dedicated program coordinators, and other student services, the BTech program, being online, also includes all the regular student support elements, through online interactions. Additionally, every student has a virtual meeting with the Program Academic Advisor at the start of their studies to develop a customized Individual Learning Plan (ILP), which serves as a roadmap to the completion of their degree. Due to the highly flexible delivery format of the program, if a student encounters a significant change in their life (professional or family obligations often arise), they can adjust their ILP accordingly. It is this flexibility that allows working professionals to balance their work and personal lives with their academic careers.

Implementation Process and Timelines

It should be stated up front that the BTech program went through an accelerated approvals process, due to the desire to initiate development early in the project, in an attempt to begin program delivery in Fall 2015. The actual approval steps and dates are shown in Table 2, while the more typical approvals timeline is shown in Appendix 4.

Table 2: Approvals Timeline

Approval	**Date**
Faculty of Engineering and Applied Science Faculty Board	November 19th, 2014
External Review	January 8th, 2015
University Units:	
Head, Robert M. Buchan Department of Mining	January 26th, 2015
Dean, Faculty of Engineering and Applied Science	January 26th, 2015
Office of the University Librarian	January 26th, 2015
University Registrar	January 27th, 2015
Chief Information Officer & Associate VP (IT Services)	January 26th, 2015
Executive Director, Budget and Planning	January 26th, 2015
Provost and Vice Principal (Academic)	January 26th, 2015
Senate Committee on Academic Development	February 4th, 2015
Senate	March 31st, 2015
Ministry of Training, Colleges, and Universities	May 22nd, 2015

Obtaining approvals is an iterative and time-consuming process. Initial development details are relatively straight-forward, and it's recommended that broad consultations with all signatories occur in the initial development phase. Once approvals are obtained, if any details need to be changed substantially, it can require restarting the approvals process. In particular, any stakeholders involved in resourcing the project (Finance, IT, Library, etc.) need to be given ample opportunity to understand the program, and what their expected contributions will be.

The key approval for the BTech program was at Senate, which allowed for the program to be advertised and promoted, and also enabled the Registrar's office to activate the program for enrollments.

Finally, external approval agencies such as the Ministry of Training, Colleges, and Universities need to be given lots of time to review the program, since it will be one of many under review, and will be prioritized accordingly.

Summary of Pathway(s) Created

One typical example of the transfer pathway is shown in Figure 8. The pathway can vary slightly depending on the program(s) at the sending institution.

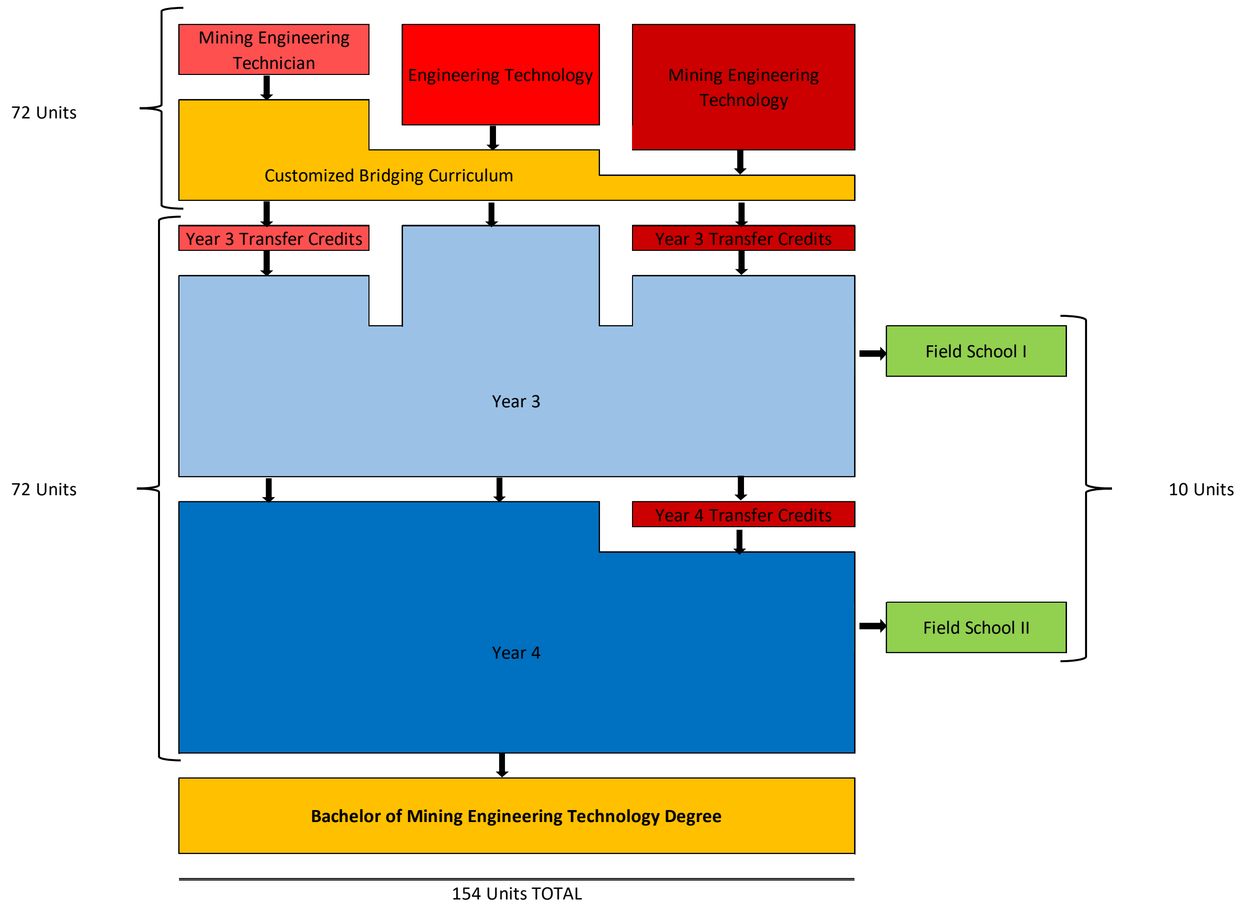

Figure 8: Transfer Pathway

Graduates of any college 3-year Engineering Technology program, or 2-year Mine Engineering Technician program will receive two years of unspecified block transfer credit for their diplomas. They are required to take a customized bridging curriculum (typically ranging from 3-6 courses), specific to the gaps identified in their prior academic record. Students are required to exit the bridge with a minimum 65% average in order to enroll in upper year curriculum (where they may be eligible for additional transfer credits, specific to their prior academic record, but evaluated on a case-by-case basis). There are twelve Year 3 courses, and twelve Year 4 courses. In the summer of each year, students are required to come to campus to complete on-site laboratories.

Upon graduation, student's will receive their Bachelor's degree in Mining Engineering Technology. While the program is unaccredited (meaning they cannot directly apply for licensure), graduates are eligible to apply for post-undergraduate study (Masters of Science, Masters of Engineering, Masters of Business Administration, etc.).

Promising Practices and Lessons Learned

Online Learning Artifacts

In online learning, students can sometimes express a feeling of disconnectedness from their classmates, the learning environment, and ultimately from the university. This sense of separation is often referred to as transactional distance (Benson, 2009)[6]. Experienced Course Development Teams actively work to minimize this perceived transactional distance in the course design and development phases, so that the instructor is set up for success once the course delivery phase begins. Guided by the philosophy of "pedagogy driving the technology choices", the Team creates a series of customized, diverse, and modern learning objects that are well-aligned with the learning outcomes in each course. These learning-objects are designed to make strong connections between the teaching team and the students. Some examples include:

- *Reality-Check videos*: These videos are not made by the instructors; they are made by Research Assistants that are closer to the age of the student (i.e. in the age range of typical Teaching Assistants). This allows for a different perspective on the material that resonates with many students. These videos do not duplicate the purpose-built videos made by the instructor, but rather build upon those foundations, by guiding the student to make connections between real-world engineering applications, and the underlying theory itself. The Reality-Check videos have a higher "production value" from a look and feel perspective than most instructor-led purpose-built video, which enhances the student experience, while visually bringing a younger, more practical perspective into the course.

- *Lightboard-enabled problem solving videos*: Engineering relies heavily on the ability to express the discipline visually by hand; whether sketching out a diagram, solving a problem, or illustrating a concept. The FEAS has built a lightboard made of architectural glass to facilitate hand-annotation of concepts for online learners. The videos created using the lightboard allow the instructor to make a direct eye-to-eye visual connection while hand annotating material on the board. The result is a high-impact learning object, far better than a textbook equivalent of a solved problem, that promotes a connection between the teaching team and the student.

- *360° spherical video*: A major challenge in all professional programs is the ability to give students a better sense of the types of physical real-world environments that represent the workplace. The challenge is exacerbated somewhat in online learning settings because students typically have a high degree of geographic diversity. One way to mitigate this problem is to bring the environment to the student. The BTech program employs 360° spherical video as a method that enables students to explore the environment in a virtual 360° fashion. A brief showcase of learning object examples used in the BTech program can be found at: https://vimeo.com/183852353.

To further enhance the student-to-student interaction and relevance of the courses in the BTech program, Course Development Teams also focused on the assessment piece. Assessments are

[6] Benson, R., & Samarawickrema, G. (2009). Addressing the context of e-learning: Using transactional distance theory to inform design. *Distance Education, 30(1), 5-21.*

required elements in post-secondary courses and traditionally most methods are individual in nature. The culture in the FEAS strongly supports the development of team working skills in accordance with engineering accreditation bodies across the world. In order to foster teamwork and relevancy in online courses, student-to-student interaction is built into the assessment scheme in various forms; including team projects, group presentations, small group discussions, and cooperative student-to-student peer assessment and feedback. Some of this requires both synchronous and asynchronous student-to-student or student-to-Teaching Team interaction. As required, all online courses in the BTech program provide the necessary supports for students to navigate the technical tools required to interact together, regardless of their geographical location, or degree of mobility during any academic semester. Furthermore, to extend the interaction outside the online classroom, the BTech program strategically leverages social media in the form of LinkedIn, Facebook, and Twitter, enabling students to make social connections with each other, employers, the university, and practitioners. This ability to network is an essential factor to developing solid life-long learning skills in BTech graduates.

Together these approaches and learning objects are carefully integrated within the course, creating a pedagogically sound course that is stimulating and differs significantly from traditional online training modules, many of which have less effective types of designs such as “click-click-click-go” low levels of interaction, or they simply act as repositories of documents.

Online Quality Control

In the course development process described in the Methodology section, Phase 4 is a quality-assurance phase; however, quality does not end there. Prior to the first day of class, instructors receive an orientation, as well as some coaching on effective online teaching practices, if required. During the course delivery, instructors continue to have on-demand access to instructional designers and multimedia support personnel. Instructors also interact closely with the BTech Program Coordinator to monitor and ensure that appropriate service standards for instructor-to-student interaction are in-place, and that student satisfaction remains high.

Students are informally asked to complete an anonymous survey within the first four weeks of the course in an effort to explore if any minor adjustment of the teaching approach could benefit the students. If a student is identified as “at-risk” (e.g.: failing tests, not logging into the system, low participation rates in discussion boards, etc.), the Program Coordinator and the Instructor work together to develop an intervention plan. In the last three weeks of the course, students are invited to complete an anonymous end-of-course Student Evaluation of Online Teaching Effectiveness survey (Bangert, 2008)[7]. In addition, after each course’s inaugural delivery, a detailed Post-Delivery Report is generated that has three parts: 1) the results of the End-of-Course Survey, 2) a Time-Audit of student effort, and 3) an internally-generated Quality Matters assessment. This detailed report will inform decisions and drive the first cycle of the iterative adjustments necessary in order to evolve, keep current, and strengthen the online course year-over-year.

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[7] Bangert, A (2008). The Development and Validation of the Student Evaluation of Online Teaching Effectiveness. *Comp in the Schools 25(1):25-47*.

Several student supports are in place at Queen's to contribute to course quality and promote student success. They include:

- *Technical Support:* Support for the Brightspace learning management system (via 1-800 telephone and in-browser online live-chat) is available 24x7x365. Non-Brightspace technical support is accessible via an online support/trouble ticket system year-round, or by telephone (Monday – Friday, 8:30am - 4:30pm).

- *Remote access:* Students have remote access to extensive electronic library resources including services and consultations offered through Student Academic Success Services (i.e. Writing Centre and Learning Strategies Unit).

- *Accessibility:* The Learning Management System, as well as specific course materials include several accessibility elements that meet the needs of a diverse set of students. For example, videos are closed-captioned, slides used in purpose-built presentations are available for download, and the interface is compliant with common accessibility standards such as Section 508 of the United States Rehabilitation Act, the Access for Ontarians with Disabilities Act (AODA), and Web Content Accessibility Guidelines 2.0. Students also have remote access to disability support services and consultations, with the assurance that appropriate academic accommodations will be implemented.

- *Exams:* Where applicable, the proctored final exam will be administered by an established network of distributed exam centers to ensure a high level of academic integrity, and students who find themselves in particularly remote geographical locations will be encouraged to use a web-based secure invigilation service.

Community of Learners

Several factors have been identified to facilitate student persistence in taking online courses (Hart, 2012)[8], including:

- *Flexibility:* Students lead complex lives, often with family and professional responsibilities that need to be balanced with their educational studies. Flexibility in the BTech Program means students can progress dynamically through the curriculum at a pace of their choosing (full-time vs part-time), with a curriculum calendar that spans three semesters a year. Courses are designed to minimize the need for a student to be available at a specific time during the week. When necessary to satisfy a specific objective, synchronous student-to-student interaction exists; however, the program is built with the intent of minimizing these encounters in favour of asynchronous interactions, which provide more individual flexibility and puts the locus of control for time management into the hands of the students.

- *Relevance:* Students report satisfaction when they perceive quality in the courses and relevance of the course material to their real-life contexts. Every effort is made to provide

[8] Hart, C. (2012). Factors associated with student persistence in an online program of study: A review of the literature. *Journal of Interactive Online Learning, 11(1), 19-42*.

real-life mining context, examples, case studies and connections within elements of the online courses. The BTech program has forged many useful industry partnerships that allow students to interact closely with many of the tools and technologies being used in the industry today from within their courses.

- *Social Connectedness, Instructor Presence, and Student Engagement:* A strong predictor of learner persistence in online programs is their ability to "engage" in a broad sense. To form connections with classmates in small or large group work activities, to perceive a connection with the teaching team, and to engage in active learning are elements that when assembled together form a rich tapestry that supports engagement. Learning activities and opportunities for feedback are included in online courses that promote these factors. For example, the Course Development Team includes elements in courses that challenge learners to analyze, synthesize, evaluate and create relevant material. Due to the technical nature of the BTech program, many of these active learning activities lend themselves well to analysis of physical environments, experimentation, simulation, and design projects. These activities are often present in the courses as "Active Learning Labs" or "Projects" that are sometimes performed with the aid technical lab kits.

Laboratory Experience

It is accepted that the engineering curriculum must prepare students to practice engineering, applying the rules of science to the design of safe and functional systems. The exact role of the laboratory in engineering education varies according to its nature. It can be supported that research laboratories serve the purpose of collecting experimental data to learn about a new process or to test a proposed design, while teaching laboratories serve the purpose of preparing students for the challenges of their careers. The objectives of engineering Instructional Laboratories (outlined by Feisel and Rosa (2005)[9]) are to provide a useful reference for designing the laboratory experience of the students in our online program.

According to these objectives, the students must apply sensors, test models, conduct experiments, collect analyze and interpret data, design products and systems, learn from failures, be able to solve real-world problems with creativity and independently, be able to operate engineering tools, identify safety and environmental issues, communicate effectively, work in teams effectively, behave ethically and find solutions to relevant real world problems.

Meeting these objectives is not an easy task in a purely online environment. Training in the applications of sensors, testing of theories, data acquisition analysis and interpretation may be accomplished through computer simulation or use of laboratory kits (i.e. programmable data acquisition units and sensors) or recorded laboratory experiments. These techniques are being used in some of the online courses of the BTech program. One example is the Metrology and Data Analysis course, which uses Arduino boards and sensors sent to students, which are sent to the students, and are used by them to collect data. The courses in physics and chemistry have pre-

[9] Feisel, L. D., & Rosa, A. J. (2005). The role of the laboratory in undergraduate engineering education. *Journal of Engineering Education, 94(1), 121-130.*

recorded experiments which generate data for discussion and interpretation. However, many of the previous objectives remain unfulfilled, requiring a hands-on experience.

The proposed solution was to augment the active learning elements found directly in the online courses by adding two face-to-face extended sessions into the curriculum. These “Field Schools” enable students to perform experiments at the laboratories of the institution over a one-week period in the summer. Each laboratory project is seen as an opportunity to apply engineering tools to conduct investigations, collect, analyze and interpret data, enhance safety awareness, make the connection to real world problems, work in teams, and produce an engineering report. The laboratory sessions planned cover a wide range of topics to provide adequate hands-on experience in surveying, mining instrumentation, mineral processing, geomechanics, blasting, ventilation, metallurgical techniques, geomatics and orebody modelling.

Let us now use, as an example of the proposed laboratories, the blasting laboratory, which has a duration of three days. The students use sensors and data acquisition systems to measure commercial explosives performance under a variety of conditions, collect far field and close to source vibration data, examine the effect of wave superposition, collect air shock and sound wave pressure measurements, produce and interpret attenuation relationships for blast design and conduct a small scale blast, where they analyse the effect of timing and other blasting parameters on blast fragmentation. The University laboratory has the equipment needed, enables quick data dissemination, and provides an appropriate classroom to assist instruction, interpretation and team work, as well as optimum conditions for a high pace of learning in which most, if not all, of the previously identified objectives can be met in a single laboratory session.

The Challenge of Design

In the BTech program, a variety of courses provide traditional engineering science education and use engineering design problems, consisting of made up projects, created by the course authors. These typically reinforce the application of engineering tools and techniques, or offer design examples in the various areas of the program (i.e. planning and design software in open pit and underground mining, design software in blasting, etc.). The students are instructed in course specific design tools, and instructional videos on the use of these tools provide effective ways of transferring knowledge to the students. However, mining involves systems thinking and design, requiring a realistic project-based learning approach. To satisfy this requirement, the program intends to build a capstone project course into the curriculum, where real world design concepts are examined in projects provided by industry. However; several challenges are anticipated.

At the start of the design project students will need to generate a discussion amongst themselves, as well as with their instructors and clients to define objectives and understand constraints (Dym et. Al., 2005)[10]. With a focus on the mining industry, the intent will be to design a complex system, in which students will need to consider interdependencies of components, economics objectives and constraints, social and environmental impacts, as well as the ability to deal with uncertainty (incomplete information being common work practice in industry). Students will develop the

[10] Dym, C. L., Agogino, A. M., Eris, O., Frey, D. D., & Leifer, L. J. (2005). Engineering design thinking, teaching, and learning. *Journal of Engineering Education, 94(1), 103-120.*

necessary skills to cope with complexity. These skills will be supported through a coaching process (typically with the instructor; but possibly through industry expert support).

Another aspect of systems design is that it is argumentative; it can be beneficial to argue with others over advantages and disadvantages of design alternatives. Students in our online program come with a variety of technical backgrounds, and their geographical diversity provides a definite advantage towards producing a variety of viewpoints to enhance the argumentative process; however, the distance between students can also be perceived as creating a communication problem. Dym et. al. suggested that educators should “embrace the notion that engineering design courses – and perhaps many engineering courses – should be taught across geographically dispersed, culturally diverse, international networks”. The suggestion is not to benefit the argumentative process only, but to also improve the documentation process, which is often better in geographically dispersed situations. As such, the challenge becomes to enable a good discussion process between the design groups, and provide efficient coaching. Ultimately, for the capstone project, there will be a need for both synchronous and asynchronous elements in the design process. The program’s intent is to include some synchronous components, where coordinated interactions can be advantageous. An example would be at the design definition phase of the project, where the problem is introduced and discussed between client(s), coaches, and students, where milestones are defined, and timelines must be discussed. Hence, although the program primarily uses asynchronous communications, it is also possible to utilize synchronous communication, when there is an advantage to do so.