

THE IMPACT OF INDUSTRY SUPPORTED FIELD COURSES ON THE EDUCATION AND PROFESSIONAL TRAINING OF GEOLOGICAL ENGINEERS AT QUEEN'S UNIVERSITY, CANADA

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ABSTRACT

The capstone Geological Engineering course taught at Queen's University for two decades has given students the opportunity to explore the mining cycle by visiting mine, mill, smelter and tailings sites over a seven day field school. Learning about the challenges and potential solutions during the site visits from the passionate and creative site guides was very effective and inspiring. Many students reported that learning about these sites and projects inspired them for the first time to think about a career in mining. Many of the students who took these courses are working in the geological engineering aspects of the mining industry now, perhaps inspired by this course.

1 INTRODUCTION

The industry supported Geological Engineering field course discussed in this paper has been attended by many hundreds of final year and graduate students over the past two decades at Queen's University. In addition to classroom time, the course included five working days on mineral exploration sites, mine and mill sites, processing and mine waste facilities.

The field course has been supported by industry for more than 20 years, with companies providing detailed and extensive guided site visits for the students and instructors. Visits to mines, mills and tailings sites has given the students a concentrated and technically excellent introduction to these concepts, the past successes and failures at the sites, and the evolving approaches to understanding and managing challenges at the sites. Student engagement has been enhanced by pre-trip exercises focussed on assessing the mining cycle, the circular economy and the specific sites to be visited, and evening discussions and reports during the field trip. A final assignment, including a report and presentation summarizing a problem encountered at one of the sites and potential engineering solutions, provided the class members with an opportunity to focus on a topic of interest, and to hear from and ask questions of their classmates on a range of topics.

The students benefitted tremendously from learning about the issues and solutions from the people working on them and the opportunity to make personal observations about the sites. The industry "tour guides" were very generous of their time and knowledge, providing background materials and documents about the issues being discussed and areas being visited, and giving the students a "real" picture of the challenges and opportunities at their workplaces. One of the most valuable outcomes was the opportunity for students to ask questions of the site contacts to understand the technical issues, as well as the societal perception and regulatory environment being considered at each facility. Industry members appreciated the opportunity to inform students about their work, encourage them to find work at mine sites and other facilities, and to introduce them to the smaller communities they live and work in.

The consideration of the mining cycle as a central theme to the course provided students with a better understanding of the environmental and societal effects of mining and the importance of a multi-disciplinary approach to the solutions. Discussions of the professional aspects of work in this sector, including policy and regulations, changes to technical and professional practice guidance and regulations resulting from past failures, and risk-based decision making both during mining and for post operational landscapes, provided students with a more comprehensive perspective, and some skills usable after graduation.

Many students taking the course had never visited or worked in mining prior to the trip. Almost all students, over the years, were motivated by the experience, enjoying the challenges and comprehensive, and multi-disciplinary approaches to the problems. A significant number of the students trained in this way are now contributing to this sector, and effecting change in both practice and the perception of mining.

The support of industry in this course was an essential contribution to the outcomes. It was often not easy to justify the time taken by site personnel with very busy jobs, to prepare and guide the tours. In spite of this, the students were provided exceptional tours every year. In addition, the significant and legitimate safety concerns with having casual visitors on these sites was addressed by extensive pre-trip safety instruction and discussions, site specific visitor inductions, and smaller tour groups at each site to permit sufficient personnel to observe and manage safety.

2 GEOLOGICAL ENGINEERING PROGRAM DESIGN

The Geological Engineering program at Queen's is designed to meet the requirements of the Canadian Engineering Accreditation Board, and to provide students the knowledge and skills required to work in geotechnical, geoenvironmental, mineral exploration and geophysics specializations. The program is structured to include foundational building blocks in both geology and engineering, as well as mandatory and elective courses in the key areas of specialization. Field and / or laboratory teaching is a fundamental component of all of the courses offered. The conceptual design of the program is illustrated in Figure 1, including a general overview and a more detailed listing of the core topics to be covered in each area. This material was developed by Dr. Mark Diederichs during a significant program revision and redesign in 2011.

3 GEOLOGICAL ENGINEERING COURSE DESIGN

The professional accreditation of engineering programs in Canada requires that student competence be assessed against a number of graduate attributes for which learning outcomes are measured. The Geological Engineering degree program is built year by year, through:

- foundational courses in general engineering in first year;
- geo “materials” courses in second year, including mineralogy, sedimentary geology and stratigraphy courses, a field mapping school, as well as mechanics and strength of materials;
- geo “mechanics” courses in third year, including soil mechanics, rock mechanics and hydrogeology, mineral exploration, structural geology, geophysics and geochemistry; and
- geo “engineering” design courses in fourth year, including mandatory courses in engineering design and numerous electives to permit some specialization by the students.

All of the Geological Science and Geological Engineering courses at Queen's include “hands on samples” and/or computer labs and many have field trips to sites of interest in the local area. The emphasis on field based teaching has been maintained by the department, through financial support from alumni, and field trip fees paid by the students, in spite of financial pressures to reduce or remove these courses. As an example of the importance the department places on field based teaching, all faculty position postings indicate that interest in field based teaching is an asset.

At Queen's University, all engineering students undertake the Engineering Design and Practice Sequence (EDPS) set of courses, to develop “competence in design process methods and tools, problem analysis, creativity, economics and entrepreneurship, engineering communications, professionalism, and ethics” (Frank et al, 2011). The early year courses within the sequence are common across all of the engineering disciplines, to lay the foundational knowledge from a multi-disciplinary perspective. During the second half of the degree, each engineering program offers design courses relevant to the subject(s) they cover. In the case of Geological Engineering, this includes the integration of geological knowledge into geotechnical, geoenvironmental, mineral exploration and geophysics projects and designs. In addition to a full year, multi-disciplinary team design project, the Geological Engineering students took the capstone field course discussed in this paper. The field course was intended to expose students to then-current challenges and opportunities within the mining cycle, by visiting numerous sites over a seven day trip, with associated academic exercises assigned and completed before, during and after the trip.

The capstone field course for Geological Engineering students at Queen's University focussed on the mining cycle, and the ways that program graduates can become involved in mining related work, including mineral exploration, geological model development and ore evaluation modelling, extraction, processing, waste reuse or disposal including progressive decommissioning, closure planning and implementation, and throughout the process, the support for informed decision making through engagement with stakeholders.

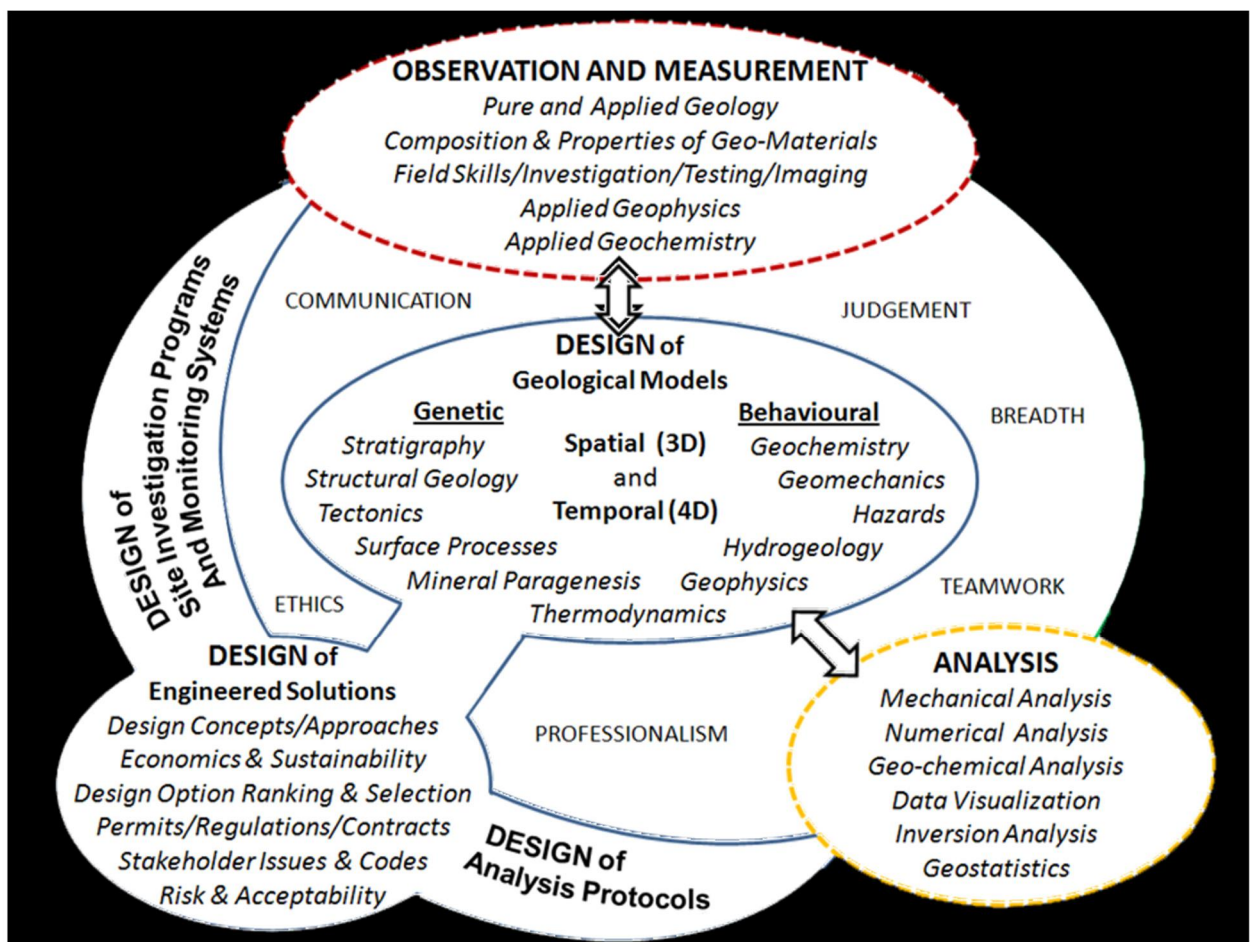
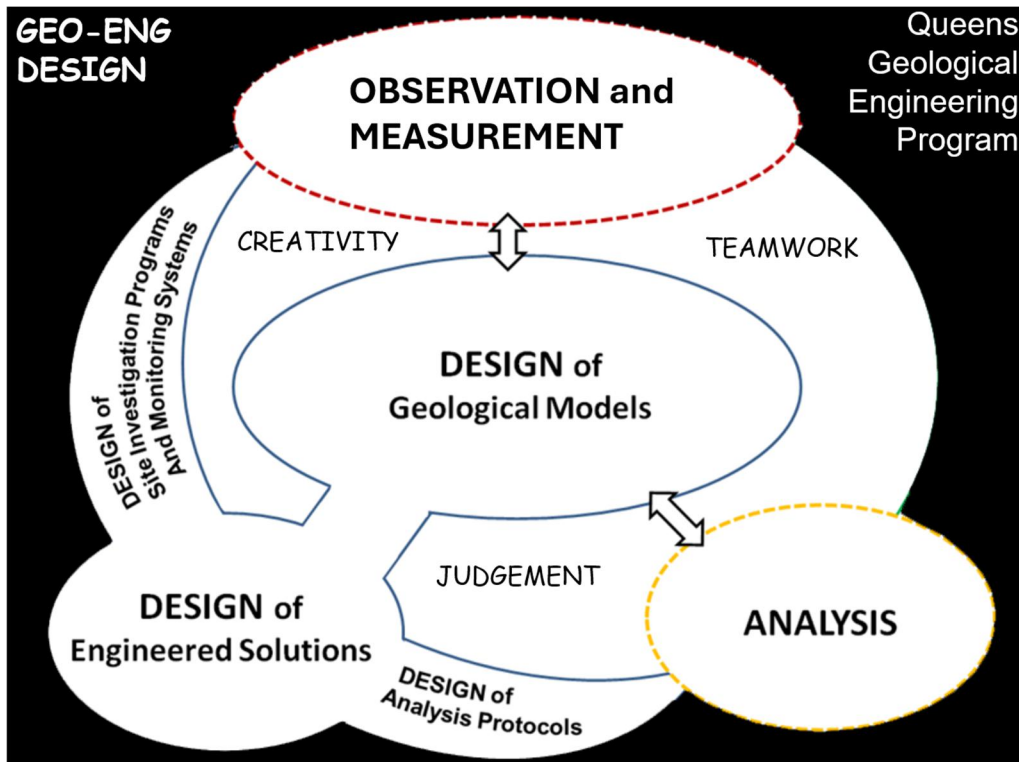


Figure 1: Geological Engineering program design at Queen’s University, in general (upper image) and including specific topics included in various courses (lower image). Images courtesy of Mark Diederichs, 2011.

4 CAPSTONE FIELD COURSE STRUCTURE

The work included within the field course comprised attendance at a number of lectures, completion of pre-, during- and post-trip assignments, and attendance during all days of the field trip (except in the case of illness). Because this course was offered in the final year of the Geological Engineering program, the students were already well prepared with pre-requisite information, as they had already taken many geology, science and engineering courses, including structural geology, mineralogy and mineral exploration, as well as numerous courses covering the mechanics and design of rocks and soil, the mechanical influence and chemistry of water and waste, were familiar with mineral exploration including using geochemistry and geophysics, and had considered stakeholder perspectives and communication with the public about Geological Engineering projects. Lectures included discussions of all of the stages of the mining cycle, including the circular economy whereby waste is diverted for other uses; and how evolving technologies, public knowledge and perceptions, as well as regulations and technical guidelines must be considered to support evidence based decision making and to retain (if possible) the social license to complete resource projects.

The assignments for the course are described in more detail during the course, but a one page summary sheet was also provided, to give the students an easily accessible reminder of the work to be completed and the deadlines. A sample is given in Appendix A.

A typical route for the trip is shown in Figure 2, travelling from Queen's University in Kingston to the mining hubs and communities of Sudbury and Timmins, Ontario.

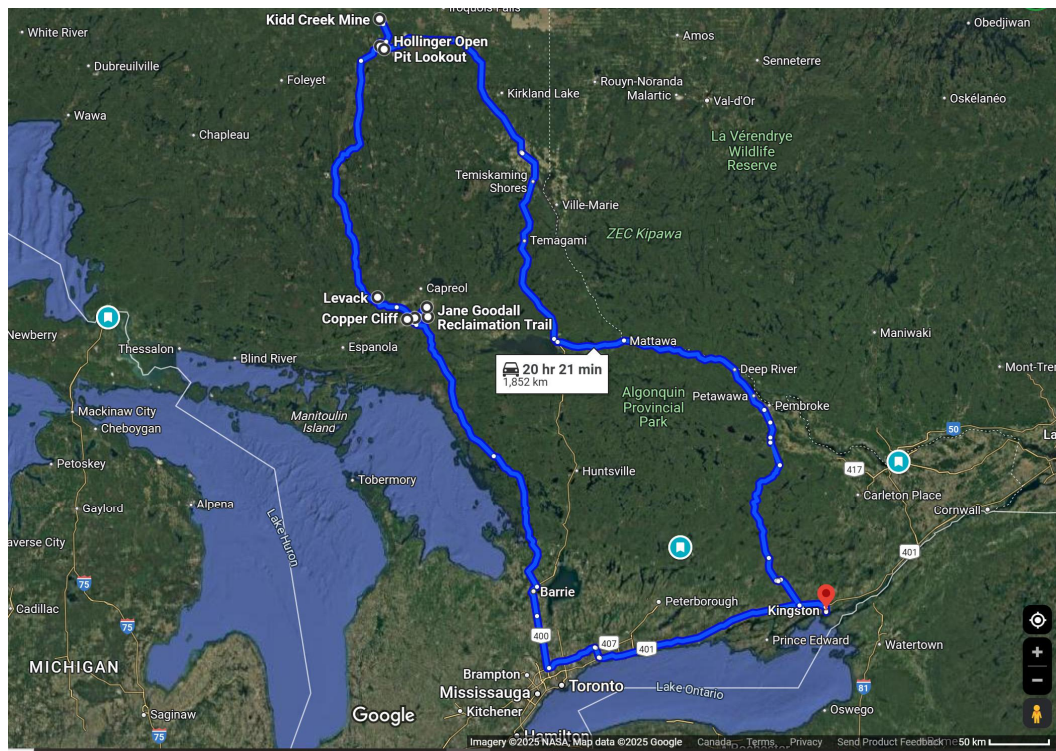


Figure 2: Typical field course route between Kingston, Ontario and the mining hubs and communities of Sudbury and Timmins, Ontario.

Technical lectures offered prior to and during the trip included physical and environmental considerations in the assessment, design, operation, progressive rehabilitation and closure of open pit and underground mines, including crown pillars, tailings impoundments, waste rock piles and general mine infrastructure. Speciality lectures were offered by faculty members regarding mine waste management, acid rock drainage testing and mitigation, milling and smelting processes, and mineral exploration for orebodies similar to those visited on the trip. Guest lecturers discussed indigenous stakeholder consultation and indigenous ways of knowing about the land, post mining landform design and other topics of interest.

4.1 PRE-TRIP ACTIVITIES

At the start of the course, each student selected a site and a design topic from a list of sites provided. The topic selections were reviewed and approved as they were submitted by the students, and direction was given by the instructors to ensure that a breadth of topics was being considered by the class members. Some background materials were provided, particularly those which are not easily found, grouped as: Geological information and Mineral exploration, Geotechnical issues, Geoenvironmental issues, Regulations and Closure planning, Mining and Milling, Tailings dams, Stakeholder communications and public policy, Impacts of legacy mining, History of Sudbury and History of Timmins.

The students were tasked with researching and writing a brief summary report to develop an understanding of the technical challenges at the site as well as in the broader industry, and to generate a list of two or three questions to be asked during the site visit. They were also directed to include consideration of the geological setting / geological model where applicable. These documents were compiled and made available to all students at the start of the field trip travel day, to give them more broadly based knowledge, before visiting the first site.

The students benefitted tremendously from learning about the issues and solutions from the people working on them and the opportunity to make personal observations about the sites. The industry “tour guides” were very generous of their time and knowledge, providing background materials and documents about the issues being discussed and areas being visited, and giving the students a “real” picture of the challenges and opportunities presented by their workplaces during the site visits. One of the most valuable outcomes was the opportunity for students to ask questions of the site contacts to understand the technical issues, as well as the societal perception and regulatory environment being considered at each facility. Industry members appreciated the opportunity to inform students about their work, encourage them to find work at mine sites and other facilities, and to introduce them to the smaller communities they live and work in.

It was also important for the students to consider the societal perspectives related to the resource extraction industry. For a second pre-trip assignment, they were assigned a persona, and a “for” or “against” perspective for a resource project that was under consideration or protest at the time they took the course. The points of view represented included:

- In favour: Geotechnical Consultant, Geoenvironmental Consultant, Mayor of the local community, Mining Company Board member, Lawyer representing First Nations communities to negotiate Impact Benefit Agreement,
- In opposition: Geoenvironmental Consultant, Mayor of downstream community, Mining Watch Canada representative, Lawyer specializing in land use rights and First Nations claims representing First Nations communities in opposition,
- Neutral, fact checking for regulations and facts about the specific cases: Ministry of Northern Development and Mines, Ministry of the Environment at both Federal and Provincial levels.

This required the students to complete some less conventional research, using newspapers, popular magazines and web pages, in addition to any other published materials in order to understand the project, the technical and societal challenges and to consider the many different viewpoints that are expressed in these discussions. Each person was given the opportunity to make a statement from their persona’s perspective and to ask questions of their “opponent”. The objective was to have the students consider multiple perspectives, the nuances of deciding whether challenging resource projects will be permitted and the impact of historical mining operations and practices on current day understanding and perspectives, both good and bad. At the end of the exercise, the students were asked to critique the information that they provided, and were asked which side of the discussion they were personally aligned with, and whether they thought the project should be permitted to advance or not.

4.2 DURING-TRIP ACTIVITIES

The students had several assignments during the trip. All had to write a legible field note book for every day of the site visits, recording factual information and observations, as well as personal observations and questions. While the latter information is not normally included in a professional field note book, it was helpful for the students with their development of critical thinking and considering the course themes and questions. The field notebook was turned in at the end of the trip, reviewed and marked. This process provided the students with some feedback on their work, and ensured that the students were engaged with and listening to the site contacts at all times. The site personnel made favourable remarks on this exercise regularly, and were often interested in the drawings students were doing to work out complex ideas or record visual observations.

At the end of each day, on the trip back to accommodation, ¼ of the students were tasked with writing out two or three questions that might be addressed during the discussions held each evening. These questions ranged from clarification of concepts discussed during the site visit, to more open ended discussions about the role of scientists and engineers and the development of new approaches and methods, to more philosophical discussions about the impact of mining on economic

development and opportunities versus environmental impacts / loss of pristine sites, to name just a few topics. The instructors reviewed the submissions and selected several for the discussions.

After the last discussion of the evening, which were often quite animated and had to be terminated to permit sufficient sleep before the next day, the students each wrote a half page summary of the most important lesson they learned that day and any residual questions remaining.

On the bus home, after the last day, the students wrote a short reflection of their experiences on the trip. They were asked to comment on the impact of the course on their understanding of the resource cycle, the major lessons learned from discussions with the site contacts and for any suggested changes for future years. They also had the opportunity to provide anonymous course reviews at the end of term, where they could comment on the course both positively and negatively, in terms of the teaching team, the effectiveness of the assignments to support their learning and any recommendations for what should be kept and what they would recommend changing for future years of the course. Comments drawn from these reflections are included later in the paper in the discussion of the impact of the course on students.

4.3 POST-TRIP ACTIVITIES

The final deliverable for the course was a Geological Engineering design report and professional presentation. The students worked in pairs on this, generally combining diverse interests and perspectives on the topic they selected. They were tasked with considering an ongoing challenge at the sites visited, based on a thorough understanding of the geological setting and the technical issues, and developing conceptual designs for possible solutions, and a monitoring and decision making framework to guide final selection and optimization. This work took place for several weeks after the trip. At the end of the academic term, the full class attended all of the presentations and were encouraged to ask questions of their classmates. This deliverable was the most scrutinized during engineering accreditation reviews to assess the students' abilities to work through a credible engineering design process.

5 FIELD COURSE PLANNING CONSIDERATIONS

The design of the course changed over time, mostly in response to changing opportunities to visit sites, and considering lessons we learned from running the course and soliciting input from students about the course content and structure.

Each instance of the course was designed to expose students to exploration, extraction (open pit and underground), processing (milling and smelting) and waste management (tailings, waste rock, effluent, and mining impacted water). As noted before, several discussions explored the opportunity to reuse waste materials and to consider long-term solutions and conditions, providing an opportunity for students to develop a more holistic and critical perspective of the sites visited.

In addition to the pedagogical design of the course, other challenges and solutions include:

Challenge 1: Ensuring students are prepared.

When the course was initiated, several sites rejected visit requests, due to the poor reputation and behaviour of university groups coming to site unprepared, uninterested, sleep deprived and hung over. To combat these problems the course was designed to introduce the students to the sites and concepts before the visit, through lectures and assignment work, and to engage them in exercises every day during the trip. A contract was developed with the students, and signed by them, in which they agreed that they would not drink or take drugs during the trip, and that they would bring and wear all required PPE. The field trip safety plan was developed and discussed with the students during class time to ensure all aspects were included and the hazards and mitigations were well understood. For many of the students, this course provided their first opportunity to visit an industrial site, and for almost all of the students, an opportunity to visit an underground operation, so this preparatory work and the focus on health and safety was essential.

Challenge 2: Ensuring students are engaged with the site contacts.

The level of high quality and focussed student engagement was a constant source of pride for the instructional team. Most sites welcomed us back year after year, indicating that the trip was a highlight for the site contacts. All of the pre- and during- trip work was designed to give the students information and knowledge, make them curious about the issues and solutions, and require them to be attentive at all times during the contacts with the site contacts.

Challenge 3- Justifying industrially based field courses in an academic environment.

While many people at this conference understand the value of field based learning and engaging with the most pressing problems in our resource industries, this type of course and the instructional component offered by the field contacts are not typical of most university courses. Indeed, most administrators initially thought of these as field trips, not courses, with a focus on passive observation. This type of trip requires much higher than usual per-capita spending, compared to on campus courses, and particularly when compared to large enrollment seminar courses without any lab or tutorial

content. Higher instructor to student ratios are required for field based teaching, to ensure the students are safe in unfamiliar industrial settings. There are significant travel and accommodation expenses.

At Queen's, a field trip fund has been created and generously supported by alumni and companies, all of whom recognize the value and importance of field based training opportunities. This has the advantage of providing funding but also demonstrating the significance of these types of courses to our alumni, who also support other initiatives across the university. An annual report was prepared for alumni and donors to provide an update on the course each year, including quotes from some of the students' reflections, used with their permission.

Challenge 4 – Ensuring the H&S of all students.

As noted above, the students were involved in all aspects of planning the field trip safety form, considering potential hazards, impacts and actions. However, this could not prepare them for a trip to an industrial site or underground. As a result, the class participated in a "trial run" to a tourist mine, built out of an old near surface mine with both shaft and adit access. They could gauge their own level of comfort with the environment, and we used the displays to present the geological setting, the different support systems used at the site, and various excavation methods. Having developed a level of comfort first, the students were then better prepared to engage in the technical learnings during the site visit and to better understand their personal responsibility for safety. This also meant that they paid strict attention during the site specific safety briefings provided by the H&S personnel at each site. After twenty years and site visits by hundreds of inexperienced students, there were limited number of incidents, although there were two lost time incidents involving students rolling their ankles on rough drift floors under water.

6 INDUSTRY SUPPORT

This course would not have been possible without the tremendous support by industry and site personnel. At almost every site, there were multiple person-days expended to prepare for the visit by providing advance information, planning for the visit including on site transportation, and the inclusion of several technical personnel at each site to cover all of the aspects to be discussed, and post-trip follow up with the student teams with any remaining questions. At the end of each trip, we asked the students to calculate the number of hours expended by the guides and to estimate the cost of salaries to have the guides working on our behalf and not on their regular jobs – a very eye opening exercise.

A number of the site contacts would pro-actively contact us each year before agreeing to other requests for site visits, because they valued the interaction with our students so highly. There are no formal metrics of the value of this course to industry, but a number of graduates moved to the mining communities we visited or similar small communities to take up employment, and more work in resource related industries as a direct result of this experience.

7 IMPACT ON STUDENTS

There are no formal metrics to measure the impact of this course on students, either during their program and when they started working. However, as noted above, the students wrote a "reflection" assignment about the trip.

Hundreds of students have taken the course in the final year of their program at Queen's University, and the vast majority reflected that the course had increased their understanding and positively improved their perspectives on both the benefits and solutions to the impact of mining and the role of Geological Engineers within the mining cycle. Many wrote that they were inspired by the passion of the site contacts and the opportunities and challenges presented by the mining and processing industries to consider work in this field which they had not considered before the trip. A selection of comments is included below to demonstrate both the value of a field course and the interactions with the site personnel.

"During our tours we met workers who had recently graduated from university, and others who have spent their whole careers in the mining industry and have reached high ranks within their companies. It was interesting to see the knowledge and responsibility that the engineers-in-training or geologists-in-training had gained at their job. Everyone was extremely welcoming, helpful and answered all of our numerous questions."

"For any of us who were not too sure about heading into the mining industry, this trip has cleared up any misunderstandings and shown us how safe they are as well as what our future jobs may be. This trip has been a great learning experience and I enjoyed every part of it."

"The field trip was an incredible experience. It provided me with the opportunity to visit multiple underground mines and see the dynamic workings. It is an excellent opportunity to take the concepts learned in the classroom and see how they are applied in multi-million dollar operations. It is a truly amazing feeling to be 7500 feet below surface and see copper stringer mineralization in person in the drift walls. It is very encouraging to see how far the industry has come and progress that has been made

for every component of the mining cycle. It also makes me wonder where the mining industry could be headed given that technology continues to advance each and every year support and extraction techniques continue to be refined. One of the most special moments of the trip for me was visiting the tailings ponds at Strathcona (see Figure 3). I questioned myself if I was looking at a tailings pond or a lake in Muskoka. I thought it was so remarkable that they were able to use the physical geography of the land to their advantage and produce an amazing treatment system. I thought it was incredible that they were able to grow different varieties of crops on the tailings slime with no trace metal elements. I thought this was so promising for the future of mining and a step closer to how the mining industry could be perceived in a different light.”

David Bonneau

“Given the uncertainty involved with mine design, and geological uncertainty, it was especially interesting to see the ingenuity employed by management. Part of being a geological engineer is being able to identify, evaluate and ultimately create a plan of action for unique problems. After visiting this mine, the methodologies employed to identify and mitigate potential hazards was especially interesting, and forced me to think unconventionally.



Figure 3: Final polishing pond contained within tailings facility at Strathcona Mill, Levack, Ontario.

The course described in this paper was the inspiration for the field based course included in the professional Masters of Earth and Energy Resources and Leadership program also offered at Queen’s University¹. The students in this program are from numerous countries, and the program is designed to be of benefit to professionals with a wide variety of background knowledge and areas of practice, for both mining and energy resources. The field trip route for this course is in western Canada, and generally includes visits to a copper producing open pit mine, mill and tailings dam, a smelter, a proposed coal mine at a brownfields site, a gas processing plant, and a hydroelectric dam and powerhouse. The reflections offered by these students provides an opportunity to measure the impact of this type of course at a later stage in their careers, and for people with a variety of very different educational backgrounds. While not directly relevant to the practice of Geological Engineering, the comments selected below are intended to highlight the outcomes and value of this field course from the professional students’ perspectives.

“As an economist and policy professional by background, the field school gave me an opportunity to visit physical sites of operation (including mine sites, reclamation sites, hydro facilities, and oil and gas production sites). Speaking with the operators of these facilities provided me with the technical insights into the challenges that various operations face in driving production operations and implementing physical changes that respond to regulatory requirements. The field school provided me with a platform to understand the extractive sectors in a way that was not possible from an office setting, nor from within

¹ <https://www.queensu.ca/earthenergyleadership/>

the government in a policy-making capacity. This broadened perspective enabled me to immediately apply better practices in the development and amendment of government policies and regulations, with a stronger lens to developing policy that can practically and efficiently be implemented by operators.”

Mark Zanewick

“What stood out most was the openness and generosity of the industry professionals we engaged with on-site. They not only exchanged technical insights but also unvarnished perspectives on leadership, operational culture, and responsible resource development. The opportunity to engage directly with professionals who operate in world-class operations was both exceptional and significant, and their insights have had a lasting effect on me.

The experience profoundly reshaped the way I approach my own projects. It broadened my perspective and reignited my motivation to return to my home country, Peru, with a more strategic and purpose driven mindset. Today, I lead a family-run mining group dedicated to the generation, development, and production of mining projects, with a strong emphasis on community engagement. The field school played a pivotal role in refining my strategic thinking and strengthening my ability to navigate the complex intersection between project development and stakeholder management. “

Manuel Rodrigez

8 CONCLUDING STATEMENT

The unique and special opportunity to educate students in the field is a key element of a comprehensive geological education. Although this concept is well understood by most engineering geologists / geological engineers, these types of courses are increasingly under threat and disappearing from University curricula, due primarily to budget pressures and retirement of faculty members capable of and interested in teaching field courses. As a result, a significant opportunity to expose students to field work is being missed, preventing them from understanding the value and importance of in situ learning and the excitement of working in the field, and delaying the development of their ability to think about observations within a larger picture of the geological model and anticipated material behaviour.

One of the student reflections provides an excellent summary of student perceptions of the important and impact of this course:

“When we talk about the value of the learning environment in Geology, a learning environment where students and their professors alike enjoy small classes and excellent hands-on learning opportunities, it is easy to get hung up on the differences between geology and bigger faculties. Something I believe is very important to consider when comparing geology to these other programs, however, is the nature of the work geology and geological engineering graduates find themselves doing. Many students, myself among them, chose geology as a discipline partly because it allowed for outdoor employment. The outdoor office is a very different environment than any classroom can emulate, and the way one works outdoors is often quite different from their indoor work habits. The development of real world skills for fieldwork at the university level is a godsend for employers, as mine have told me repeatedly, and in my (albeit inexperienced) opinion is a crucial part of an education in geological sciences or engineering. By making fieldwork a mandatory part of our program, the school is enriching everyone’s education. For people similar to myself, who find themselves more comfortable in the field than the classroom, it is an opportunity to learn a great deal. I can honestly say that I learned more in one week in Sudbury and Timmins than I have learned in the majority of term-long courses I’ve taken, and more importantly, the things I learned to identify and/or understand are the exact same things I will likely be dealing with in my career, as opposed to classroom or laboratory models. Those people who find fieldwork to be a more daunting learning environment than the classroom may not learn as much about geotechnical issues during a field trip such as the one I just enjoyed, but they will come away from the trip with different lessons about overcoming any personal discomfort and enhancing productivity in the same fieldwork situations they will no doubt find themselves in again once entering the workforce.”

Cam MacKay-Stotesbury

Organizations like AGS (<https://australiangeomechanics.org/courses/>) and AIG (<https://www.aig.org.au/professional-development/events/>) are needed to fill this gap, and to support further professional growth and development. These efforts are to be commended, encouraged and supported.

9 ACKNOWLEDGEMENTS

The field schools discussed in this paper were the result of many people's work, collaboration and enthusiasm. Grateful acknowledgements are due to:

Co-instructors: Rob Harrap and Dr. Heather Jamieson and the many graduate students who worked as Teaching Assistants on this course.

Company representatives – GEOE 410: Glencore – Strathcona Stephanie Marshall, Samantha McGarry and Joe Fyfe; Glencore – Kidd Creek Mine Dave Counter; Vale – Samantha Espley and Quentin Smith; Hollinger Mine – Josh Metcalfe and John Henning.

Queen's Alumni supporting the Field Education fund - in particular Mike Rose and Sue Riddell Rose who provided the initial substantial investment in the fund and also provided funds earmarked for the early versions of this course.

Queen's Students – for exceptional engagement, critical thinking and fun times, including gamely watching “The Core”, “Volcano” and other assorted geology disaster movies with me on our long drives.

10 REFERENCES

Frank, B.M., Strong, D.S., and Sellens, R. 2011. The Professional Spine: Creation of a Four-year Engineering Design and Practice Sequence. Proceedings of the Canadian Engineering Education Association (CEEA), June. DOI: 10.24908/pceea.v0i0.3586

Appendix A:

Assignment summary sheet for GEOE 410 field school. The timing of the activities is indicated by the highlighted text – Pre-trip as yellow, During-trip as teal, and Post-trip as green.

GEOE 410 Assignments: Fall, 2022

Assignment 1: Select a topic of interest from the list provided. Conduct research on that topic, in general terms and also specifically related to one of our sites, if you can find them. Write a summary of the topic, including at least three technical references – from the collection posted on Teams and/or your own search. Generate two or three technical questions related to this topic that you hope to ask when on the trip.

- Summary report due: Sun Oct 2 at 23:59.
- Max length = 2 pages, point form text. List questions and references on an additional page, as well as any key figures.
- Individual, 20%.

Assignment 2: Keep a professional, complete, organized and legible field notebook. This includes recording the time and date of your visit, the weather conditions and the name and title of the people you meet on each site. Take care to distinctly identify each area visited, using the local names. Be sure to attribute important factual statements to the appropriate speaker. You may later use some of these statements as (personal communication, name, 2022) in your report.

- Due Friday October 14th, at the time that you board the bus for home.
- Individual, 20%.

Assignment 3: When you depart the bus at the end of your assigned day, propose one or two issues, in writing, for group discussion that evening. This should be relevant to observations you have made while on site. Participate in the discussion period every evening, remaining respectful and factual at all times.

- Due at the end of bus ride on your assigned day.
- Contributions to the evening discussion are expected throughout the trip.
- Individual, 15%.

Assignment 4: Provide a technical summary of each day, at the end of the discussion period, including the most interesting engineering fact that you learned. If additional questions arise, that have not been answered during the discussions, please add these to your summary. Please submit on individual pieces of paper.

- Due at the end of the evening discussions on T, W and Th on the trip.

- Maximum length = 1 page / day.
- Individual, 10% total, 3.33% / day.

Assignment 5: Write a reflection on your experiences of the trip. What did you learn? How did the field setting support this learning? Some of this content may be used in promotional material related to field education funding or in letters of thanks to field fund donors. Please advise if you would like to remain anonymous, if we do use any quotes from your reflection.

- Reflection due: Friday October 14th, at the dinner stop.
- Individual, 5%.

Assignment 6: In a team of two, propose a design solution to one of the issues encountered during the trip. Conduct additional research, as required, to support your analysis. Once your topic has been approved, prepare a 15-minute presentation, outlining statements of the engineering issue and the design scope, including observations and findings from the trip, and justify the selected solution. Your work should result in a fact based, technically feasible and justified solution, including high level economic analysis for the option selected.

The powerpoint file should include figures and tables, photos from the field trip if appropriate and available, and multiple technical sources. All of these items must be fully referenced in the slides and included in a reference list. Where possible links to the references should be embedded in the ppt file. Each slide should include full speaker's notes to summarize the information conveyed – this can be in point form, but must be fully referenced.

- Thurs October 20th by 23:59 – topic title and one paragraph each for problem statement & project scope, submitted by one member of your pair.
- Sunday Nov 6 by 23:59 – ppt files submitted electronically.
- Tuesday Nov 8 – presentations in class period.
- Deliverables include:
 - Ppt file with full referencing and speaker's notes.
 - Your team of two making a presentation of your design solution.
- Pairs, 30%.