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Transformation of geological sciences and geological engineering field methods course to remote delivery using manual, virtual, and blended tools in fall 2020

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Abstract. Geological (Engineering) Field Methods (GEOE/L 221) is a core course for two programs at Queen's University in Kingston, Ontario, Canada where students learn foundational knowledge, skills, and methods to conduct field work that is used to investigate geological and geological engineering aspects of the Earth. Typically, this fall-term course involves weekly field trips in the Kingston area to visit a variety of rock outcrops to learn and practice methods of field navigation, observation, and measurement. Remote delivery of this course in fall 2020 due to COVID-19 without in-person field trips required a significant transformation, which included creating field and demonstration instructional videos, using 3D digital photogrammetry models of rock samples and outcrops, developing independent outdoor activities for pace and compass navigation, manual sketching, and graphical measurements on paper, and utilizing a culminating immersive 3D video game style geological field mapping exercise. This paper examines these new course elements, how well the course learning objectives were achieved in a remote setting, and the successes and limitations of remote delivery. Although many new virtual elements enhance the course and will be incorporated to future offerings, a return to in-person teaching for geological sciences and geological engineering field methods courses is strongly recommended.

1. Introduction

Geological Field Methods (GEOL 221) and Geological Engineering Field Methods (GEOE 221) are second year core courses in the Geological Sciences and Geological Engineering undergraduate programs, respectively, at Queen's University in Kingston, Ontario, Canada. They are integrated into a single fall term course (GEOE/L 221) where all students participate as

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one class and learn the same material, which promotes interdisciplinary learning. The university calendar description of these courses is as follows: *"[the] (engineering) field study of surficial deposits, rock types, and geological processes, based on the geology of the Kingston area. Descriptions, samples, and measurements acquired on several field trips will be analyzed, and the results recorded in maps, sections, and reports throughout the course"* (Queen's University, 2020a, 2020b). The author instructed the course in fall 2019 and fall 2020, and was responsible for the course redesign and implementation for remote delivery in fall 2020.

This is primarily a skills-focussed course delivered through lectures, tutorials, field trips, and labs, using the geology of the Kingston area as topical context. Bedrock geology in Kingston features nearly flat-lying early Paleozoic limestones and sandstones that border Precambrian lithologies of the Frontenac Arch (Helmstaedt and Godin, 2008; Carr et al., 2000). The skills learned through this course include field orienteering and navigation, field observation and identification of lithological units, geological structures, and historical geology, measurement of orientations and characteristics of geological structures, recording of field data and sketches in notebooks and traverse maps, data analysis and synthesis of geological models and creation of geological maps, sections, and stratigraphic columns, structural data analysis using stereonets, use of engineering geology tools to characterize rockmass strength, and professional, integrated reporting of geological and engineering data and interpretations.

This course is also a crucial opportunity for the students to develop their class community that they will interact with in core courses for the rest of their undergraduate degree programs. In the past five years, the course enrollment has consisted of approximately 20-40 students from each of the GEOE and GEOL programs, for a total ranging from approximately 40-80 students. In fall 2020, 24 GEOE and 33 GEOL students were enrolled, for a total class of 57 students.

In fall 2020, this course was offered remotely on an emergency basis due to the impacts of COVID-19, which required a significant transformation to deliver the course without field trips or in person tutorials and other labs. The regular in-person activities of live lectures, interactive tutorials, and hands-on field trips and lab periods were redesigned to be pre-recorded lectures, live virtual tutorials and labs via video conference calls, and pre-recorded demonstration videos about field sites, field skills, and lab skills. These course activities were supplemented with digital tools including online group editing software for interactive written discussions of lectures, readings, and other course content, 3D photogrammetry models of hand samples and outcrops hosted on Sketchfab (2021), and the Lighthouse Bay immersive virtual field exercise by Houghton and Robinson (2017). Critical hands-on (manual) skill elements were maintained in the remote course delivery, including use of compasses for orienteering and navigation, measurement of geological structures, use of field notebooks for handwritten and drawn field observations and sketches, and use of drafting tools for manually drafted geological maps and sections, stereonets, and topographic contour problems.

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This paper describes the Course Learning Outcomes (CLOs), course structure, virtual and manual skills-based learning elements, and community building elements of GEOE/L 221. A discussion is presented on the successes and limitations, and informal student feedback of the remote delivery of GEOE/L 221 in fall 2020.

2. Course Learning Outcomes

This course and others at Queen's University follow an outcomes-based education model and framework that promotes a learner-centered approach and clarifies competencies of courses and, more broadly, degree programs (McCombs and Whistler, 1997; Weimer, 2002; Pillay, 2002; Kolomitro and Gee, 2015). CLOs are developed at the course level and are mapped to degree program level Graduate Attributes, as part of the Ontario Government and Canadian Engineering Accreditation Board program structure requirements (e.g. Hutchinson, 2001; Remenda, 2010). The Geological Sciences and Geological Engineering program curricula at Queen's University have been developed using a Concept Map approach that identifies and maps knowledge and skills into categories of observation and measurement, analysis, design of geological models, and design of engineered solutions involving site investigation programs, monitoring systems, and analysis protocols; all of these categories are linked through development of foundational skills such as ethics, professionalism, communication, judgement, and teamwork (Remenda, 2010; M. Diederichs, pers. comm.). The CLOs for GEOE/L 221 that were used in both fall 2019 (in person) and fall 2020 (remote) are listed in Table 1.

Table 1: Course Learning Outcomes (CLOs) for GEOE/L 221 Geological (Engineering) Field Methods in fall 2019 and 2020

CLO No.	Description
CLO-1	Demonstrate that they can plan and conduct field investigations in a safe, ethical, socially, and environmentally responsible manner with scientific and academic integrity.
CLO-2	Demonstrate facility with basic field and lab techniques for reliable and meaningful measuring and characterizing of key geological and geological engineering parameters.
CLO-3	Categorize and compare the rocks in an area and be able to explain the variability of the characteristics of components in a natural system.
CLO-4	Demonstrate proficiency with basic principles of historical geology which they will be able to use to logically determine the sequence of geological events in an area.
CLO-5	Apply knowledge to solve geological and geological engineering problems with an incomplete or sparse data set in three dimensions.
CLO-6	Begin demonstrating spatial and temporal reasoning on all scales in real time during field work and during analysis of field data.
CLO-7	Select, analyze, synthesize, discuss (oral), and professionally report (written, visual) on geological data as presented on maps and cross-sections.
CLO-8	In groups and individually, critically evaluate geological data and related information from a variety of sources on specific topics in field geology, and report the results in a variety of formats.
CLO-9	Collect and interpret data obtained while on the field trips, and design and submit a written report with maps and recommendations on a site-specific engineering problem.

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3. Regular In-Person Course Delivery

The regular in-person course delivery of GEOE/L 221, most recently offered in fall 2019, is scheduled over a 12-week term. The first 7 weeks of term include weekly field trips in the Kingston area during 4-hour afternoon lab timetable slots. The remaining 5 weeks of term have indoor labs where the students transition from focussing on field observations, data collection, and preliminary analyses, to more advanced data analysis and synthesis of geological models and engineering solutions. The themes of the 7 field trips are as follows:

- Field Trip 1 (On-Campus): initial learning of field skills including pace and compass navigation, and orientation measurements of planar and linear structural features;
- Field Trip 2 (Barriefield, Joyceville): lithological identification, structural orientation measurements, and age relationships of gently folded Ordovician limestone and jointed Proterozoic syenite outcrops with contacts to intrusive dykes and other younger/older units (Figure 1a);
- Field Trip 3 (Moreland-Dixon Road Part 1): scanline mapping of outcrop with Proterozoic quartzite, gneiss, mafic dykes, and faults;
- Field Trip 4 (Perth Road): outcrop stops through Proterozoic syenite pluton, including transition from metamorphic country rock and into core of pluton (Figure 1b);
- Field Trip 5 (Wollastonite Mine): off-road mapping of folded strata, tour of local Wollastonite mining operation, and engineering geology assessment of rock slope stability;
- Field Trip 6 (Moreland-Dixon Road Part 2): mapping a stratigraphic section through Ordovician limestones (Figure 1c); and
- Field Trip 7: field exam on rock identification, relative ages of units, and structural measurements.

Each field trip includes a deliverable such as submission of field notebooks, traverse maps, completed geological maps and sections, engineering geology analysis, and stratigraphic sections. Developing skills in field data collection is emphasized such that students learn how to observe and record geological descriptions, structural measurements, and outcrop sketches, among other data types.

The lectures include topics on geological processes, geological materials, relative ages of rock units, geological models and reporting, engineering geology, economic geology, and a variety of guest lectures from faculty and graduate students in the department to introduce students to the various applications of geological (engineering) field methods. Tutorials are practical and hands-on where students are led through examples of identifying lithologies of hand samples, developing geological models, creating geological maps and cross sections from field data, and analyzing structural data using stereonets. A summative group project uses field data collected by students around the Kingston area to create their own geological maps and sections and report on their interpretation of the geology and geological history of the Kingston area. Examinations

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included both oral and written formats, where the oral format focused on skills and the written format focused on geological and geological engineering principles and problem solving.

Figure 1: Example field trip locations in the Kingston area of GEOE/L 221 in person; (a) Field Trip 2 (Joyceville), (b) Field Trip 4 (Perth Road Pluton), (c) Field Trip 6 (Moreland-Dixon Road Part 2).

4. Remote Course Delivery in Fall 2020

The fall 2020 remote course delivery was implemented on an emergency basis due to the impacts of the COVID-19 pandemic. Course assessments included professionalism, lab assignments, a group project, and exams through the term (Table 2). A decision was made at the department level to reschedule fall 2020 courses from a full load of approximately 5-6 courses over 12 weeks (plus exam time) to a full load of 2-3 courses over two sub-terms of 6 weeks each (plus 1 exam week). The lecture schedule increased from 2-3 lectures per week to up to 6 lectures per week. It should be noted the recommended practice for pre-recorded lectures, as of fall 2020, was to be up to approximately half the length of an in-person lecture. Thus, 50-minute lectures from fall 2019 became up to 25-minute lectures in fall 2020. Normally 8 lab assignments in a 12-week term were condensed to 5 lab assignments. The group project was conducted over 4 weeks instead of 6 weeks. Midterm and final exams were replaced with weekly quizzes and a final oral exam.

Table 2: GEOE/L 221 course evaluation in fall 2020

Assessment Item	Time	Grade Weight
Professionalism, Individual	Ongoing	5%
Q&A Course Engagement	Ongoing	5%
Lab Assignments (5, Individual)	Weeks 1-5	30% (Subtotal)
Group Project (Written Report)	Weeks 4-7	30% (Subtotal)
Term Quizzes (6)	Weeks 1-6	20% (Subtotal)
Final Oral Exam	Week 7	10%

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A hybrid linear-spiral structure curriculum model of GEOE/L 221 was adopted in fall 2020 and is illustrated in Figure 2. Linear curriculum models are designed to proceed sequentially through the course in order to promote skill development and are graphically represented as a pyramid structure (Oxford Cambridge and RSA 2016; L. Anstey, pers. comm.). Spiral structure curricula are designed with a focus on central concepts and/or skills that are introduced and revisited to promote mastery as the learner moves through the course (Harden and Stamper 1999; L. Anstey, pers. comm.). The linear curriculum structure is the basis for the storyboard framework, but the internal elements of "acquisition", "practice", and "production" are rooted in the spiral curriculum structure.

In this course framework, "acquisition" components of the course include lectures, readings, and video demonstrations. As the term progressed, the number of lectures and readings reduced, and video demonstrations were emphasized in the middle of the course. "Practice" components include practice exercises that provided students with guided solutions that were not part of the course evaluation, where students had opportunities to learn and practice hands-on skills and problem-solving exercises. The "practice" components were emphasized in the first half of the course. "Production" components included lab assignments, quizzes, and group project deliverables. These occurred throughout the course and their length and complexity increased toward the end of the course. Two "major assessments" were highlighted in Week 5 (individual) and Week 7 (group) in the storyboard because they were culminating deliverables, namely the immersive virtual field mapping exercise and the desktop site investigation report on the geology of the Kingston area, respectively. The "collaboration" components occurred in the latter half of the course where students worked on the term group project. The final group report deliverable was preceded by smaller table of contents (in Week 4) and executive summary (in Week 5) deliverables.

The skills-based learning elements of the course can broadly be categorized into virtual elements, manual elements, and blended virtual-manual elements. Virtual elements included video demonstrations, manual elements included hands-on skills with compasses and drafting tools, and blended elements included use of 3D photogrammetry models and the culminating immersive virtual field mapping exercise.

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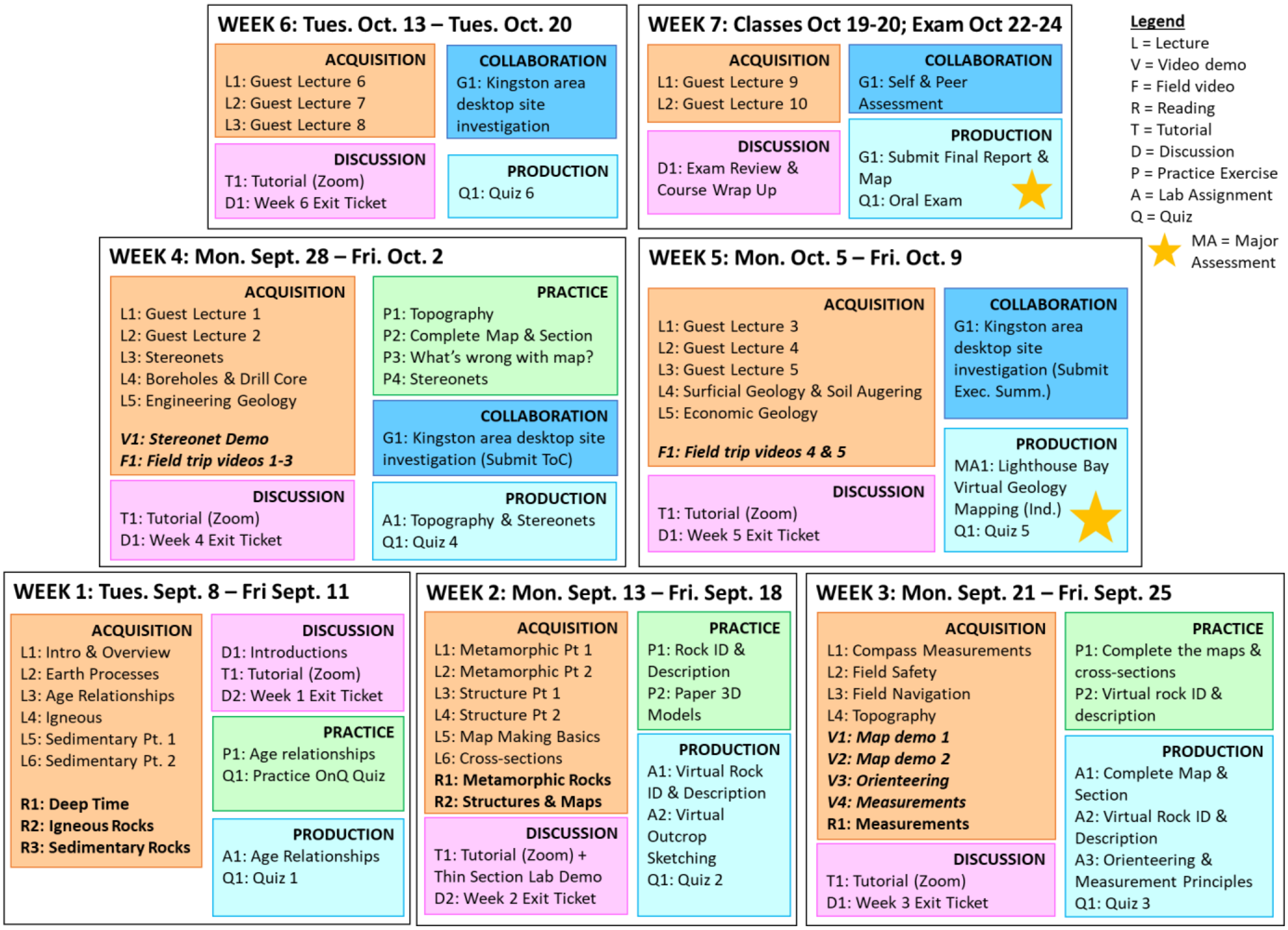

Figure 2: Hybrid linear-spiral curriculum model storyboard of GEOE/L 221 in fall 2020 with remote delivery showing weekly course activities and deliverables.

4.1 Virtual Learning Elements

The virtual learning course elements included video demonstrations and 3D photogrammetry models. Video demonstrations are an acquisition curriculum component and include field site tours, geological map and section demonstrations, and field skill demonstrations of orienteering and structural measurements. Examples of these videos are shown in Figure 3. All videos were made available online for students to view asynchronously and as many times as they wished.

The field site videos consisted of a suite of five videos where the author (and course instructor) introduced students to key outcrops in the Kingston area that are normally visited during the in-person version of the course. In addition, the field site videos provided an opportunity to demonstrate identification of lithologies in outcrops, age relationships between geological units, and measurements of key geological structures, which supplemented other course material in the context of a real field

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site and in the Kingston area. Students were also able to use the field site videos as a source for their desktop study group report on the geology of the Kingston area.

The geological map and section demonstration videos presented a real-time narrated tutorial by the author (and instructor) on interpreting geological models and drafting maps and sections. Two videos were created with different levels of geological difficulty. These videos provided a detailed overhead view of the steps in this exercise that rivalled the experience of live overhead document camera demonstrations normally done during in-person tutorials, in addition to the benefit of on demand viewing opportunities.

The two field skill videos created by the author (and instructor) demonstrated (i) pace and compass navigation and (ii) orientation measurements of planar and linear geological structures using two types of compasses. The user perspective of reading measurements off a compass, aided with embedded video graphics such as arrows to direct the viewer to relevant details, provided by the videos, in addition to asynchronous and on demand availability, provided students with excellent opportunities to learn at their own pace.

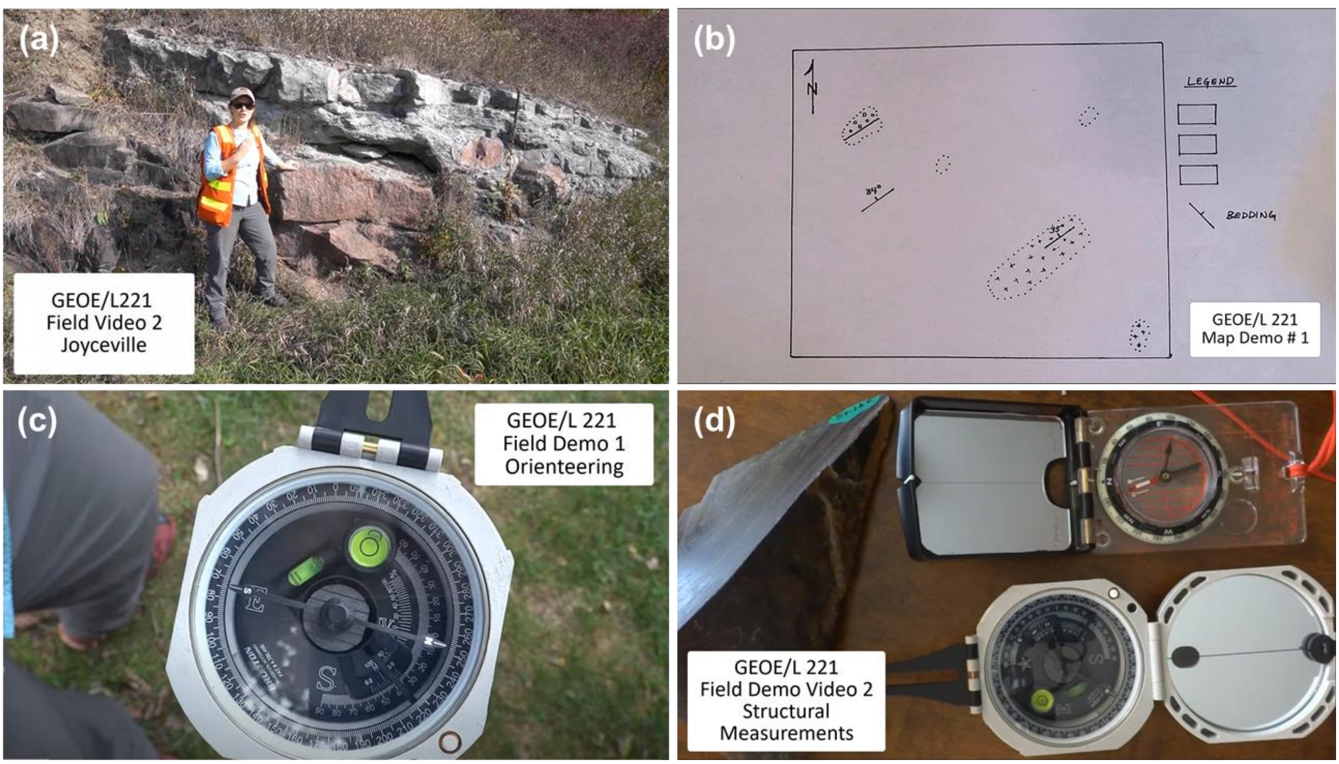

Figure 3: Examples of video recorded course content; (a) one of five field videos at a Kingston area outcrop; (b) one of three map demonstration videos; (c) field demonstration video on orienteering; (d) demonstration video on measuring orientations of planar and linear structural features (strike/dip and trend/plunge, respectively).

4.2 Manual Learning Elements

The manual learning course elements included pace and compass navigation, compass measurements of geological structures, and hand drafted stereonet plotting and analysis. Students were required to purchase a geological compass, field notebook, and drafting equipment in time for the beginning of the course to use them for practice exercises and lab assignments.

Pace and compass navigation skills were developed through acquisition and production curriculum components, where students learned the concept and skills through lectures and a video demonstration (acquisition) and were tasked with an independent outdoor lab assignment to conduct a closed loop traverse (production). The closed loop traverse assignment deliverable included (i) a traverse plan in students' own neighbourhoods of a 1.5-2 km route with at least 8 linear segments (in different orientations) in Google Earth (© Google 2021), (ii) a hand drawn traverse map showing the travelled route and bearing, pace count, and distance (in metres), and (iii) a graph of the students' pace factor. Examples of the first two submission items are shown in Figure 4.

Skills to measure orientations of geological structures using a compass were developed through acquisition and production curriculum components. Students learned the skills through a video demonstration, while lecture content and field site video demonstrations discussed identification of geological features suitable for measurement during field mapping (all acquisition). Students were tasked with creating their own demonstration video for a lab assignment (production) that included measurements of both planar and linear structures, using strike/dip and trend/plunge, respectively. Students measured the planar orientation of an inclined surface in their homes (strike/dip) and taped a provided paper template with a line onto the inclined surface to measure its linear orientation (trend/plunge).

Stereonet plotting and analysis skills were developed though acquisition, practice, and production curriculum components. Students learned the concept of stereonets through pre-recorded lectures, an instructor demonstration video, and live teaching assistant tutorial demonstrations (acquisition). Stereonet problems were included in practice exercises where solutions were provided and discussed during live tutorials (practice). Students demonstrated their use and analysis of stereonets in lab assignments and the final oral exam (production).

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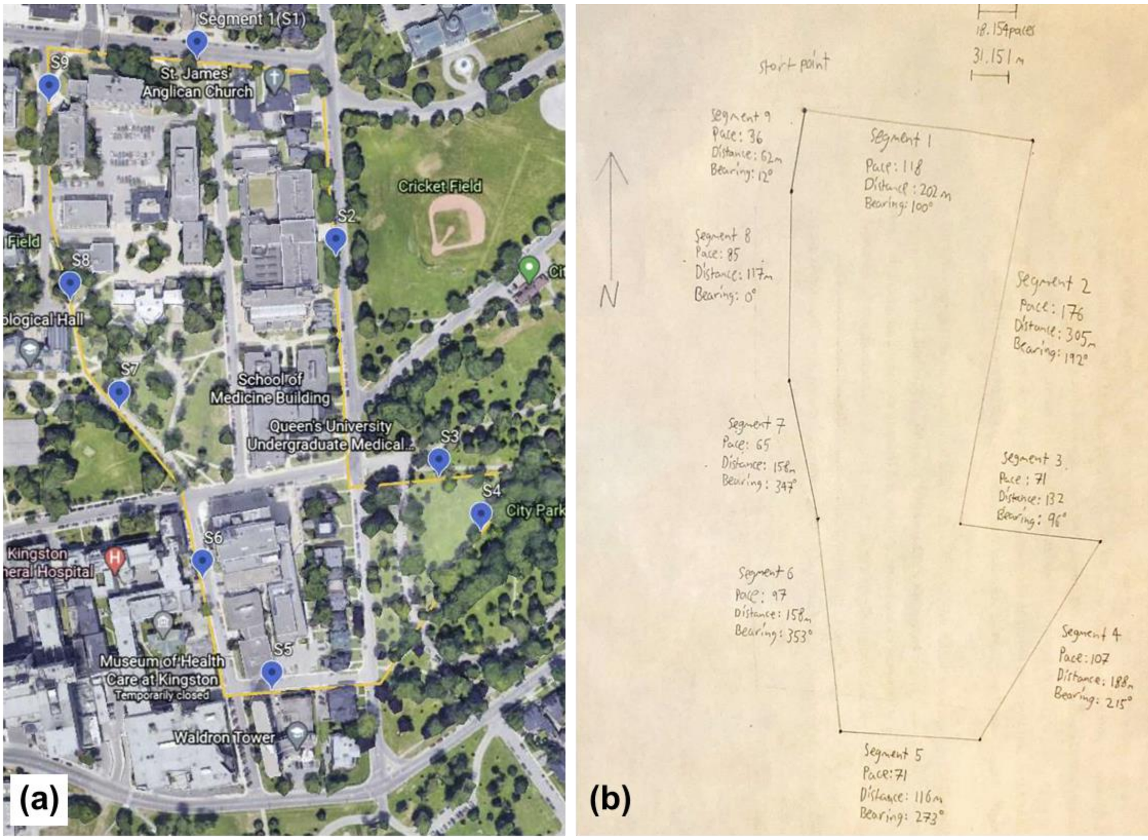

Figure 4: Example lab submission of independent outdoor closed loop traverse lab; (a) Google Earth satellite image map (© Google 2021) with traverse plan and (b) hand drafted traverse map.

4.3 Blended Virtual-Manual Learning Elements

The blended virtual-manual learning course elements included use of virtual 3D photogrammetry models of rock hand samples and outcrops, as well as the culminating immersive virtual field mapping exercise.

4.3.1 Virtual Rock Samples and Outcrops

The virtual 3D photogrammetry models of rock hand samples and outcrops were used for skills development in rock observation, classification, and outcrop sketching, through acquisition, practice, and production curriculum components. Examples of hand sample 3D photogrammetry models are shown in Figure 5. Students were introduced to these skills and concepts through lectures and live teaching assistant tutorial demonstrations and discussions (acquisition). Practice opportunities were included in tutorial exercises where solutions of rock identification and classification, as well as examples of sketches, were presented and discussed. Students demonstrated their understanding of identification, classification, and

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sketching of rock photogrammetry models and photographs through lab assignments, quizzes, and the final oral exam. An example of an outcrop photogrammetry model, featuring a normal fault, and an accompanying sketch submission are shown in Figure 6. Other outcrop photogrammetry models used in the fall 2020 course offering featured Jurassic sandstone with cross-bedding from Landram Bay, East Devon Coast, United Kingdom (Mahon, 2015), and an anticline from near Lunenburg, Nova Scotia, Canada (Young, 2020).

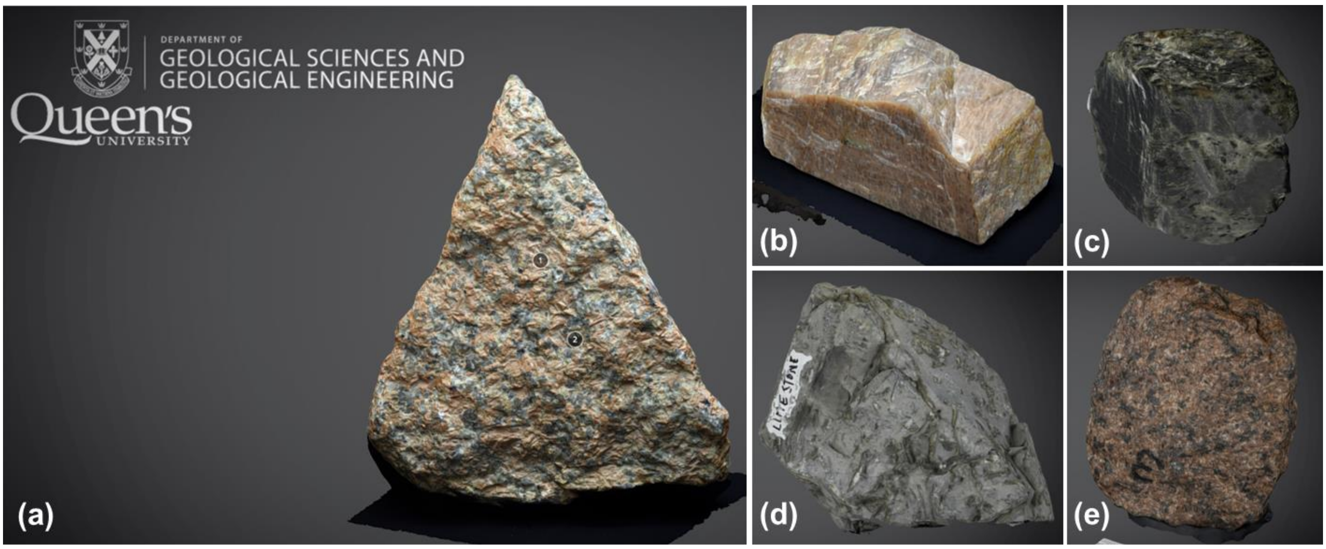

Figure 5: Examples of hand sample 3D photogrammetry models created by the Department of Geological Sciences and Geological Engineering at Queen's University (GSGEQueens, 2020); (a) granite; (b) potassium feldspar; (c) amphibole; (d) limestone; (e) syenite.

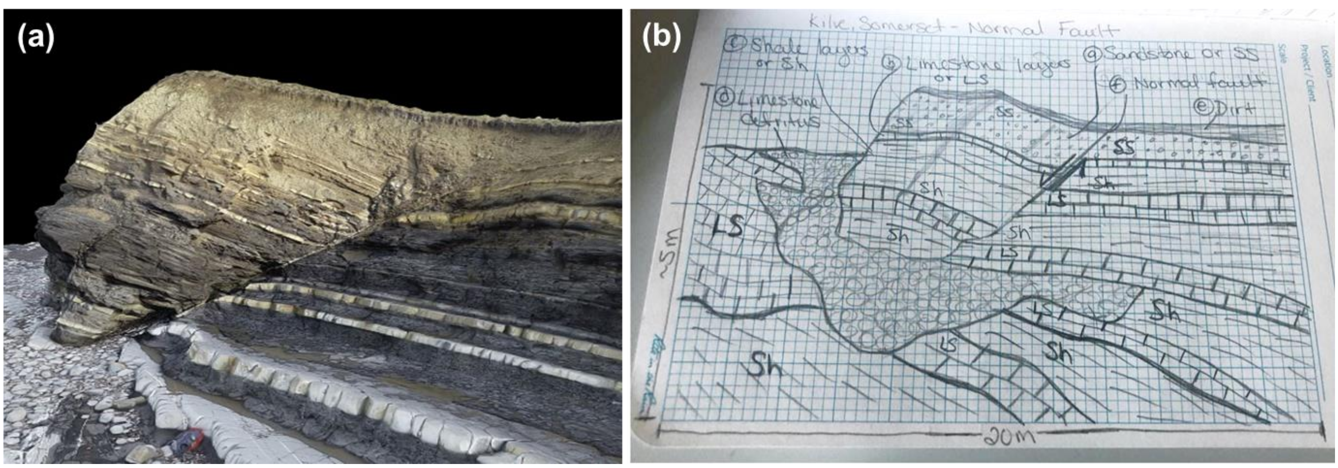

Figure 6: (a) Example 3D photogrammetry outcrop model (Peacock, 2020) and (b) example sketch submission.

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4.3.2 Immersive Virtual Field Mapping

The Lighthouse Bay Virtual Landscape immersive virtual field mapping exercise by Houghton and Robinson (2017) was used as a culminating major lab assignment. The Lighthouse Bay software offers an immersive video game style experience (Figure 7a) where the user (student) is free to explore the field area with the use of embedded GPS and compass tools, discover outcrops, and collect field data that is provided by virtual field notebooks located on each outcrop. The virtual video game style experience limits users to a walking pace, so concepts of time management and traverse planning are embedded. Other field investigation aspects that are part of this experience include recording field data and sketches in personal, physical field notebooks, and using topography to guide mapping (Kingston has low topographic relief and is therefore not emphasized in the in-person field components of GEOE/L 221). Field skills that are not used or practiced, however, include pace and compass traversing, identification and characterization of geological features, and manual measurement of geological structures.

An accompanying base map with topographic contours and landscape features is available from Houghton and Robinson (2017) and offers the blended aspect of the learning elements. With this, students manually drafted their geological map and section interpretations based on their field investigation (Figure 7b and Figure 7c). Leading up to this lab assignment, students learned how to develop geological interpretations and complete geological maps and sections through practice exercises and earlier lab assignments.

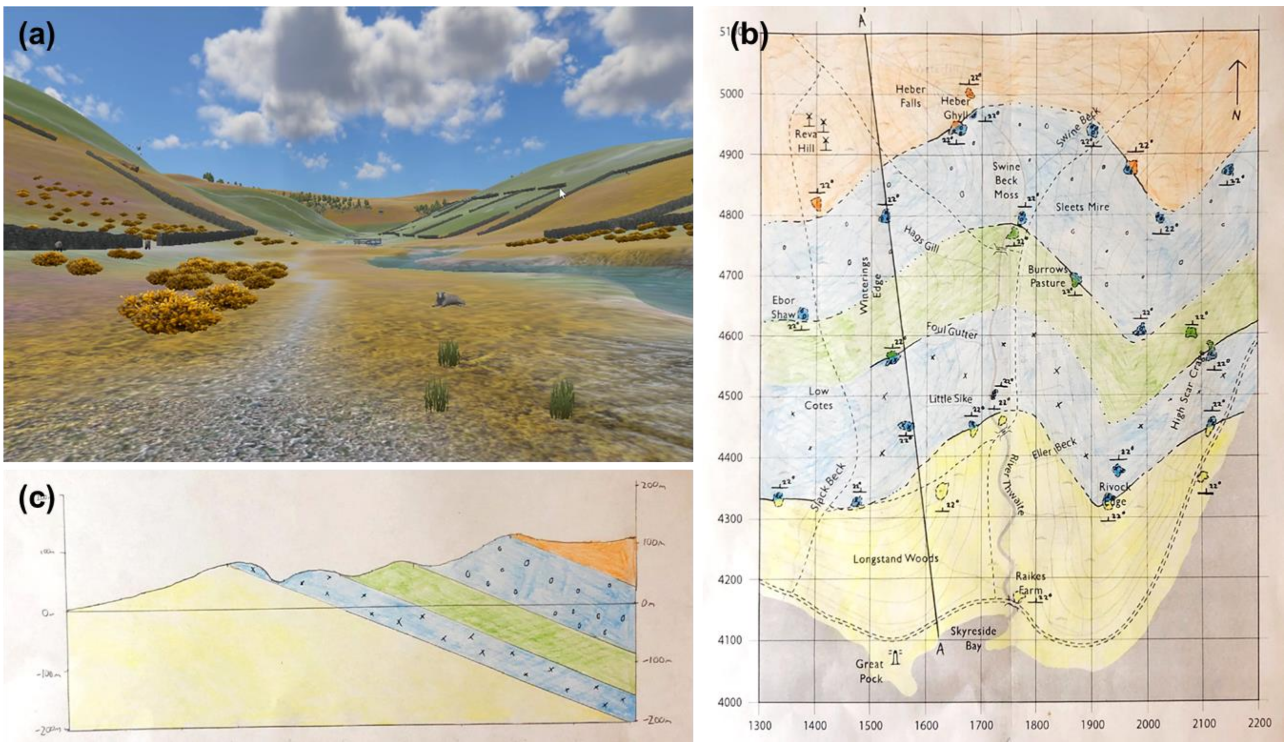

Figure 7: (a) Immersive virtual field mapping exercise, Lighthouse Bay Virtual Landscape (Houghton and Robinson, 2017); Example of a student submission of the interpreted (b) geological map and (c) cross-section.

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4.4 Building Community

GEOE/L 221 is an important opportunity for each class of undergraduate Geological Sciences and Geological Engineering students to develop relationships and build their community that will carry them through the remainder of their degree programs. At the beginning of fall term of second year, many students in these courses have never met because they came from large common core first year programs with multiple sections for each course. Therefore, providing opportunities for students to begin building their class community was an important consideration in the remote course design for fall 2020. These included use of online, asynchronous editable documents (e.g. Google Slides and Google Docs (© Google 2021)) to facilitate a virtual gallery walk (McCafferty and Beaudry, 2017) of personal introductions, and weekly discussions about lecture and reading materials. Synchronous tutorial and lab periods were scheduled virtually by video conference calling and, for the working time during these calls, students were randomly sorted into breakout sessions of 3-4 students per group where they had opportunities to work together. In this setup, students were sorted into different groups each class with the objective being they would meet and work with all their classmates at least once during the course. Lastly, the group project was organized to have 3-4 students per group where they worked together for half of the course. A timeline of these community elements that were embedded into GEOE/L 221 in fall 2020 is illustrated in Figure 8.

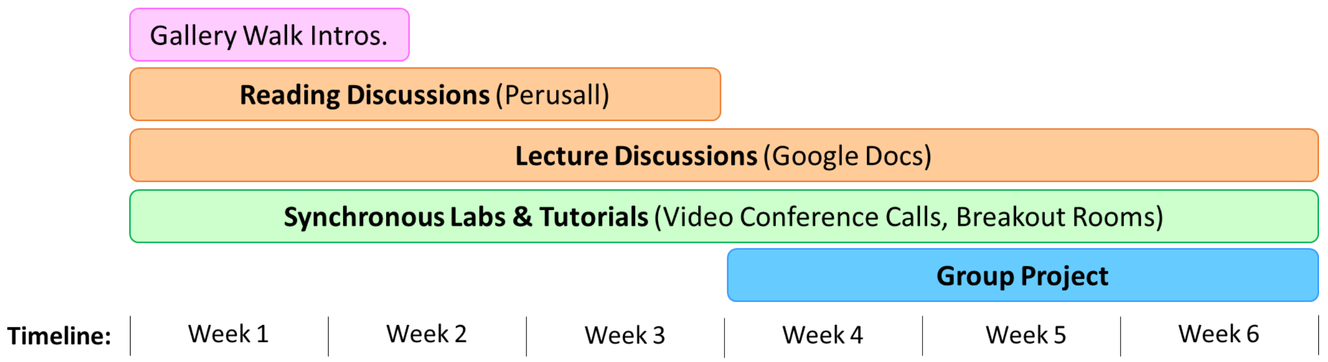

Figure 8: Summary timeline of elements for building class community embedded within GEOE/L 221 in fall 2020.

5. Discussion

The emergency remote offering of GEOE/L 221 Geological (Engineering) Field Methods in fall 2020 successfully achieved coverage of all CLOs carried over from the previous in-person course offering in fall 2019. The CLOs that correspond to each assessment item are listed in Table 3. This indicates that students were successfully taught the course concepts and skills and they were able to demonstrate their understanding in at least one course assessment. Field methods, however, is by nature a cumulative subject with a spiral structure where there is an impressive evolution of learning from basic skills for field data collection, to data analysis, integration, and synthesis into geological models and other results, and reporting the results in the

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form of geological maps, sections, stratigraphic columns, stereonets, and written and oral summative reports. In this remote course offering, students had many opportunities to practice some skills, including:

- Rock sample observation, identification, and classification (virtual 3D model samples);
- Rock outcrop observation and sketching (virtual 3D model outcrops);
- Geological map and section completion (hand drafting); and
- Plotting orientation data on stereonets and interpreting geological trends (hand drafting).

However, students had only one opportunity to perform:

- Pace and compass traverse navigation (outdoors);
- Measuring orientations of geological structures (manual compass operation); and
- Traverse planning and time management (virtual field exercise);

And no opportunities to learn or practice:

- Rock sample observation, identification, and classification in person, with a hand lens and other field identification tools, and in the contexts of one or multiple outcrops with multiple units;
- Identifying and measuring orientations of geological structures on outcrops;
- Integrating pace and compass traverse navigation with geological field mapping; and
- Integrating the field data results from multiple traverses with a desktop study to report on geological and geological engineering problems.

Therefore, although the CLOs were all achieved, the missed opportunities to practice these field skills, which are normally part of the in-person course, demonstrate the need to return to in-person field methods learning once the pandemic emergency is resolved.

Table 3: CLO distribution in GEOE/L 221 assessments in fall 2020

Assessment Item	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5	CLO 6	CLO 7	CLO 8	CLO 9
Professionalism, Individual	X								
Q&A Course Engagement	X								
Lab Assignments (5, Individual)	2	2	2	3	3	4	2		
Group Project (Written Report)							X	X	X
Term Quizzes (6)	2	5	6	4	1	4			
Final Oral Exam			X	X		X	X		

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5.1 Student Feedback

Overall, student feedback was positive in the context of their first fully remote term during COVID-19. Based on informal discussions and comments, students found the following remote course activities extremely helpful and valuable:

- Recorded video demonstrations combined with the live tutorials;
- Hands on practice exercises that preceded lab assignments;
- Weekly checklists that listed all course activities and deliverables;
- Asynchronous written discussion opportunities for lectures and readings; and
- The immersive virtual field lab assignment that provided a sense of what is done in the field.

Students found they learned a great deal from the course but experienced a high workload, which is partly attributed to the condensed term for this offering (7 weeks compared to a normal 12-week term). Because of this condensed term, some students also felt they did not have time to fully process and understand the material as thoroughly as they may have in a 12-week course. Other students, however, preferred the condensed term in this remote environment where they only had to focus on 2 or 3 courses at a time. Further, some students found lab assignments to be much more difficult than the practice exercises. Certainly, the remote delivery reduces opportunities for students to approach teaching assistants or instructor with questions about assignments; however, very few students made use of the weekly office hours with the teaching assistants or instructor.

6. Conclusions

In the context of the COVID-19 pandemic, the fall 2020 emergency remote offering of GEOE/L 221 was very successful. The course was redesigned to employ a combination of virtual, manual, and blended virtual-manual course elements, while achieving all course learning outcomes. The author (and instructor) owes the geoscience community a debt of gratitude for sharing many digital and virtual resources during the pandemic, especially those cited in this paper.

It is critical to emphasize the cumulative subject matter of field methods requires multiple opportunities to learn and practice field skills and develop an integrated understanding of related concepts. Although all course learning outcomes were achieved in this remote delivery of GEOE/L 221, many concepts and skills were learned in relatively isolated activities. The integrative aspects of learning field methods that truly require in-person field experience are lacking in this remote environment. These results demonstrate the need to return to in-person geological and engineering field methods learning as soon as it is safe to do so, in the context of the COVID-19 pandemic. It should be noted, however, that some new course elements should be integrated into in-person course deliveries to enhance students' learning.

To overcome these limitations of this remote delivery, a series of optional field trips is planned in fall 2021 (pending a safe COVID-19 situation) for students who completed GEOE/L 221 in fall 2020, where they will have an opportunity to practice

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and develop their integrated field skills. It is anticipated this activity will solidify students' understanding of second year concepts and skills and add the important perspective of in-person, physical field work to their knowledge and experience for entering their third year of studies.

Data Availability

Access to the digital hand sample models created by the Department of Geological Sciences and Geological Engineering at Queen's University are available via Sketchfab at https://sketchfab.com/GSGEQueens.

Author Contribution

Jennifer Jane Day conceptualized the work, conducted the investigation, and created the written work.

Competing Interests

The author declares that she has no conflict of interest.

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