Redesigning Field School: E-Participation in Geotechnical Field Exercises

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GEOQuébec 2015
Challenges from North to South
Des défis du Nord au Sud

ABSTRACT
There is much academic debate in terms of what to include in undergraduate and graduate programs for GeoEngineering students at Canadian Universities (and abroad) in order for a student to gain fundamental knowledge and become fully prepared for the challenges associated with the workforce. In determining the proper balance of methods and tools to be utilized within a Geological / Geotechnical Engineering graduate program, a number of factors need to be considered. The most prevalent of these factors are: The current state of industry and their requirements, technological improvements, sustainable development and social demands as well as the advancement of educational tools and techniques. This paper highlights the use of blended (online/onsite), synchronous/asynchronous interactions for the purposes of enhancing geological and geotechnical field exercises; not limiting the experience to those physically on the field exercise. This proof of concept case study demonstrates that field exercises, related assignments and real world learning do not have to be limited to those that can afford to participate in such excursions. The paper will underscore the relevance of the inclusion of such activities, technologies and associated teaching methods balanced against the very real time, fiscal and technology constraints and a need to optimize these efforts.

RÉSUMÉ
Il y a beaucoup de débats académiques en ce qui concerne ce qu'il faut inclure dans les programmes de premier cycles et d'études supérieures pour les étudiants en géo-ingénierie des universités canadiennes (et à l'étranger) afin qu'ils soient prêts pour les défis associés à la main-d'œuvre. Pour déterminer le juste équilibre des méthodes et outils à utiliser dans un programme d'études supérieures d'ingénierie géologique/géotechnique, un nombre de facteurs doivent être considérés. Les plus courants de ces facteurs sont : l'état actuel de l'industrie et ses exigences, l'amélioration technologique, le développement durable et les revendications sociales, ainsi que la promotion des techniques et outils pédagogiques. Cet article met en évidence l'utilisation des interactions synchrones/asynchrones aux fins d'améliorer les exercices des domaines géologiques et géotechniques sur le terrain; en ne limitant pas l'expérience physiquement sur le terrain. Cette preuve de concept d'étude de cas démontre que les exercices de terrain, les affectations et les apprentissages du monde réel n'ont pas à être limités à ceux qui ne peuvent se permettre de participer à de telles excursions. Ce document soulignera l'importance de l'inclusion de telles activités, technologies et méthodes d'enseignement associées, mises en balance avec les contraintes financières, de temps réelles et de la technologie, ainsi que la nécessité d'optimiser ces efforts.

1 INTRODUCTION

The geological and geotechnical fieldtrip setting is a highly complex semi-formal learning environment. It usually employs problem-solving learning strategies with specific objectives, such as defining a geological material or feature, or design of an engineering structure. Often, field trips involve collaborative tasks that resemble real-world working settings. The learning outcome is to experience the processes of conducting geological/geoengineering research or work-related activities in the real world. For many students, geological field trips can pose a challenge, especially if they have little exposure to successfully participating in learning activities and attaining educational outcomes outside highly structured and controlled artificial settings, i.e. the lecture halls.

The many advantages of using of technology have been accepted in field exercises, for educational as well as research purposes. The mobile web and location awareness of handheld devices, where such devices 'know' their geographical position through the use of positioning technology such as GPS, Wi-Fi or cell towers, are technologies that are expected to evolve significantly in the near future (Gartner, 2010). The means by which we can receive or create data at any time and any place is easier and more widespread than ever before, offering a plethora of opportunities to students and professionals to seek and receive information while in a field exercise.

While various challenges arise with the introduction of technology in the orchestration of learning in the field (i.e. battery life, processing power, visibility, durability and usability, as well as the user's varying levels of trust and reliance on different technologies) and these have been discussed in current literature, students can gain substantially if the use of online resources and distance learning practices are carefully incorporated in their field exercises, with pedagogy in mind. Technology-enhanced field exercises can provide a richer context in the learning process for the student; it can afford an annotation of the environment, similar to an annotated bibliography resource (Vavoula & Sharples, 2001; Squire & Klopfer, 2007). This paper aspires to be the first of a series of papers on technology-enhanced field exercises with pre-field, onsite and meta-field components. The challenge that is posed here is to employ technology in order to enhance context in field exercises. Context can be defined as “the formal or informal setting in which a situation occurs; it can include many aspects or dimensions, such as environment, social activity, goals or tasks of groups and individuals; time (year/month/day)” *(Brown et al., 2010: p4)*. Depending on how we use context or how it changes (due to seasonal variations, geological phenomena etc) in the natural environment, it plays a critical role in the learning experience.

The main barriers to developing technology-enhanced field exercises in higher education for geological sciences and geological engineering students are not technical but social. Instructors often have little understanding of context and learning outside the classroom, and even less about how this can be supported through new mobile learning technologies.

Within this framework, the use of synchronous and asynchronous state-of-the-art technology for the purposes of enhancing geological and geotechnical field exercises is investigated. In this way, field exercises, related assignments and real world learning do not have to be limited to those that can afford to participate in such field-related activities. The paper underscores the relevance of the inclusion of such activities, technologies and associated teaching methods balanced against the very real time, fiscal and technology constraints and a need to optimize these efforts.

2 FIELD TRIP ENVIRONMENT

It is readily apparent that many of the sciences and engineering disciplines concern themselves with the physical environment. There have been many studies associated with the inclusion of technologically in traditional classroom settings, however, within these disciplines, the physical environment is also a component of the classroom setting (Elkins and Elkins, 2005; MacDonald, Manduca, Mogk, and Tewksbury, 2005; Brown, Börner, Sharples, Glahn, Jong and Specht, 2010). Programs within Geology, Geological/Geotechnical Engineering, Environmental Engineering, Civil Engineering etc. all include studying the physical and real-world environments in the form of field trips. For example,

Fig 1. An example of graduate students in the field examining the physical environment as part of their graduate program / experience.

Figure 1 demonstrates students in the field examining underground engineering works, assessing the geology of an area and obtaining environmental water samples.

There is no question that such experiences enhance the overall learning experience through experiential learning, however, the organization of such field trips needs to be pointed and incorporate specific learning outcomes. The authors do not profess to replace such physical excursions with virtual tours but rather to allow access to such activities to others that are not on site and/or to systematically organize the information as well as participant-generated material gathered during such field trips for future use by students.

Within the undergraduate Civil Engineering Department at the Royal Military College, there are many course that include a field component. These courses include but are not limited to: CEE 235 – Introduction to Earth Sciences, CEE 360 – Geomatics I, CEE 363 – Survey School, CEE 393 – Field School and others that include mostly one-day site visits to various relevant sites (i.e. construction sites, water treatment plants etc.). At the graduate level, the author through cross-appointment to Queen’s University also teaches GEOL 840 – Field Technical Tour of Tunnelling and Underground Works in Greece within the Geological Sciences and Geological Engineering Department. Currently, these courses do not have a distance learning “twin”. The research encompasses the implementation of technology enhancement for such courses as stipulated by the objectives summarized in the following section.

3 OBJECTIVES

The objectives of this ongoing field-related research include:

a. The incorporation of technology within the classroom with educational theory underpinnings;

b. The creation of sustainable field training with a view to re-evaluating field exercises at the university level (graduate and undergraduate) based on a cost / learning outcomes ratio;

c. The production of learner-centered field teaching material with distance technologies; and,

d. Addressing the needs of today’s *global* Geoscientist and GeoEngineering professional by:

   i. Building an Open Access FieldEx Database (for faculty and students); and,

   ii. Mitigating risk through Quality Assurance (QA) and facilitating field knowledge mobilization within the geoscience / geoengineering community.

4. BLENDED FIELD EXERCISES: E-PARTICIPATION IN THE FIELD

The use of context-aware mobile devices, with global positioning system (GPS) positioning (among other capabilities) is prevalent in many aspects of the young geoscientist/geo-engineering student and processional in the field. By designing blended field spaces with the use of technology, where physical and digital spaces come together, we can produce rich learning opportunities taking advantage of the natural environment and the advantages of distance technologies. The focus (and challenge) is to incorporate such technologies into the learning experience with proven and relevant educational theories. As an example, the combination of experiential learning in field exercises and outcomes-based instruction can be realized by asking the students to record their experiences while onsite with a view to incorporating it in future field trip preparations. While at the field location, the instructors can advise the students about the creation of the content, thus further focusing their learning. As well, the social interactions that can occur around the information made available by mobile devices on the field trip the form of browsing content produced by others, or creating new content for others to view (either new observations, or as a critique/feedback to existing information) are an important part of learning and knowledge construction (Vygotsky, 1978; Jonassen, Howland, Moore, and Marra, 2003; Clough, 2009a; Clough, 2009b). It is important to note here that, while onsite, the instructors together with the students have the opportunity to discuss the validity of information available online about a particular site and compare content produced by others with real-time observations. Further, by generating their own content, the students are immersed in experiential thinking, i.e. internalising the new information by being involved in hands-on activities. Also, students' reflective thinking and meta-cognition can be encouraged by reviewing existing information about the field location while onsite, author their own reflections and share with peers synchronously and asynchronously (potentially, as a post-field trip exercise (e-participation) or make it available for use by future participants in field exercises).

5. DESIGN AND CONDUCT OF FIELD TRIPS

The authors propose that there are 3 main phases when designing and executing field trips with the use of technology. These are presented in Table 1 and include:

a. Phase 1 - Pre-field activities;

b. Phase 2 - In field activities; and,

c. Phase 3 - Post field activities.

Bloom's Taxonomy offers a comprehensive framework where these field activities can be designed within. As Krahwohl points out, it offers "a means for determining the congruence of educational objectives, activities, and assessments in a unit, course, or curriculum" (Krathwohl, 2002). Each of the three phases is important in the successful implementation of a technologically-enhanced field trip. The focus is on the learner and meta-cognition whereby the student retains and gets the most out of the field.

The pre-field activities include but are not limited to organizing the field trip from an administrative perspective. Technologies need to be proven (i.e. checked for serviceability and applicability) and detailed instructions as to how to apply such technologies as well as how to gather and organize data need to be prescribed. Clear and obtainable objectives need to be established in order to guide and focus the students. For example, the recording of the position of where and when (and why) a photo was taken with a relevant field note (i.e. metadata) and how to capture and organize such data should be stipulated in detail.

The in-field activities phase includes the valuable on-site instruction, experience and collection of data. Access to previous databases (asynchronous) of field trips can be used in conjunction with on-line resources (synchronous) and discussions with on-site experts that augment the overall field exercise experience. Authoring of student-generated content onsite with real-time observations (that includes reflections on information available online about the site) as well as completion of assignments and activities as predetermined in Phase 1.

Table 1. Blended Field Learning based on Bloom's Taxonomy.

Theory	'Traditional' Field Application	Technology Enhanced
Evaluation / Creation	Generating, Planning, Producing (using the field ex as stepping stone for next research and educational activities).	+Higher-level discussions on a global level. Outcomes fed back into Open FieldEx database. Capturing and sharing of resources, commenting on field experience in online Discussion Fora for later asynchronous open use.
Synthesis	Validation of material taught in class.	
Analysis	On-site discussion with hands-on field exercises.	Review of online resources *onsite* Contribution to online discussion fora. Authoring of mspace tools with observations and feedback from field activities. Experiential learning, social learning and metacognition activities (student-generated material).
Application & Comprehension	Completion of applicable Lab Assignments and Student Projects on Field sites to be visited.	Use of online Discussion Fora to augment Critical review of student projects on Field sites to be visited, with student and faculty feedback. Student projects are openly accessed by RMCC & Military community.
Knowledge	Review of bibliography prior to the Field Ex.	Selection of relevant online resources to be reviewed onsite, during Field Ex.

(Bloom et al., 1956; Anderson,Krathwohl, Airasian et al., 2000)

Post-field activities can include the final organizing and sharing of information amongst students and staff alike. For instance, an interactive map of the student's experience can link to the student's m-space (Fig 2). These products can be organized in such a way as to include in geographic information system (GIS) platforms. Other students can then comment on the product of the field exercise by adding their own views and experiences to the forum. Post-field activities should also incorporate feedback from the students concerning the use of technology and the overall field experience. These can then be evaluated to produce lessons learned that can be used to improve the next series of field trips.

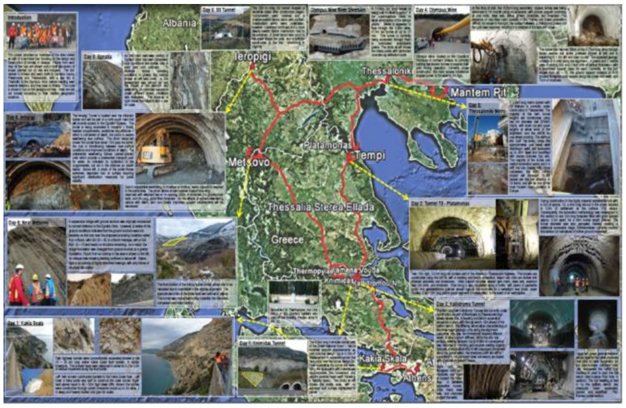

Figure 2. Indicative product (not meant to be read) produced by students from geological engineering field trip in Greece as part of a graduate field technical tour. The product details specific locations on a map and a record and photo of what was seen at these locations.

6. MULTI-DISCIPLINARY ENVIRONMENT

In order to properly create, design and implement a geotechnical field trip, there are many core competencies that are required. As seen in Figure 3, expertise in many disciplines are required in order to effectively design a geotechnical (in this case) field trip. The main fields are:

a. <u>Geology</u> – are requirement for the understanding of the physical environment and processes that are evident within the area of study;

b. <u>Engineering</u> – knowledge in how to construct engineering works in such environments and applying material properties to geomaterials (as defined by the geologist). and characterizing the ground in terms of engineering properties;

c. <u>Learning Sciences</u> – being able to incorporate sound educational practices and theories of learning into the curriculum or field expercies; and,

d. <u>Technology / Computer Services</u> – Advanced technical knowledge and support in terms of the correct serviceability of the support as well as the proper use and implementation of such technology to augment the overall learning objectives is also a key component.

There are subject matter experts in each of these disciplines; however, there are limited individuals that possess such cross-disciplinary expertise and skills. The field trip should therefore, draw upon the salient components of each of these fields in order to effectively design and execute the field course; keeping in mind the learner for whom the course was intended for. The learner must be placed at the forefront as they are the ones that must benefit the most from such experiences, with a view to addressing the needs of modern students and professionals.

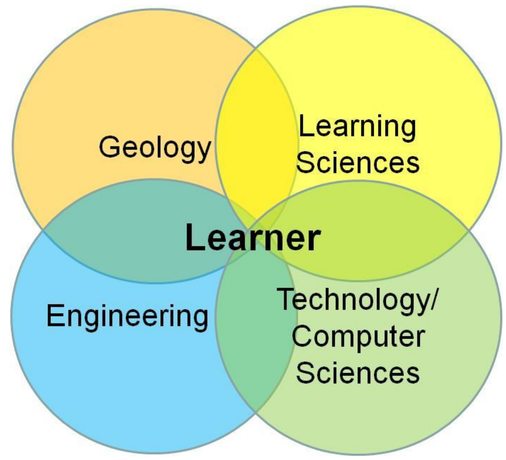

Figure 3. Competencies of fields that are required in order to successfully design and implement Geotechnical field trips.

7. STUDENT FEEDBACK

As mentioned previously, student feedback is important in order to determine if the field trips are organized correctly and are effective for the learner. Priestnal, Brown, Sharples and Polmear (2010) conducted a study using five different technologies in order to examine the overall experience of a museum visit. Their findings with respect to using technology to augment the museum experience for visiting schools are included in Table 2.

The feedback obtained from Table 2 is of a technical nature and also highlight environmental setbacks. The feedback does not address the quality of the learning which is the focus of this paper.

Preliminary feedback that was obtained by students participating in the current study that involved the use of technology on a geological engineering field trip (primarily from the GEOL 840 – Field Technical Tour of Tunnelling and Underground Works in Greece course) was collected. Positive feedback indicated that such a technologically enhanced field trip experience was improved by real-time accessing of:

a. Digitalized data sets of the area;

b. Material and structure properties; and,

c. Results of numerical tools.

Student feedback also indicated certain concerns that are included in Table 3.

Table 2. Feedback from a study on technology-enhanced visits to museums (Priestnall et al., 2010).

Technique	***Positive Observations***	***Negative Observations***
Computer-generated acetate	*-Successful format and simplicity. Electronic acetates offered as a vision for the future.*	*Difficult in windy conditions. Predetermined viewpoints were a drawback.*
Custom PDA application	*On-screen sketching facility, interactive legend and audio were popular.*	*Stability, incl. GPS connectivity. Screen visibility with bright sunlight ahead.*
Mediascape on a mobile phone	*Easy authoring (control over media placement)*	*Screen size and visibility rendered graphical media less effective.*
Google Earth on a tablet PC	*Large screen and Google Earth's data exploration environment popular.*	*Screen visibility, battery life, pen-based interaction (Google Earth designed for desktop machines)*
Head-Mounted Display	*Fun, engaging, good for heavily graphical information.*	*Technical complexity, robustness, heavy, not waterproof.*

Table 3. Preliminary feedback by students participating in a technology-enhanced geological engineering field trip (primarily from the GEOL 840 – Field Technical Tour of Tunnelling and Underground Works in Greece course, Queen's University).

Student feedback on technology-enhanced learning in field exercises (Preliminary)	
a.	*The introduction of multiple platforms may become overwhelming*
b.	*Data abundancy / consistency might lead to confusion*
c.	*The introduction of multiple platforms may become overwhelming*
d.	*Less reliance on engineering judgment instead of helping its development*
e.	*Concerns that technology may substitute field observations instead of enhancing its purpose.*

Effective, well thought-out design of the learning can mitigate these setbacks or address these concerns, always keeping in mind that the dynamics change and the field trips need to be tailored to the needs of the students each time.

4. CONCLUSIONS

It has been shown that technology can be incorporated to enhancing the overall field experience. The focus must remain on providing the student with the best resources in order to improve learning. These strategies can be employed in order to re-evaluative the Costs / Learning Outcome Ratio by encouraging use of online resources in field exercises as a quality assurance activity. This can include instruction and advice on critical review of openly available information offered by subject matter experts (SME) to the students. As well, this can lead to a re-evaluation of number, duration of and participation in field exercises within a program based on the richness of available and already amassed field material (i.e. properly organized database);

Such practices can lead to the overall effectiveness and sustainability of field programs through the creation of open field exercise databases with student-generated (and SMEs reviewed) material and E-participation in field exercises; This leads to reducing scientific and engineering risk (i.e. good, reliable and available data leads to superior decisions). As such, the redesigning of higher education learning activities, including field exercises, can be implemented using cost optimization and proven educational theory.

ACKNOWLEDGEMENTS

The authors would like to thank the students who provided feedback for this purpose. Support provided by the Royal Military College of Canada as well as Queen's University and the National Technical University of Athens is also appreciated.

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